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POSVEĆENA TEMI

TORPEDO — POVIJEST I BAŠTINA

150. GODIŠNJICA IZUMA LUPPIS-WHITEHEADOVA TORPEDA

•

7TH INTERNATIONAL CONFERENCE ON INDUSTRIAL HERITAGE
THEMATICALLY RELATED TO

TORPEDO — HISTORY AND HERITAGE

150TH ANNIVERSARY OF THE INVENTION OF THE LUPPIS-WHITEHEAD TORPEDO



PRO TORPEDO Rijeka
Rijeka, 2024.

VII. MEĐUNARODNA KONFERENCIJA O INDUSTRIJSKOJ BAŠTINI

TORPEDO – POVIJEST I BAŠTINA

150. godišnjica izuma Luppis-Whiteheadova torpeda

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150th anniversary of the invention of the Luppis-Whitehead torpedo

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Posvećena temi

TORPEDO – POVIJEST I BAŠTINA
150. godišnjica izuma Luppis-Whiteheadova torpeda

Thematically related to

TORPEDO – HISTORY AND HERITAGE
150th anniversary of the invention of the Luppis-Whitehead torpedo

ZBORNIK RADOVA
CONFERENCE PROCEEDINGS

"THE SMALL WHITE FLEET" – VISIT OF THE US NAVY TO TRIESTE AND FIUME IN 1904

„Mala bijela flota" – posjet mornarice SAD-a Trstu i Rijeci 1904.

György Ákos*

SUMMARY

A squadron of the US Navy under the command of rear admiral Albert S. Baker visited the Mediterranean in July 1904. This fleet, which may be aptly called the "Small White Fleet" – a forerunner of the "Great White Fleet" of 1907 was to visit Lisbon, Gibraltar, Piraeus, Corfu and Trieste. Fiume/Rijeka has been added to the list of ports, primary for the sake of the Whitehead Torpedo Factory. The fleet totaled 13 vessels, including six battleships. The presentation describes the fleet visit to the ports of the Austro-Hungarian Empire – Trieste and Fiume on hand contemporary pictorial evidence and historical documentation, including the visit to the Torpedo Factory and test firings of torpedoes by the battleship USS Kearsarge.

Keywords: *torpedo, Torpedo factory, US Fleet, Trieste, Fiume*

SAŽETAK

Brodska eskadra mornarice SAD-a pod komandom kontraadmirala Alberta S. Bakera posjetila je Mediteran u srpnju 1904. Ta je flota, koja se prikladno može nazvati Malom bijelom flotom*, a prethodnica je* Velike bijele flote *iz 1907., trebala posjetiti Lisabon, Gibraltar, Pirej, Krf i Trst. Fiume/Rijeka dodana je popisu luka prije svega zbog Tvornice torpeda* Whitehead. *Flota je imala ukupno trinaest brodova, uključujući šest ratnih. Prezentacija opisuje posjet flote lukama Austro-Ugarskoga Carstva Trstu i Rijeci uz pomoć slikovnih i povijesnih materijala, uključujući one o posjetu Tvornici torpeda te probnom ispaljivanju torpeda s ratnog broda* USS Kearsarge.

Ključne riječi*: torpedo, Tvornica torpeda, flota SAD-a, Trst, Rijeka*

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JOHANN/GIOVANNI LUPPIS – A SIGHT FROM THE WAR ARCHIVE (KRIEGSARCHIV) VIENNA

Johann/Giovanni Luppis – pogled iz bečkoga Ratnog arhiva (Kriegsarchiv)

Ana Alebić-Juretić*

SUMMARY

With regard to the 150th anniversary of production of the first torpedo in Fiume/Rijeka, we will focus on one of his inventors, Giovanni/Johann Luppis. He was born in 1813 in Fiume/Rijeka, where his family had moved due to business, as they owned a commercial maritime company. As the original documents are missing, there is still some dispute about the nobility of both parental families. Though some sources indicate that he finished the Gymnasium in Fiume/Rijeka, the Qualification list in the War Archives states that he graduated from the Maritime School in Fiume/Rijeka. The file from the Viennese archive states that he continued his education for two (out of five) years at the Naval College in Venice (Collegio Maritimo), where he entered the Venetian-Austrian Navy in 1835, at the age of 22. The most peculiar fact about his naval career is that his name is missing from the School Registry (Matricola) that contains all the students that ever attended the school, no matter what their final results were. He spent 25 years in the navy, reaching the position of the commander of frigate in 1856. The same year he was appointed director of the Arsenal, the shipyard in Trieste that was in bankruptcy proceedings. According to the personal list he was caught in a secret activity described as "…valuable to his own sake". Though it is not stated what that activity was, one might assume that there was something connected with "Salvacoste", a forerunner of the future torpedo. Such an incident was condemned by his superiors and prevented his advancement in the navy. In his last personal list he was qualified as "not having all qualification for a commander of the battleship", and therefore he left the navy in 1861.

Keywords: *Giovanni Luppis, Naval College in Venice, Austrian navy,* Qualifikation list

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The name of Johann/Giovanni Luppis (Fig. 1) is worldwide known as inventor of technical device- a weapon to protect coastal area in wartime, with adequate name as "salvacosta" or literarily "Coastal saver". The original idea was to load a boat with explosives and to direct it via ropes from the coast to the enemies on board in boats. The initial idea was further developed and improved by British engineer Robert Whitehead, and his son John in Fiume (today Rijeka, Croatia) and the weapon became later well known as Whitehead's torpedo. Though the torpedo usage in war caused numerous victims, the sole development of the weapon resulted in numerous technical improvements that are still used in everyday life, e.g. gyroscope, liquid air etc.



Figure 1. *Giovanni Blasius Luppis*
(http://history.info/on-this-day/inventor-of-the-torpedo-1875/, 29.03.2017)

Although a lot of literature is dedicated to this invention and inventors, there are still some doubts about Giovanni Luppis. Lacking the original documents, there are still three unanswered questions: 1. the family origin; 2. his maritime education and 3. the end of his naval career. This work will deal with some data found in the War archive, that does not necessary clarify the missing parts.

1. THE FAMILY ORIGIN

Giovanni Luppis is also known with his Croatian name (translated) as Ivan Vukić. From the Book of Mediterranean Nobility [2] the Lupis family had ancestors in the noble family originating from Giovinazzo, small town in southern Italy, opposite to today's Dubrovnik, Croatia (Fig. 2).



■ **Figure 2.** *Giovinazzo, town in Southern Italy where the family Luppis come from* (http://www.thenicolaushotel.com/en/hotel-in-bari/the-destination/around-bari/giovinazzo/)

In the 13th century one of the Lupis family members moved to Ragusa (today Dubrovnik, Croatia), and from there they spread to the peninsula of Sabioncello-Pelješac, Croatia, forming a Dalmatian line of the Lupis family. In the Slavic neighborhood they changed the family name to Vukić or Vukašinović. In the second half of 18th century the family moved to Istrian peninsula and to Fiume (now Rijeka). Moving to the Northern Adriatic the family name was changed to Luppis. His father Ferdineo Carlo Ermenegildo Luppis, was described as maritime captain [3, Birth register], merchant [4, Personal file] and/or owner of the merchant fleet and had two buildings (at two opposite sites) in the harbor of Fiume [1, 5]. His mother was Giovanna-Ivana Perich, noble woman from Ragusa-Dubrovnik. As his father, Giovanni Biagio Ignazio Ferdineo Lupis was born 27.1.1813 in Fiume. He got married with baroness Elisa de Zotty, belonging to Istrian nobility from Parenzo-Poreč. The Personal file gives doubtful information about the Luppis heirs: in 1853 it states that he has one daughter, while the next year one son. Their only son, Giovanni Luppis von Rammer died in 1898, thus ending this family line.



Figure 3. *Entrance to former Cloister St. Anne in Venice that hosted Marine Kollegium from 1810-1848*



Figure 4. *Inner yard of the complex with two memorial plaques to remember: the founder of the Collegium Frederic, Archduke of Austria, vice-admiral and higher naval commander posed by sudents in 1867 (upper) and the anniversary of the foundation in 1810 and reorganization in 1820 posed in 1834 by vice-admiral and commander of navy Amilcare Paulucci delle Roncole (lower)*

There is doubt about the nobility of the ancient Lupis family, since Giovanni Luppis was awarded Austrian nobility for his military merits. According to the literature [2], both parents were descendant from the noble families. This does not mean that they really belonged to the nobility. One should know that nobility is inherited directly from father to son, and not all family members own the titles. On the other hand, it is possible to bear more than one and different level noble titles. There is no reason to doubt the Mediterranean Nobility Book, as the nobles have to prove their status from time to time.

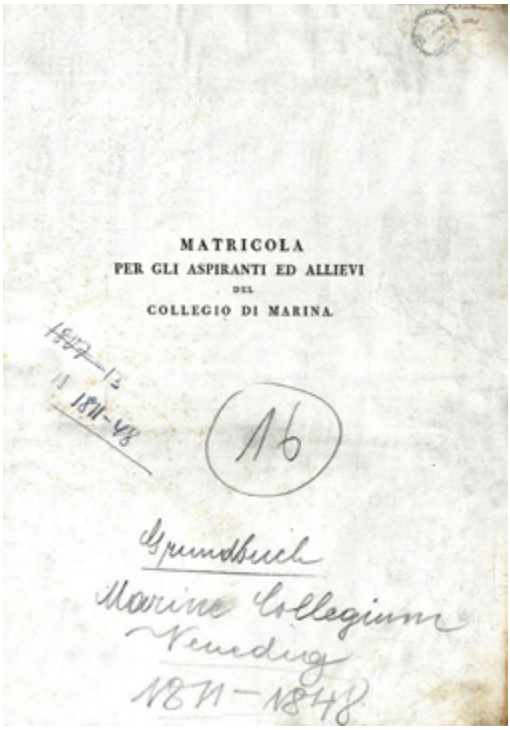
2. MARITIME EDUCATION

Though one would expect exact personal data from the naval Personal file (Qualifikationliste), this is not the case. Even the year of birth is biased: while the birth certificate states 27.01.1813, the personal file gives 1814 [4]. From the School register in 1825/26 he attended gymnasium in Fiume, while according to the Personal file [4], he attended Civil maritime school in Fiume and gained experience in commercial maritime traffic prior joining the last two years at Maritime College in Venice (Fig. 3 and 4).

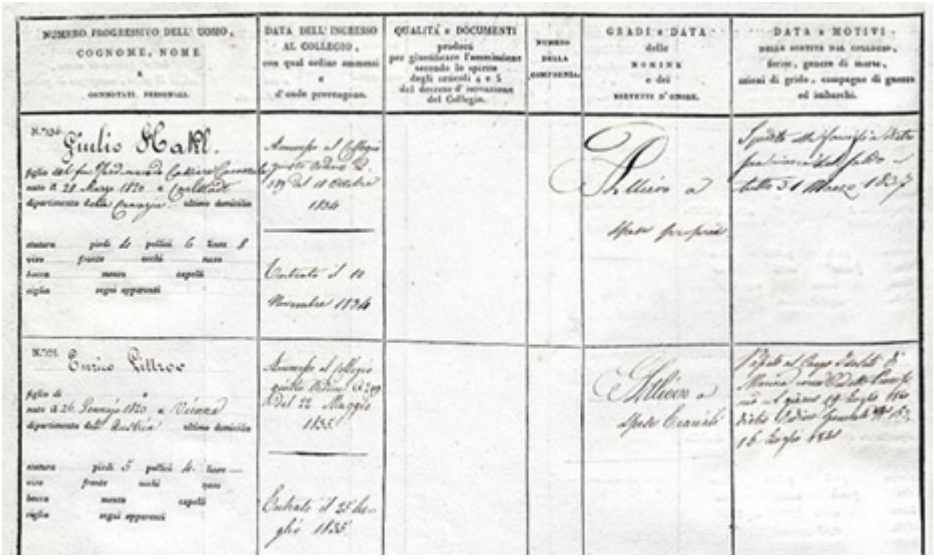
It is possible that all is true. The gymnasium lasted 8 years, starting at the age of 10. As he attended the Venician Maritime College only last two of 5 years, se started the College at the age of 19 or 20. There is a difference of 4-5 years, between lower gymnasium and Venician College, that he could spent in Civil maritime school and sailing on merchant boats. In fact, in those days, the necessary maritime education consisted of sailing on the merchant boat for 5 years and passing the respective exams [6].

All students that ever attended the Maritime College in Venice were registered in the respective book called "Matricola" (Fig. 5), where all important details about cadets were written, i.e. the enlistment, achievements in study, reasons for leaving the College [7].

Interestingly, though checked out several times, the name of Giovanni Luppis is not found in Matricola. Though documents from the 1830' are missing, from the available documentaton from 1810' it is evident that the Director complained about promotions of cadets without attending the College [8]. Having in mind that Luppis had experience in sailing, this could be the case. Registration of another cadet – Heinrich von Littrow from Fiume is given as an example of the enlistment in Matricola (Fig. 6).



■ **Figure 5.** *The cover page of the Matricola, book where all students ever enlisted in Collegium were registered. (Kriegsarchive/ Marine/Grundbuch)*



■ **Figure 6.** *The page of Matricola showing the registration of: a. Giulio Hahl from Carlstadt (today Karlovac, Croatia) who studied on his own cost, and was return to the family before ending the studies, and b. Enrico Littrow (Heinrich von Littrow) from Vienna who studied on errarial costs, and embarked as temporary cadet to a navy after completing the study. He later moved to Fiume (Rijeka) subsequent leaving the navy. (Kriegsarchive/Marine/Grundbuch)*

3. END OF NAVAL CAREER

Giovanni Luppis joined the navy in 1835 and spent there subsequent 25 years. He started as temporary cadet, and following regular promotions reached the position of frigate captain in 1856. In the turbulent 1848 he was engaged on the frigate Belona in the blockade of Venice, while in the year 1859 he spent on frigate Venus in Dalmatia. His superior described him as having practical knowledge and being very diligent. He spoke fluent Italian and "Slavic" (i.e. Croatian) and had good knowledge of German and French.

His behavior towards enemies was described as somewhat withdrawn. As social skills, he was described as the one looking for the company, and following the fashion in dress. His communication with subordinates was described as somewhat arrogant, correct with those with equal rang and permissive with superiors. He also spent some time in Triest, first as member of the commission, and than as trustee in bankruptcy at the arsenal. From the evaluation for the year 1856 it is clear that he was caught to "be valuable in his own sake". And therefore was transferred to Pola to take charge of wood used for construction of ships and subsequent to temporary port admiral in Trieste. Though, he got promoted to frigate captain in 1856, and that was his last [4].



Individual-Beschreibung

über nachbenannten Marine-Rath Offizier

für das Jahr 1860

Fregatten Capitaine Johann Luppis

Ritter des päpstlich Sylvester Ordens

gebürtig zu Fiume

im Jahre 1814. Vaterstadt

seit seinem Eintritte

Rang vom 19 September 1836.

Dienstzeit

seit 16 November 1835.

4	6	1
2	2	14
2	11	3
2	9	12
3	2	.
2	.	15
3	5	2
3	10	18
24	11	15

53

■ **Figure 7.** *The last annual evaluation of Giovanni Biaggio Luppis from 1860 (Kriegsarchive/Marine/Qualifikationliste)*

His last annual evaluation dates from 1860, and put some more light to what had happened. Stating "During his employment as trustee in bancrupcy in the arsenal in Trieste, he showed soon evidence of interest for certain weapon, hardly in compliance with technical requirements." [4] Though it is not clear what was about, it is very likely to imagine the "salvacoste" as this weapon.

Due to his unfavorable evaluation that described him with the words: "He does not fulfill all the requirements that a certain captain of battleship must have" [4], his promotion failed.

That might be the reason why he left the navy in 1861, at the age of 48. Most sources about Giovanni Luppis state that he got retired [9]. Without other prove one should accept this reason, though at that time the naval officers were retired at the age of 60 years. He than moved to Fiume (Rijeka) and started the well known story about torpedo…

Expectation to clarify some facts in the War Archive in Vienna, also failed. Even the Military archives have some mistakes and doubtful data, and further work is required to make proved corrections.

Acknowledgement: Work in the War archive in Vienna was possible due to the Richard Plaschka grant received in 2014.

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SAŽETAK

*Vezano uz 150. godišnjicu proizvodnje prvog torpedo u Fiume/Rijeci usredotočit ćemo se na jednog od izumitelja torpeda, Giovannija/Johanna Luppisa. Rođen je 1813. u Fiume/Rijeci gdje se njegova obitelj preselila zbog posla, odnosno njihove trgovačke pomorske tvrtke. Budući da nema izvornih dokumenata, različita su mišljenja o pripadnosti plemstvu obje roditeljske obitelji. Iako neki izvori upućuju na to da je završio gimnaziju u Rijeci, u popisu kvalifikacija iz Državnog ratnog arhiva stoji da je završio pomorsku školu u Fiume/Rijeci. U jednoj datoteci iz bečkoga Državnog ratnog arhiva piše da je nastavio školovanje (dvije od pet godina) na Fakultetu ratne mornarice (*Collegio Maritimo*) u Veneciji gdje se 1835., kada je imao 22 godine, pridružio venecijansko-austrijskoj vojsci. Najneobičnije je to što se njegovo ime ne nalazi u knjizi studenata tog fakulteta (*Matricola*), u kojoj su imena svih studenata koji su ga ikad pohađali, bez obzira na njihove konačne rezultate. Luppis je proveo 25 godina u mornarici, postavši 1856. komandant fregate. Iste je godine postavljen za direktora Arsenala, brodogradilišta u Trstu, koji je bio u stečajnom postupku. Prema njegovim osobnim podacima, uhvaćen je u tajnoj aktivnosti „... od vrijednosti samo za njega". Iako nije navedeno o čemu se radilo, može se pretpostaviti da je to bilo nešto povezano sa* Salvacosteom*, njegovim izumom koji je prethodio torpedu. Njegovi su nadređeni osudili taj incident i spriječili njegovo napredovanje u mornarici. U njegovim posljednjim osobnim podacima stoji da nije imao sve kvalifikacije potrebne za komandanta ratnog broda pa je stoga 1861. napustio mornaricu.*

Ključne riječi: *Giovanni Luppis, Fakultet ratne mornarice u Veneciji, Austrijska ratna mornarica,* Qualifikation list

MODERNI INDUSTRIJSKI SKLOP ELEKTROINDUSTRIJE *KONČAR* NA TREŠNJEVCI U ZAGREBU (1945. – 1949., Stjepan Gomboš, Mladen Kauzlarić, Vladimir Juranović, Otto Werner)

Modernist complex of Končar electroindustry in Zagreb (1945 – 1949, Stjepan Gomboš, Mladen Kauzlarić, Vladimir Juranović, Otto Werner)

Zrinka Barišić Marenić*

SAŽETAK

Industrijski sklop tvornice Končar *na zagrebačkoj Trešnjevci ostvaren je neposredno nakon Drugoga svjetskog rata u sklopu inicijalno potrebne industrijalizacije i elektrifikacije ratom porušene zemlje. Djelo zagrebačkih arhitekata Stjepana Kauzlarića i Mladena Gomboša (s inženjerima Vladimirom Juranovićem i Ottom Wernerom) osvojilo je prvu nagradu na raspisanom javnom natječaju. Arhitektonsko rješenje dosljedno je zasnovano na temeljima hrvatske moderne arhitekture međuratnog razdoblja, a dosege realizacije toga modernističkog ostvarenja prezentira splet najviših strukovnih nagrada za arhitekturu, dodijeljenih koncem četrdesetih godina 20. stoljeća. Velebni sklop elektroindustrije realiziran u tadašnjem jugozapadnom predgrađu Zagreba (ograničen, ali i povezan tadašnjom postojećom infrastrukturom), anticipira urbanitet te rubne zone grada modernom arhitekturom s iznimnim konstruktivnim rješenjima. Postaje žarište rada za stanovnike grada i okolnog područja te dolazi do izgradnje pratećih objekata za stanovanje i školovanje, koji se intenzivno ostvaruju sa svim popratnim društvenim sadržajima. Izgrađen kompleks tvornice djelovao je kao pokretač razvoja u tom području grada, istodobno potičući infrastrukturni razvitak, koliko i socijalni. Sama potreba za izgradnjom kompleksa industrijskih hala rezultat je transformacije i pojačane industrijalizacije nakon koje postojeća proizvodnja poprima novi oblik. Upravo je logika proizvodnje, kretanje proizvoda od početka do završetka njegove izvedbe, ključna za specifičnu organizaciju parcele tvorničkog kompleksa unutar granica ograničenoga prostora.*

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Rješenja nastala u kompleksu izraz su funkcionalnih veza industrijskog pogona – izraz proizvodnje. Položaj i oblikovanje arhitektonskih elemenata afirmiraju taj proces, a istodobno i ulogu industrije u razvoju i oblikovanju grada i društva. Urbanistička, arhitektonska i jedinstvena konstruktivna rješenja svjedoče o radikalnim promjenama nastalima zbog industrijalizacije na različitim područjima. Uz navedene arhitektonske i urbanističke odrednice, značenje tvornice koja uspješno djeluje više od šezdeset godina, u danas deindustrijaliziranoj Hrvatskoj osobito dolazi do izražaja u socijalnom i gospodarskom kontekstu. Kompleks Končar *danas je neprepoznata vrijednost industrijske baštine kao dijela kulture društva.*

Ključne riječi: *moderna arhitektura, urbani razvoj Zagreba, industrijski sklop, arh. Stjepan Gomboš i Mladen Kauzlarić*

1. UVOD

Današnja Grupa *Končar* ima gotovo stoljetnu tradiciju elektroindustrijske proizvodnje. Tvornica *Rade Končar* osnovana je 1921. godine. Formalno je upisana u trgovački registar Kotarskog suda I. u Zagrebu pod nazivom *Jugoslavensko Siemens d.d.* Prvi počeci rada uglavnom su vezani uz trgovačku djelatnost, tek poslije se prelazi na vlastitu proizvodnju radi koje je 1925. na zagrebačkoj Trešnjevci osnovana mala radionica električnih motora kao jugoslavenska podružnica njemačke tvornice *Siemens*.

Radionice izvedene zapadno od potoka Črnomerec proširene su tijekom Drugoga svjetskog rata dogradnjom dvaju bočnih brodova. Ratne 1943. izgrađeno je novo troetažno skladište i nadstrešnica. Neposredno uz tvornicu bilo je izgrađeno igralište za tenis i bazen za plivanje, što je u okviru Zagreba jedinstveno programsko obogaćenje programa tvornice sportsko-rekreacijskim sadržajima.

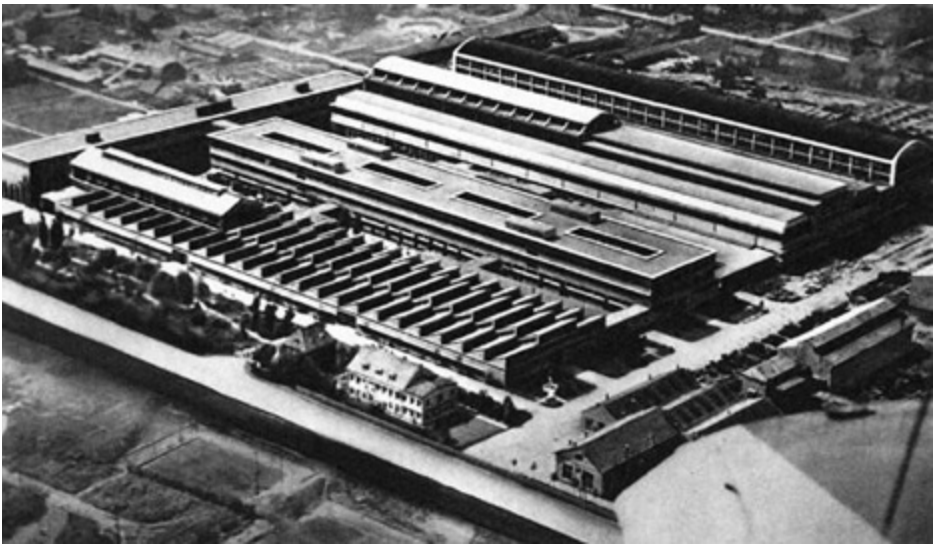
Nakon Drugoga svjetskog rata osniva se Elektro-industrija Hrvatske (ELIH), a tvornički sklop se razvija na spomenutoj lokaciji na Trešnjevci. Tada dolazi do transformacije i pojačane industrijalizacije nakon koje postojeća proizvodnja poprima nov oblik, povećava se izgradnja i dolazi do naglog širenja izgrađenoga tvorničkog, ali i stambenog prostora. Nakon Drugoga svjetskog rata tvornički kompleks elektroindustrije Hrvatske dobio je ime prema Radi Končaru koji je u poduzeću *Siemens d.d.* radio od 1937. do 1940. godine. Bio je član Komunističke partije Jugoslavije, organizirao je niz demonstracija i štrajkova te je smatran antifašističkim herojem.

„Jedno od najvećih poduzeća na području bivše Jugoslavije, SOUR *Rade Končar*, zapošljavao je i do 25.000 radnika u brojnim tvornicama od Samobora do Skopja. S asortimanom proizvoda od glačala do lokomotive i megaprojektima u stotinjak zemalja, *Končar* je zaista bio (ne samo) domaći industrijski gigant. Isporuke za nebrojene elektrane od Islanda do Indije, te nuklearne institute u Švicarskoj i Velikoj Britaniji zahtijevale su i kontinuirano ulaganje u

razvoj vlastitih istraživačkih resursa."[1] Proizvodnja tvornice *Rade Končar* odvijala se na više lokaliteta u Zagrebu, Hrvatskoj i Jugoslaviji. Danas nastavlja proizvodnju na nekoliko lokacija u Zagrebu. Zbog prepoznatljivosti na svjetskom tržištu elektroindustrija je djelomično zadržala ime te danas djeluje pod nazivom Grupa *Končar.*

2. SITUACIJA

Moderni industrijski sklop tvornice *Rade Končar* na zagrebačkoj Trešnjevci ostvaren je neposredno nakon Drugoga svjetskog rata, u sklopu prioritetno potrebne elektrifikacije i industrijalizacije ratom porušene zemlje. Trešnjevka je gradska četvrt u zapadnom dijelu grada, smještena južno od željezničke pruge. Prevladavajuću urbanu supstancu njezine sjeverne cjeline čine obiteljske kuće nastale na temelju regulacijskih planova (primjerice naselje Prve hrvatske štedionice Zdenka Strižića 1934. – 1935.) ili većinom bez planske osnove. Unutar svojevrsnog „tepiha" takve niske izgradnje dominiraju sklopovi velikog mjerila industrijske, odnosno prometno-infrastrukturne namjene, primjerice sklopovi tvornice *Rade Končar* i tramvajske Remize. Od značajnijih modernih arhitektonskih ostvarenja iz tridesetih godina 20. stoljeća uz Selsku cestu izvedeni su i osnovna škola i južnije naselje invalida i Istrijana arhitekta Ivana Zemljaka te crkva sv. Marka Križevčanina arhitekta Marijana Haberlea.



■ **Slika 1.** *Tvornica* Rade Končara*, Fallerovo šetalište 22, Zagreb; 1946. – 1949., M. Kauzlarić, S. Gomboš, V. Juranović, O. Werner Uchytil; Barišić Marenić, Kahrović, 2007: 121*

[1] Citat s izložbe *Skriveni dizajn – Odjel dizajna Končar 1971. – 1990.*, HDD galerija, kustosica Koraljka Vlajo

Zbog kontinuiteta proizvodnje na području Trešnjevke projektni sklop elektroindustrije razvija se na postojećoj parceli, južno od postojećih radioničkih objekata prijašnjega *Siemensova* pogona. Na lokaciji zapadno od potoka Črnomerec, sjeverno od Baštijanove ulice, istočno od Ulice Dragutina Golika te južno od Klanječke ulice[2] planirana je izgradnja modernoga tvorničkog sklopa.

3. PROJEKT I IZVEDBA TVORNIČKOG SKLOPA

Projekt tvorničkog sklopa elektroindustrije povjeren je zagrebačkim arhitektima prof. Mladenu Kauzlariću[3] i Stjepanu Gombošu[4], koji surađuju s drugim

[2] Navedeni su današnji nazivi ulica.

[3] Arhitekt Mladen Kauzlarić rođen je 1896. u Gospiću, a umro 1971. u Zagrebu. Građevnu stručnu školu završio je u Zagrebu. Radio u atelijeru H. Ehrlicha (1921. – 1931.), surađivao s J. Denzlerom (1925. – 1931.). Diplomirao na Akademiji likovnih umjetnosti u Zagrebu (1930.; D. Ibler). S arhitektom S. Gombošem osniva i vodi samostalan arhitektonski atelijer (1931. – 1941.). Član je društveno angažirane likovne grupe *Zemlja* (1931. – 1935.). Od 1940. zaposlen je na Arhitektonskom odjelu Tehničkog fakulteta u Zagrebu; predaje na Brodarskom odjelu Tehničkog fakulteta (1949. – 1957.). Laureat je nagrada za životno djelo *Viktor Kovačić* (1964.) i *Vladimir Nazor* (1965.). Član je JAZU-a od 1950. Izbor radova: 1929. Stambeno-poslovna zgrada Srpske pravoslavne općine, Preobraženska 2 / Ilica, Zagreb (+ J. Denzler; S. Kliska); 1929. Željeznički nadvožnjaci, Savska cesta, Jukićeva ul., Kranjčevićeva ul., Zagreb (+ J. Denzler); 1931. – 1933. Stambeno-poslovna zgrada Frisch, Petrinjska 11, Zagreb (+ S. Gomboš); 1931. – 1933. Vila *Spitzer*, Novakova 15, Zagreb (+ S. Gomboš; adaptirana, dograđena u zoni krovne terase); 1931. – 1933. Gradska kavana, Veliki arsenal, Pred dvorom, Dubrovnik (+ S. Gomboš, adaptirana); 1936. Vila *Pučar*, Novakova 24, Zagreb (+ S. Gomboš); 1938. – 1939. Ljetnikovac Svilokos na Koločepu (+ S. Gomboš, danas Vila *Ruža*, depandansa hotela *Koločep*); 1945. – 1949. Tvornica Rade Končara, Fallerovo šetalište 22, Zagreb (+ S. Gomboš, V. Juranović, O. Werner, I. savezna nagrada za arhitekturu Ministarstva građevina NRH 1947. i Nagrada Vlade FNRJ 1949.); 1964. – 1972. Arheološki muzej, Forum – Poljana pape Ivana Pavla II. 7 / Trg opatice Čike 1, Zadar (realizaciju dovršili S. Sekulić Gvozdanović, Z. Vrkljan); 1954. – 1976. Muzej hrvatskih arheoloških spomenika, Ulica Stjepana Gunjače bb / Šetalište Ivana Meštrovića, Meje, Split (realizaciju dovršili S. Sekulić Gvozdanović, Z. Vrkljan). Izvor: Uchytil; Barišić Marenić, Kahrović, 2007: 119.

[4] Arhitekt Stjepan Gomboš rođen je 1895. u Somboru. Diplomirao je arhitekturu na Visokoj tehničkoj školi u Budimpešti. Prva stručna iskustva stječe u Zagrebu kod arhitekta Rudolfa Lubynskog te Huge Ehrlicha. S arhitektom M. Kauzlarićem osniva i vodi samostalan arhitektonski atelijer (1931. – 1941.) te sudjeluje kao gost na izložbama umjetničke grupe *Zemlja* tridesetih godina. Za vrijeme Drugoga svjetskog rata interniran je u Italiju. Nakon rata kratko obnaša dužnost voditelja Povjereništva za tehničke poslove ZAVNOH-a, potom radi u Ministarstvu građevina NRH. Od 1946. vodi projektantsku grupu u Arhitektonskom projektnom zavodu Hrvatske i radi u arhitektonskom birou Plan u Zagrebu (1951. – 1962.). Na zagrebačkom Tehničkom fakultetu radio je kao honorarni nastavnik i predavao Industrijsko graditeljstvo. Upravo se ta činjenica smatra ključnom u razlici glede podjele rada između S. Gomboša i M. Kauzlarića. Međutim, indikativan je navod S. Gomboša nakon smrti kolege i suautora M. Kauzlarića: „Kod svih projekata koji su bili povjereni bilo Mladenu, bilo meni, dopunjavali smo se. Ja sam uglavnom davao inicijativu i tehnička rješenja, a on je projekte umjetnički dotjerivao. Mladen je dao svoj doprinos osjećajnošću te kulturnim i umjetničkim sklonostima." Uz navedene zajedničke radove s M. Kauzlerićem (u prethodnoj bilješci), u poslijeratnom se razdoblju uglavnom bavio industrijskim graditeljstvom. Kao tehnički voditelj i glavni projektant uz suradnike izgradio je niz tvorničkih sklopova: uz prikazanu tvornicu *Rade Končar* za koju je primio I. saveznu nagradu za arhitekturu Ministarstva građevina NRH 1947. i Nagradu Vlade FNRJ 1949., ostvario je i tvornice: *Prvomajska*, Tvornica parnih kotlova, *Jedinstvo*, RIZ u Zagrebu, *Đuro Đaković* (rekonstrukcija i proširenje) u Slavonskom Brodu, *Florijan Bobić* u Varaždinu, tvornice pokućstva u Novoj Gradiški,

stručnjacima, konstruktorima prof. dr. ing. Vladimirom Juranovićem i dr. ing. Ottom Wernerom. Dvojac, akademski arhitekt Mladen Kauzlarić i inženjer arhitekture Stjepan Gomboš, ostvario je tridesetih godina 20. stoljeća niz zapaženih realizacija na području stambene arhitekture i visokih plasmanana na javnim arhitektonskim natječajima. Nakon diskontinuiteta zajedničkoga projektantskog rada tijekom Drugoga svjetskog rata, suautorstvo je nastavljeno u sklopu Ministarstva građevina NR Hrvatske, ali zbog promjene društveno-političkog sustava pod drukčijim organizacijskim okolnostima i s novim projektnim zadacima. Nakon ukidanja projektnih službi raznovrsnih ministarstava, projektna djelatnost centralizirana je u okrilju novoosnovanoga Zemaljsko-projektnog zavoda NR Hrvatske, poslije Arhitektonsko-projektnog zavoda. „Suradnja pogonskih stručnjaka i konstruktora s arhitektima bila je rijetka i često neučinkovita pa ne iznenađuje da je pogon *Končara* u literaturi često istican kao jedan od rijetkih kvalitetnih rješenja", navodi dr. sc. Sandra Križić Roban.[5] Projektni je zadatak bio velik i kompliciran, a proces projektiranja tekao je gotovo usporedno s izvedbom koja je započela već 1945. godine.

U prvim proizvodnim planovima bilo je predviđeno da će se u tvornici *Rade Končar* objediniti sva prijeratna proizvodnja električnih proizvoda u Zagrebu.[6] Prvobitno rješenje bilo je odraz funkcionalnih veza jednog industrijskog pogona. Osnovna pretpostavka odvijanja rada bila je ta da bi se materijal, odnosno proizvod kroz hale kretao u pravcu sjever-jug, tj. sa sjeverne strane hale bi ulazile sirovine (sirovi proizvod) u proizvodnju, a na jugu bi izlazio gotov proizvod. Na bazi toga zamišljena je izgradnja ulaznog skladišta na sjevernoj strani (koje, međutim, nije izvedeno). Okomito na njega, u smjeru sjever-jug, postavljene su proizvodne hale. S južne strane proizvodni proces, odnosno linija kretanja proizvoda okončana je izlaznim skladištem gotovih proizvoda (dispozicije istok-zapad). Ta je zamisao osnova koncepta koji je dijelom ispoštovan i izveden. Nakon djelomične realizacije prvog projekta, počeo se mijenjati proizvodni plan tvornice.

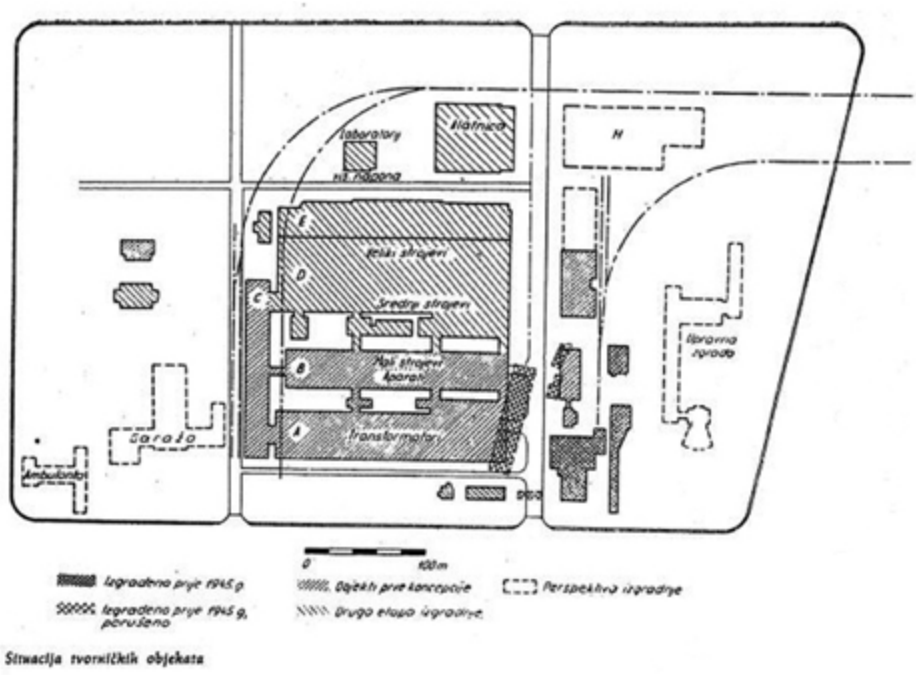
Petogodišnjim planom (tzv. prva petoljetka) u kojem je obuhvaćena i elektrifikacija zemlje, postavljeni su 1946. sasvim **novi zadaci pred tvornicu**. Trebali su izraditi transformatore velikih snaga, generatore, visokonaponske aparate itd. Svojevrsna „laka" proizvodnja, koja je do tada bila razvijena u tvornici, kao i proizvodi slabe struje, predani su drugim specijaliziranim

tekstila u Zaboku, polivinilklorida u Kaštel-Sućurcu, celuloze i papira u Belišću, Plaskom, Prijedoru (BiH), Ivangradu (Crna Gora) i dr. Objavio je niz članaka u stručnim časopisima *Arhitektura, Čovjek i prostor* i *Naše graditeljstvo*. Lauerat je nagrada za životno djelo *Viktor Kovačić* 1967. i *Vladimir Nazor* 1971. Umro je u Zagrebu 1975. godine.

5 Križić Roban: 2012: 101

6 Na osnovi tih perspektivnih planova projektirane su između južnog i sjevernog skladišta tri tvorničke hale smjera sjever-jug (paralelne s istočnim potokom Črnomerec). Jedna je hala bila predviđena kao nastavak i proširenje predratne proizvodnje *Jugoslavensko Siemens*, a druga za proizvodnju akumulatora, telefona i kućanskih aparata.

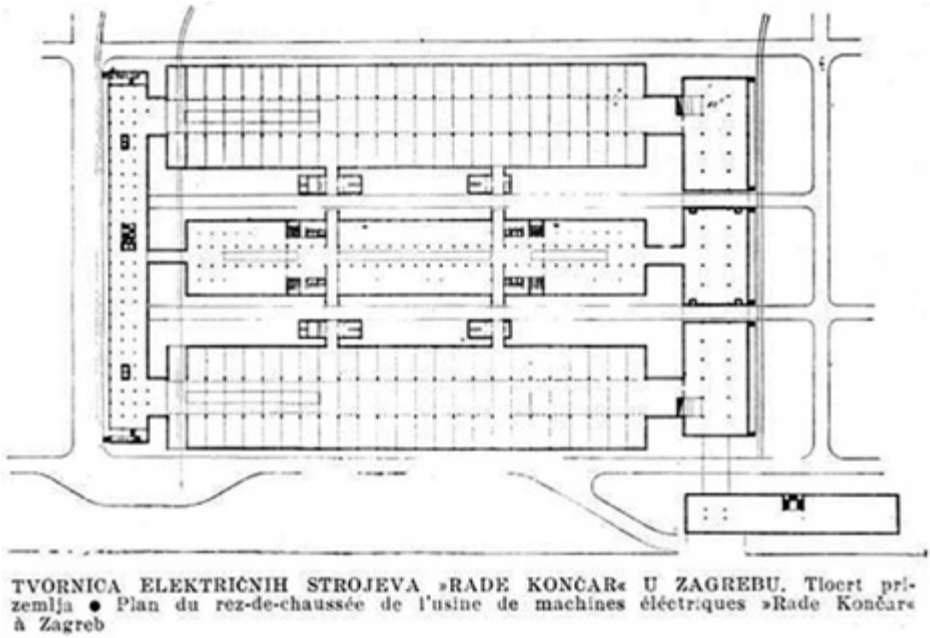
tvornicama. Pojavile su se teškoće s obzirom na to da je hala B bila građena za tzv. laku proizvodnju. Pri projektiranju prevladala je koncepcija razvijanja zasebnih proizvodnji koje bi bile potpuno samostalne.



■ **Slika 2.** *Situacija tvorničkog sklopa* Rade Končar *na Trešnjevci, Zagreb, 1956, izvor: ***1956.*

Tako je nastao današnji oblik tvornice, koji se više nije bitno mijenjao. U halu A smještena je proizvodnja transformatora, u halu B proizvodnja elektromotora i aparata, a za generatore je bila projektirana nova hala D. S obzirom na izgradnju hale D odstupa se od prvobitne koncepcije te sjeverna i južna strana hale nisu povezana s ulaznim i izlaznim skladištem. Zbog toga i zbog redukcije izvedbe sjevernog ulaznog skladišta, sjeverno pročelje industrijskog sklopa nije kompozicijski dovršeno i uravnoteženo. I sama hala D svojim je dimenzijama i nužnim vezama s izgrađenim površinama narušila jedinstvenost formalnog rješenja prvobitnog projekta. Arhitekt Mladen Kauzlarić ne navodi halu D kao autorsko ostvarenje, već u prikazu svojih radova prikazuje samo prvu i drugu halu (hale A i B) i izlazno skladište (hala C), izvedene prema projektu iz 1945. – 1946. godine.[7] U grubim crtama izvorni koncept tvornice je ostvaren, ali projekti su često mijenjani zbog mijenjanja planiranja proizvodnih zadataka.

7 ***(Galić, ur.): 1991: 95



TVORNICA ELEKTRIČNIH STROJEVA »RADE KONČAR« U ZAGREBU. Tlocrt prizemlja ● Plan du rez-de-chaussée de l'usine de machines électriques »Rade Končar« à Zagreb

■ **Slika 3.** *Izvorni projekt, tlocrt prizemlja (izvedene hale A, B, C, hala D izvedena prema izmijenjenom projektu, sjeverno dopremno skladište nije izvedeno), izvor: Gomboš, 1950: 40*

Godine 1948. ponovno dolazi do velikih promjena proizvodnih planova. Hala A i hala D nisu više bile prikladne za proizvodnju traženih količina proizvoda, dolazi do proširenja i planira se gradnja hale E. Nova hala predviđena je za montažu velikih transformatora i generatora, kao i za vitlanje generatora.

Svi objekti se mogu svrstati u četiri grupe:

– stari Siemensovi objekti (prije 1945.)
– objekti izvedeni prema izvornom projektu tvornice – prva etapa (hala A, B, zgrada C, toplinska stanica, izlazno skladište)
– naknadno projektirani objekti – druga etapa (hala D i E, alatnica, visokonaponski laboratorij i dr.)
– dovršetak cjeline i dodatna izgradnja manjih hala prema potrebi.

3.1. Tijek izgradnje prve etape

Najveći je problem bio smještaj velikog programa na nepovoljnoj lokaciji koja je određena obodnim ulicama, što je sprječavalo daljnje širenje industrijskog sklopa. Zbog toga nastaje osnovni projekt prema kojem su hale međusobno povezane unutarnjim dvorištima, nastao kao čisti izraz funkcionalnih veza jednog industrijskog pogona.



Slika 4. *Hala A (izvorno za proizvodnju transformatora), izvor: ***1956.*

Hala A krajnja je istočna hala proizvodnog sklopa, pozicionirana u smjeru sjever-jug (1945.). Sa sjevera preko dolaznog skladišta predviđen je dovoz sirovina (te otprema produkata veće dimenzije) i otprema gotove robe preko južnog objedinjenog izlaznog skladišta (hale C). U interijeru su smještene i kranske staze. Halu A obilježavaju poprečna struktura *shed*-krovova tri uzdužna broda. Specifičnost je veća visina središnjeg uzdužnog broda (također s poprečnim *shed*-krovovima) i specifičan bazilikalni poprečni presjek uzgibane pete fasade.[8] Jedinstveno je to rješenje koje ostvaruje bogato osvjetljenje radnih prostora ove proizvodne hale, koja je danas u funkciji skladišta. Refleksije autorskog pristupa arhitekta Mladena Kauzlarića, odnosno projektantsko iskustvo stečeno na ovoj proizvodnoj hali očituju se u muzejima koji su okrunili njegov autorski izraz, Muzeju hrvatskih arheoloških spomenika u Splitu i Zadru.

[8] Iznimka je u južnoj zoni glavnog broda redukcija *shed*-krova da bi se dobila njegova veća visina.



Slika 5. *Muzej hrvatskih arheoloških spomenika, Meje, Split (1954. – 1976., M. Kauzlarić, realizaciju posthumno dovršili S. Sekulić Gvozdanović, Z. Vrkljan), izvor: Uchytil; Barišić Marenić, Kahrović, 2007: 121*

Paralelno je građena i **hala B**, središnja peterobrodna hala proizvodnog sklopa (181 x 30 m). Troetažni je to objekt s nadsvjetlima duž središnjeg broda. Sedamdestih godina djelomično je interpoliran uredski trakt, čime je narušena izvorna dnevna prirodna osvijetljenost i prozračivanje interijera hale. U njoj su se nalazili uredi odjela prodaje, konstrukcijski biro i galvanizacija. Hala je galerijom povezana s halom C. Danas se u hali B proizvode manji motori, a na 2. katu je uprava.



Slika 6. *Hala B – proizvodnja aparata i malih motora, izvor: ***1956: 18*

Hala C (izlazno skladište) pozicionirana je u smjeru istok-zapad i nalazi se na južnom dijelu proizvodnog sklopa. To je dvokatna zgrada koja služi za skladište gotovih proizvoda. Okomita je na poziciju uzdužnih osi hala A, B i D te ih tangira s juga. Hala je projektirana kao **izlazno skladište** (1946.), što objašnjava i razlog drukčijoj poziciji i oblikovanju. Tlocrtnu dispoziciju prizemlja i prvog kata izdužene zgrade obilježava otvoreni prostor s četiri uzdužne skeletne osi te pet vertikalnih jezgri (od koje su dvije samo s dizalima). Drugi kat je dvotraktne tlocrtne dispozicije s uredskim prostorima. Izvornu funkciju izlaznog skladišta obilježava longitudinalna armirano-betonska nadstrešnica (s konstrukcijom ljuske zakrivljene po poprečnoj osi, u podgledu konkavne konture) koja se proteže duž cijeloga južnog pročelja zgrade. Podno nje je podest s kojega se u izvornoj fazi iskrcavala roba, gotovi proizvodi na kamione i vagone, koji su se odvojcima željezničkih kolosijeka odvozili na trasu obližnje sjeverne željezničke pruge do krajnjeg kupca/korisnika. Željeznički kolosijeci i danas su dijelom sačuvani na parceli sklopa. Izvorna funkcija je napuštena, danas se u tome prostoru proizvode generatori i mali električni strojevi te djeluje niz drugih poduzeća.

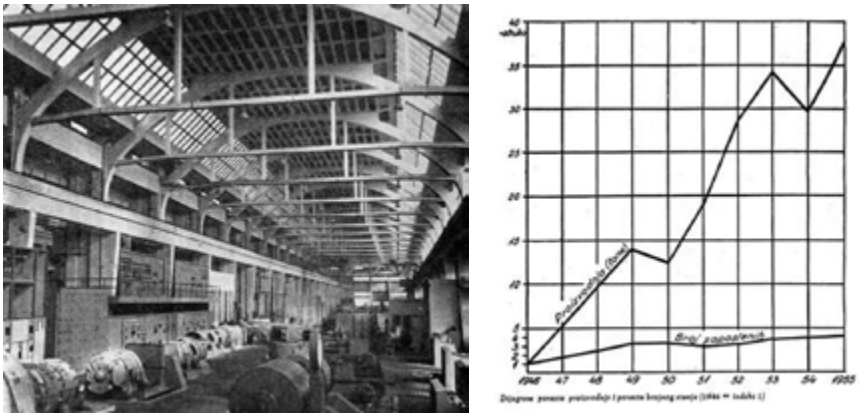


Slika 7. *Hala C – otpremno skladište, južno pročelje, podest s nadstrešnicom, izvor: Gomboš, 1950: 21*

Za konstrukciju navedenih hala korišten je armirani beton koji je u tim vrlo skromnim poratnim vremenima bio iznimno skup, a njegova uporaba rijetko dopuštena, navodi arhitekt Juraj Bertol.[9] Primjena armiranobetonskih konstrukcija velikog raspona govori o prioritetima ratom razrušene zemlje, industrifikaciji i elektrifikaciji, jer je elektrifikacija zemlje bila je na iznimno niskom stupnju i prije ratnih razaranja. Industrijski karakter sklopa u eksterijeru oplemenjen je korištenjem nežbukane opeke koja obilježava niz pročelja raščlanjenih potezima trakastih prozora. Oblikovna je to refleksija na historicističke industrijske pogone Zagreba (primjerice zgrade Tvornice koža Janka Jambrišaka, Janka Holjca i dr., Tvornice *Franck* i Pivovare arhitekta Kune Waidmanna), ali i moderno ostvarenje Gradske klaonice njemačkog arhitekata Waltera Fresesa (1928. – 1931.) u jugoistočnom dijelu grada.

3.2. Druga etapa: objekti za „tešku" industriju

Projektirana **hala D** inicijalno je zamišljena kao simetrična hala hale A, no za vrijeme izgradnje sklopa došlo je do promjene projekata. „Umjesto zapadne hale, jednake hali 'A' izgrađena je znatno veća 'D' hala koja kraj svih individualnih kvaliteta ruši valeur izlaznog skladišta i mjerilo cjeline," navodi arhitekt Stjepan Gomboš 1950. godine.[10] Nova velika hala D projektirana 1947. sa svojim srednjim brodom raspona 22,5 m, s dvije bočne lađe raspona 17,5 m i sveukupnom duljinom od 190 m bila je specifično ostvarenje u našoj zemlji.[11]



■ **Slika 8.** *Bočni brod hale D i grafikon rasta proizvodnje tvornice Rade Končar, izvor: ***1956.*

[9] „...Specifičan izraz ratne i poratne arhitekture nije bio politički uvjetovan, već je bio uvjetovan neimaštinom. Za gotovo sve gradnje projektant je dobio popis materijala koji ima na raspolaganju, vrste drva, količinu, dužinu greda i sl. Korištenje armiranog betona bilo je gotovo u potpunosti zabranjeno, jer je bio skup." Usmeni navodi arhitekta Jurja Bertola, intervju autorice s arhitektom održan 10. studenoga 2004. Barišić Marenić, 2007: 17-18.

[10] Gomboš, 1950b: 41

[11] ***1956: 18

Uza zgradu je izvedena moderna kovačnica za cijelu tvornicu. Upravo zbog hale D odstupa se od izgradnje ostalih objekata sklopa prema prvobitnoj koncepciji. Sjeverno pročelje industrijskog sklopa stoga djeluje kompozicijski nedovršeno. Učestala je to situacija u mnogim industrijskim sklopovima koje obilježava niz provizornih izmjena izvornog projekta, industrijskog sklopa i provizornih dogradnji, prema programu rada tvornice koji se tijekom godina ubrzano mijenja.

Dogradnja **hale E** koja je postala potrebna tijekom 1949., donijela je za građevinare neuobičajene zahtjeve. Goleme težine, velike visine zbog dizanja predmeta, široki rasponi i, na kraju, vertikalna vitlaonica u južnom dijelu predstavljali su jedinstven zadatak arhitektima i građevinarima.[12] U hali su interpolirani kranovi u dva nivoa, i to: niži konzolni i viši mostni, što je uvjetovalo veliku visinu hale. Glavni trakt ima krovni veznik i pokrov, izveden na temelju inovativnog rješenja dr. ing. Otta Wernera.[13] Krovni nosač je montažna lučna rešetka, a pokrov je od gotovih greda, izvedenih od montažne šuplje opeke.

Horizontalna vitlaonica izvedena je na jugu hale E. Glavna prostorija je cilindričnog presjeka promjera 5,4 m, duljine 9 m i zidovima debljine čak 1,5 m te prstenima za pojačanje. Posebnost je građevine što je koncipirana i izvedena tako da prima energiju eksplozije kako se zgrada ne bi raspala usred detonacije. Pri izgradnji uveden je modularni sustav, utvrđeni su novi formati betonskih prozora, vrata, nadsvjetla. Ti su detalji poslije uvedeni u cijeloj zemlji te su se pokazali iskoristivi u većini industrijskih objekata Hrvatske.[14] Tijekom izvedbe hale E i vitlaonice implementirana su nova konstruktivna rješenja te standardizacija, primjenjivi i na drugim objektima u zemlji.

„Tvornica se širi, povećava u svim smjerovima, samo ne prema sjeveru, u smjeru prvobitno projektirane zgrade ulaznog skladišta, gdje je uslijedila prva promjena koncepcije i kompozicije. Ta je činjenica u suprotnosti s temeljnim principom izgradnje industrijskih kompleksa, koji mora odrediti ne samo početak, nego i fiksni kraj izgradnje“[15], revoltirano zaključuje autorski prikaz arhitekt Stjepan Gomboš koji se u razdoblju nakon Drugoga svjetskog rata profilirao na području industrijske arhitekture. Upravo je na ovom primjeru zorno prikazano kako učestalo proizvodne potrebe i kapaciteti ubrzano nadrastaju postojeći izgrađeni okvir te izvedena zgrada i postojeća lokacija ne omogućavaju razvijanje novih programskih potreba.

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12 ***1956: 19

13 ***1956: 21

14 Gomboš, 1950a: 20

15 Gomboš, 1950b: 41

3.3. Sporedni objekti

Ostale objekte ovog razdoblja ne karakteriziraju osobita građevinska dostignuća, ali predstavljaju vrijedna djela u arhitektonskom smislu. **Alatnica** je građena od 1951. do 1954., sastavljena je od tri dijela koji su svaki za sebe odijeljeni kao i model objekata hale A, C i E.

Visokonaponski laboratorij građen je u isto vrijeme kad i alatnica te predstavlja suptilno oblikovano ostvarenje. Ostali objekti nemaju istaknuto arhitektonsko značenje, ali su projektirani u skladu s potrebama i prema osnovnoj koncepciji proizvodnje u kompleksu.

3.4. Komunikacijsko-infrastrukturni sustav

Da bi se omogućilo kompleksno funkcioniranje najvećeg onodobnog elektroindustrijskog sklopa u Hrvatskoj, tvornički sklop obilježava kompleksna struktura internih komunikacija: cestovnih trasa, odvojaka željezničkih kolosijeka s istoka i juga te pješačkih putova. Cestovna mreža izvedena je od sitnih granitnih kocaka, asfaltbetona ili sprameksa. Tvornica ima i razgranatu mrežu industrijskih kolosijeka s dužinom od 3875 m i 9 skretnica kako bi se moglo prići svakom objektu. Dio kolosijeka zadržan je do danas, ali je izvan funkcije. U interijeru velebnih industrijskih hala kranske staze i sustav dizalica omogućuju efikasno funkcioniranje najvećega proizvodnog pogona elektroindustrije Hrvatske.

3.5. Upravna zgrada

Na temelju potrebe za **upravnom zgradom** koja bi se gradila u etapama, tvornica *Rade Končar* raspisala je javni natječaj u jesen 1952. godine.[16] Na natječaj su pristigla 34 natječajna projekta autora iz cijele Jugoslavije. Godine 1953. prva nagrada dodijeljena je autorima tvorničkog sklopa Stjepanu Gombošu i Mladenu Kauzlariću te njegovu mlađem bratu Veljku Kauzlariću.[17]

Projektno rješenje omogućuje da se zgrada izvodi u tri etape; jednokatni niski trakt, dvorana i visoki neboder od osam katova (prema prvonagrađenom

[16] Ocjenjivački sud: Vinko Vrbka, ing. Ivan Sekalec, ing. Vojno Kundić (*R. Končar*), prof. ing. arh. Zvonimir Vrkljan i prof. ing. arh. Zdenko Strižić (Tehnički fakultet), prof. arh. Drago Galić, arh. Lavoslav Horvat, arh. Milan Delenardo, arh. Milan Tomičić (DARH), ing. arh. Vlado Antolić, ing. arh. Stjepan Hribar (Urbanistički zavod NO Zagreb), ***1953: 10

[17] Na prvonagrađenom projektu suradnici arhitekti su B. Kastl, Z. Jurić, M. Begović, Z. Sokičić; 2. nagrada: Marijan Haberle, Vlasta Doder, Minka Jurković, Mihovil Katanec, Ivan Seifert, Tanja Zdvorak, Željko Žlof; AB *Haberle*; 3. nagrada: Kazimir Ostrogović, Ljubo Iveta, Ivo Senegačnik, Olga Koržinek, Božidar Kolonić; AB *Ostrogović*; 4. nagrada: Fran Bahovec i Božidar Tušek; 5. nagrada: Zoja i Selimir Dumengjić; 6. nagrada: Zvonimir Požgaj; 7. nagrada: Karola Rado, Vladimir Ugrenović; Otkupi: S. Löwy; R. Bogojević; A. Ulrich, N. Kučan, D. Perak; M. Macura, V. Ostojić, S. Popović, D. Nastić, Lj. Šolaja. Barišić Marenić, 2007: 276-277

projektu).[18] Zgrada je funkcionalno kvalitetno razrađena, tako da se uprava poduzeća, kolegij i upravni odbor mogu sastati u najkraćemu mogućem roku pri donošenju izvanredno hitnih odluka. Horizontalne veze svedene su na minimum, tako da se više upotrebljavaju vertikalne, zbog čega su predviđene dvije grupe dizala. Uredima je prema natječajnom projektu namijenjena dvostrana orijentacija te se protežu cijelom širinom i gotovo cijelom dužinom zgrade. Uz južnu insolaciju, sa sjevera su obogaćeni difuznim prirodnim osvjetljenjem. U realizaciji je to izmijenjeno te su prostori jednostrane orijentacije na sjever ili jug. S viših se etaža pružaju impresivne vizure prema jugu, odnosno zelenom okviru sjeverne zagrebačke gore Medvednice.



■ **Slika 9.** *Upravna zgrada Grupe* Končar*, današnje stanje, izvor: Arh. fakultet, foto N. Žaja*

Prostori polujavnog karaktera, za primanje stranaka, disponirani su u nižim etažama (uredi za razgovor sa strankama smješteni su u prizemlju). Projekt je djelomično izmijenjen i nije izveden u cijelosti, a neboder je realiziran s ukupno 12 katova. Vertikala nebodera, izvedena u jugoistočnom dijelu tvorničkog sklopa, projektirana je kao urbanistički akcent tvorničkog sklopa i cijeloga

[18] Iz ocjene ocjenjivačkog suda: „Pojedini dijelovi građevinskih masa vrlo dobro grupirani, bez uštrba za unutarnju funkcionalnu organizaciju postignuto vrlo dobro urbanističko rješenje. Dugi, relativno niski objekt konstrukcionog biroa lijepo zatvara trg i smiruje pogled na tvornicu, a visoki objekt daje dobro odmjerenu dominantu. Dobra dispozicija prostorija. U jednokatnom traktu odjeli u vezi s pogonima, a u visokom odjeli u koje dolaze stranke. U 1. katu čitava uža uprava – povoljno za promet stranaka. Organizacija prometa i raspodjele prostorija u visokom objektu vrlo je uspjela, međutim funkcije stubišta u nižem dijelu nisu jasne. Dvorana s nusprostorijama riješena je zasebno. Kraj vrlo dobro urbanističkog rješenja, te unutarnje dispozicije, a naročito uspjelog rješenja visokog djela, autor je dao objektu sređen i ozbiljan arhitektonski izraz." ***1953: 11

zapadnog dijela grada Zagreba te je i danas značajan orijentir na području Trešnjevke. Uz *Končarev* neboder upravne zgrade, siluetom tog dijela grada dominira vertikala dimnjaka toplane HEP-a, stambeno-poslovni neboder arhitekta Slavka Jelineka na uglu Selske ceste i nekadašnje Končareve ulice (današnje Ozaljske ulice, tzv. Trešnjevačke ljepotice), neboder hotela *Panorama* istog autora te stambeni neboderi uz tramvajsku Remizu.

3.6. Dovršenje tvorničke cjeline

Izgradnja sklopa nije u cijelosti dovršena, namjena se mijenjala u skladu s potrebama, hale D i E planirale su se osloboditi lagane proizvodnje bravarije i varionice te je planirana izvedba **hale H**, koja, međutim, nije realizirana.

Istodobno se u južnom dijelu parcele izgrađuje **Elektrotehnički institut** prema projektu Ž. Medića, U. Babića, S. Kneževića i N. Maričić (1963.) te niz manjih zgrada, u okrilju već razraslog fonda stabala koja oplemenjuju industrijski sklop. Ovu cjelinu ne projektiraju arhitekti Stjepan Gomboš i Mladen Kauzlarić, ali su arhitektonski u skladu s dominantnim dijelom tvorničkog sklopa. Kasnija dogradnja na sjeveru nema arhitektonsku vrijednost niti su poznati autori te se prethodna društvena namjena pretvara u proizvodnu. Hale se izvode provizorno prema potrebi, bez osobita prostornog promišljanja.

4. GENERIRANJE UTJECAJA TVORNIČKOG SKLOPA NA RAZVOJ DRUŠTVENIH I STAMBENJIH SADRŽAJA TE INFRASTRUKTURE TREŠNJEVKE I DR.

Realizacija tvorničkog sklopa potaknula je kompletnu izgradnju društvenih sadržaja u okruženju – uključujući niz škola i zgrada za stanovanje, namijenjenima za radnike tvornice. Djelovala je kao izraženi aktivator u tom području grada.

4.1. Srednja stručna škola, viša škola poduzeća *Rade Končar* i đački dom

Obrazovanje u području strojarstva na Trešnjevci odvijalo se jugozapadno od tvorničkog sklopa.[19] Školska zgrada je češalj strukture koja se razvija uz središnju os simetrije sjever-jug. Zbog potreba za specifičnim kadrovima u

[19] Današnja adresa škole je Konavoska 2. Srednja škola inicijalno djeluje kao Obrtna škola ELIH-a, a od 1946. kao Industrijska škola. … Centar za obrazovanje *Rade Končar* od 1962. nosi naziv CZO *Rade Končar* – Politehnička škola, a od 1977. škola se izdvaja iz SOUR-a *Rade Končar* pod nazivom CZO *Rade Končar*. Razdvajanjem 1991. nastaju sljednice: Elektrotehnička škola, Strojarska tehnička škola i Viša tehnička škola. Elektrotehnička i strojarska tehnička škola nalaze se u Konavljanskoj 2, a đački dom djeluje u Selskoj cesti 119. (http://www.ss-strojarskatehnicka-fbosnjakovica-zg.skole.hr/skola/povijest)

području strojarstva i elektrotehnike tvornica *Rade Končar* utemeljila je 1959. Centar za obrazovanje *Rade Končar* koji je promijenio niz imena i ustroja organizacije do današnjih dana. Sama škola osnovana je već 1942. pri poduzeću *Hrvatsko Siemens d.d.* sa zadatkom da obrazuje stručni kadar za tadašnje potrebe tvornice, a nakon Drugoga svjetskog rata djeluje kao Industrijska škola rješenjem Ministarstva industrije i rudarstva NRH. U početku se u školi obučavaju elektromehaničari, alatničari, tokari i strojobravari. Školovanje je trajalo četiri godine. U školskoj radionici učenici su dobivali osnovnu praktičnu izobrazbu, a daljnju praktičnu poduku u tvorničkom pogonu. Sama škola, kao i viša škola, nalazila se neposredno pod upravom tvornice.[20] Učenici, većina njih, nakon školskog obrazovanja postaju radnici tvornice *Rade Končar*. Nastavno osoblje škole bilo je uglavnom sastavljeno od najboljih stručnjaka, tehničara i inženjera tvornice *Rade Končar*. Škola potom potpada pod administrativno rukovodstvo Savjeta za prosvjetu i kulturu grada Zagreba, ali u stalnoj vezi s tvornicom *Rade Konča*, koja ju je neprekidno financijski podupirala. Centar za obrazovanje poduzeća *Rade Končar* djelovao je analogno kao i srednja škola; profesorski kadar bio je iz tvornice *Rade Končar*, a najbolji studenti birani su za buduće kadrove tvornice *Rade Končar.*[21] CUO, ranga više škole, objedinjavao je Višu tehničku školu i Višu ekonomsku školu te ujedno Tehničku školu, Ekonomsku školu, Politehničku školu i Ekonomsko-opću školu.[22] Uza samu školu postojao je i đački dom, izveden 1947. – 1949. godine. Specifičan je to primjer integriranja rada i obrazovnog procesa, s ciljanim obrazovanjem budućih kadrova u čijem nastavnom procesu sudjeluju i ponajbolji stručnjaci tvornice. U blizini đačkog doma izgrađen je 1953. dom *Bratstvo i jedinstvo* za potrebe kulturne nadgradnje.

4.2. Stambene zgrade i infrastrukturna mreža stambenog naselja Voltino

Tvornica *Rade Končar* promišlja ne samo potrebe za profiliranjem svojih budućih djelatnika već i njihova stanovanja. Izgradnja tvornice tekla je brže od izgradnje stambenih naselja i u toj disproporciji pojavila se ozbiljna opasnost za pravilan rad i uspjeh industrije. Da bi se takvi problemi spriječili, počela se voditi briga o izgradnji stanova za radnike tvornica, u vlasništvu poduzeća. Tako i tvornica *Rade Končar* u fazi izgradnje prve etape i povećanog primanja radne snage pristupa izgradnji stambenih zgrada.

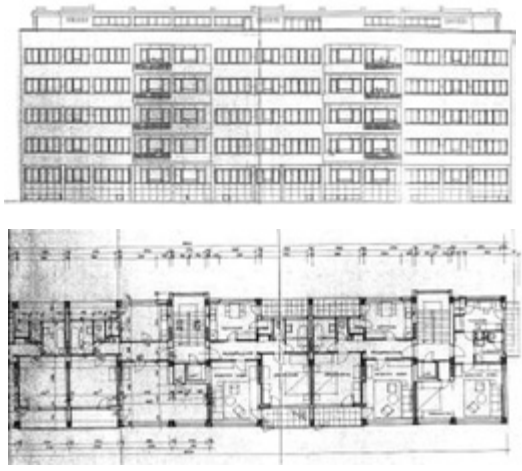
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[20] Škola je imala savezni značaj jer se nalazila pod administrativnim rukovodstvom Glavne direkcije savezne elektroindustrije u Beogradu. U prvim godinama razvitka školska je mladež znatno pridonijela uređenju radionica. U to vrijeme učenici sudjeluju na radnim akcijama u obnovi izgradnje zemlje, kao što su željezničke pruge, industrijski objekti, hidrocentrale.

[21] Preteča je to danas aktualnog modela *Clustera* koji je postojao u Sisku gdje su na Metalurškom fakultetu školovani kadrovi za obližnju Željezaru Sisak.

[22] Blau, Rupnik, 2007: 211

Na zapadnoj strani tvornice nalazilo se neizgrađeno područje te je tu inicirana izgradnja stambenog naselja sa svim suvremenim stambenim standardima. Predviđena je izgradnja cijele mreže modernih putova, nova kanalizacija i vodovod. Dakle, uz tvornički sklop izgrađuje se kompletno nova infrastrukturna mreža stambenog naselja i na taj način urbanizira periferna zona tadašnjeg Zagreba. Za slobodno vrijeme radnika predviđen je park sa stadionom i pomoćnim igralištima. Naselje je trebalo biti povezano sa središtem grada tramvajskom prugom, što se tek treba realizirati. Prve zgrade projektirane su 1947. u nekadašnjem Pupinovu naselju, a izvođenje započinje krajem godine.[23] Stambene zgrade za radnike tvornice *Rade Končar* u Voltinu naselju urbanistički su disponirane unutar ortogonalnog sustava, kao samostojeće longitudinalne zgrade unutar parkovnog okruženja, koje već u tadašnjem opsegu predstavlja zaokruženu cjelinu. Peterokatnu zgradu za samce (mlade zaposlenike bez obitelji, kakvih je bio priličan broj) osmišljava arh. Božidar Tušek, a izvedena je 1950. – 1952.[24] Gradnja takvih zgrada jasno obilježava razdoblje naglog razvoja, kad se tražilo što brže smještanje radnika, a diktirala ih je brzina, jeftina cijena i relativna mladost kadra, jer je uglavnom rabila riječ o obiteljima bez djece ili eventualno s jednim djetetom. U velikom razvoju industrijske izgradnje počelo se misliti i na veće obitelji te je 1952. počela gradnja triju zgrada sa po 16 dvosobnih stanova. Projektanti pojedinih zgrada su: arh Ivo Bartolić i arh. Bobek (1953. – 1961., Voltino 4K, peterokatna stambena zgrada) te arh. Ožegović (1953. – 1955., Voltino, četverokatna stambena zgrada)[25].



Slika 10. *Stambena zgrada za radnike tvornice* Rade Končar*, Voltino 4K – produžena Baštijanova ulica (arh. Ivo Bartolić, arh. Bobek, 1953. – 1961.), izvor: Državni arhiv u Zagrebu*

[23] Četiri zgrade su jednokatne, peta je zgrada dvokatna. Sve zgrade izvedene su kao samostalno stojeći blokovi, orijentirani u smjeru istok-zapad.

[24] Tušek, 1950: 55

[25] Državni arhiv u Zagrebu

Osim utjecaja na okolnu izgradnju na području Trešnjevke, tvornica *Rade Končar* inicira i niz drugih izgradnji.

Spomenimo samo stambene zgrade tvornice *Rade Končar* u Gajnicama (1949.) prema projektu Slovka Löwya, stambenu zgradu u Ulici baruna Filipovića / Selska cesta 1948. – 1949. te stambene zgrade u Šubićevoj ulici. Tvornica *Rade Končar*, Zagreb (s Tvornicom *Đuro Đaković* iz Slavonskog Broda) naručuje 1949. tipske projekte dječjeg vrtića za svoje zaposlenike u Zagrebu (tipovi za 50 i 100 djece) od arhitektice Zoje Dumengjić iz Arhitektonskoga projektnog zavoda.[26] Poslovni prostor za tvornicu *Rade Končar* osmišljava arhitekt Ivo Radić u sklopu stambene zgrade u Ulici Borisa Papandopula u Splitu III (1972. – 1974.).[27] To su tek neki projekti i realizacije moderne arhitekture istaknutih arhitekata hrvatske moderne za tvornicu *Rade Končar.* Ovo zorno pokazuje u kojoj je mjeri vitalna industrija generator razvoja moderne arhitekture. To je činjenica koju danas, u vrijeme gospodarske recesije, sve bolnije spoznajemo.

4.3. Drugi oblici djelatnosti i prezentacije

Skulpturu narodnog heroja Rade Končara, čije ime je tvornica godinama nosila, ostvario je skulptor Vanja Radauš. Izvorno je postavljena u perivoju, u južnoj zoni tvorničkog sklopa na Trešnjevci. Vrijedi istaknuti da je to sačuvana intaktna skulptura i nakon razdoblja socijalizma (doduše dislocirana nakon djelomične promjene imena industrije)[28] te govori o odnosu prema spomenicima, bez obzira na ideološka obilježja.

Izložbeni paviljon tvornice *Rade Končar* izveden je na Zagrebačkom velesajmu. U njemu su u sklopu sajamske manifestacije predstavljeni recentni proizvodi ove konkurentne tvornice. Danas se izlaganje na sajmovima nastavlja. Inovativni proizvodi prezentiraju se, primjerice, na najvećemu svjetskom sajmu u Hannoveru u Njemačkoj.

Značaj tvorničkog sklopa *Rade Končara* za zagrebačku Trešnjevku zorno oslikava i činjenica da je vitalna prometnica, poveznica s centrom nosila naziv **Končareva ulica** (od 1990-ih preimenovana je u Ozaljsku ulicu zapadno od Trešnjevačkog trga i Tratinsku ulicu istočno od Trešnjevačkog trga).

Uprava tvornice *Rade Končar* preseljena je na središnji zagrebački Trg Republike, današnji Trg bana Josipa Jelačića, tijekom dovršetka tzv. Zakladnog bloka, odnosno izgradnje poslovnog nebodera u Ilici 1 (arh. Josip Hitil, Slobodan Jovičić, Ivo Žuljević, 1956. – 1959.). Onodobni film *Zagrebačke paralele* (1961.) prezentira paralelu između nebodera na Trgu i tvornice na periferiji grada na Trešnjevci.[29] Reklama tvornice *Rade Končar*, odnosno logotip KON-

[26] Barišić Marenić, 2007: 252-253

[27] Hrvatski muzej arhitekture HAZU, Zagreb

[28] Doduše, premještena je iz južne zone sklopa u drugi plan, sjevernu zonu industrijskog sklopa.

[29] Blau, Rupnik, 2007: 209

ČAR-a, od šezdesetih godina 20. stoljeća dominirala je na uglovnici Zakladnog bloka, stambeno-poslovnoj zgradi Mirovinske zaklade Gradske štedionice (Gajeva 2 / Trg bana Josipa Jelačića) arhitekta Huge Ehrlicha (1932.).[30]

Prisutnošću prostora uprave i logotipa, kao reklame na središnjemu gradskom trgu, najjača elektroindustrija Hrvatske prezentirala je svoj značaj i obilježavala siluetu na ovojnici središnjega zagrebačkog trga do recentnog uklanjanja reklama s Trga bana Josipa Jelačića.

Djelatnost tvornice inspirirala je Veljka Bulajića da 1981. snimi **film *Visoki napon*** o stvaranju prvog domaćega generatora u tvornici *Rade Končar* u Zagrebu u godinama političkog sukoba s Informbiroom. „Scenarij koji su napisali Veljko Bulajić, Mirko Bošnjak i Ivan Salečić zasnovan je na dokumentarnim činjenicama o konstruiranju generatora u tvornici 'Rade Končar' te su u film integrirani originalni arhivski filmski materijali iz onog vremena."[31] Ovim sažetim pregledom široke skale utjecaja djelatnosti tvornice *Rade Končar* daleko nadilaze opseg ovoga znanstvenog rada te predstavljaju podlogu za daljnja istraživanja.

5. ZAKLJUČAK

Velebni sklop elektroindustrije realiziran je u tadašnjemu jugozapadnom predgrađu Zagreba i pridonosi urbanizaciji te rubne zone grada modernom arhitekturom te raznovrsnom tipologijom izgradnje.

Potreba za izgradnjom kompleksa industrijskih hala rezultat je transformacije i pojačane industrijalizacije nakon koje postojeća proizvodnja poprima nov oblik. Logika proizvodnje, tehnološkog procesa i kretanja sirovine i proizvoda do konačnog produkta uvjetovala je dispoziciju tvorničkog kompleksa unutar postojećih gabarita tvorničke parcele. U tom smislu evidentan je utjecaj realizacije *Fiatove* tvornice u Torinu Giacoma Matte Truccoa ostvarene pod utjecajem futurističke opsjednutosti pokretom. Naime, u Ligottu pored Torina u tvornicu automobila izvedenu 1915. – 1920. sirovina je ulazila u prizemlju, a na kružnu pistu na krovu zgrade izlazili su gotovi *Fiatovi* automobili za probnu vožnju. Rješenja nastala u zagrebačkom kompleksu izraz su funkcionalnih veza industrijskog pogona, izraz proizvodnje. Položaj i oblikovanje arhitektonskih elemenata afirmiraju taj proces, a istodobno i ulogu industrije u razvoju i oblikovanju grada i društva. Urbanistička, arhitektonska i jedinstvena konstruktivna rješenja svjedoče o radikalnim promjenama nastalima zbog industrijalizacije na različitim područjima.

Tvornički sklop *Rade Končar* predstavljao je žarište rada zapadnog dijela grada, tada izrazito suburbanog karaktera. Dolazi do izgradnje pratećega stambenog fonda i zgrada edukacijske namjene koje se intenzivno reliziraju sa

[30] https://registararhitekture.wordpress.com/2013/10/22/josip-hitil-slobodan-jovicic-ivo-zuljevic-neboder-na-trgu-bana-jelacica/ i Uchytil; Barišić Marenić, Kahrović, 2007: 89

[31] http://mojtv.hr/film/14124/visoki-napon.aspx

svim popratnim infrastrukturnim i društvenim sadržajima. Izgrađen kompleks tvornice djelovao je kao aktivator razvoja u tom području grada, istodobno potičući i infrastrukturni i društveni razvitak.

U razdoblju nakon završetka Drugoga svjetskog rata porušena je zemlja trebala elektrifikaciju i industrijalizaciju. Takvi projektni zadaci povjeravaju se iskusnim arhitektima koji su se afirmirali u međuratnom razdoblju (primjerice Lavu Horvatu, Egonu Steinmannu, dvojcu Kauzlarić-Gomboš, Ivanu Vitiću, Dragi Galiću). Oni svoje projektantsko djelovanje razvijaju u tipologiji industrijske arhitekture kojom se većina arhitekata nije značajnije bavila u međuratnom razdoblju. Postupno se industrijska arhitektura uvrštava u promišljanja arhitekata koji stvaraju na načelima moderne arhitekture.

Od malog broja međuratnih modernih ostvarenja industrijske arhitekture u Hrvatskoj treba istaknuti Gradsku klaonicu i stočnu tržnicu u Heinzelovoj ul. u Zagrebu njemačkog arhitekta Waltera Fresea (1928. – 1931.)[32], Tvornicu aluminija u Lozovcu pored Šibenika arhitekta Vladimira Potočnjaka (1936. – 1939.)[33] te Zavod za proizvodnju lijekova *Pliva* u Kalinovici pored Zagreba arhitektice Zoje Dumengjić (1939. – 1944.), čija se izvedba provodi i tijekom Drugoga svjetskog rata[34]. Istaknuto rano poratno ostvarenje ovdje je prikazana Tvornica *Rade Končar* na Fallerovu šetalištu 22 u Zagrebu, realizirana 1945. – 1949., ostvarena prema projektu arhitekata Mladena Kauzlarića i Stjepana Gomboša te Vladimira Juranovića i Otta Wernera. To je prva arhitektonska realizacija, a k tome i prvi industrijski sklop koji je polučio najviše strukovne nagrade za arhitekturu u našoj zemlji; I. saveznu nagradu za arhitekturu Ministarstva građevina NRH 1947. i Nagradu Vlade FNRJ 1949. godine. Tvornički sklop unatoč velikoj arhitektonskoj vrijednosti i nagradama danas nije zaštićeno kulturno dobro.[35]

Ovo istaknuto ostvarenje moderne arhitekture uvršteno je u najznačajnije prikaze antologijskih ostvarenja moderne arhitekture, razdoblja 1945. – 1985. prema izboru prof. dr. Nevena Šegvića 1986., Leksikona arhitekture Atlasa hrvatske arhitekture XX. stoljeća, autora Uchytil, Barišić Marenić i Kahrovića te kataloga retrospektivne izložbe *Socijalizam i modernost* veće autorske grupe[36]. Sva su ta istraživanja prezentirana i putem izložbi, a recentna izložba *Socijalizam i modernost* održana je u Muzeju suvremene umjetnosti.

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[32] Barišić Marenić, 2015: 370-383

[33] Uchytil; Barišić Marenić, Kahrović, 2007: 175, 177

[34] Barišić Marenić, Medak, 2008: 16-20

[35] Općenito, malo je registriranih ostvarenja iz razdoblja moderne arhitekture, ali i industrijske tipologije.

[36] Šegvić, 1986: 134-135; Uchytil; Barišić Marenić, Kahrović, 2007:121; Jakovina, Križić Roban, Kolešnik, Kršić, Duda, 2012. Napomena: U bibl. jedinici Šegvić, 1986: 135 uz prikaz Tvornice *Rade Končar* greškom je uvrštena fotografija *shed*-krovova Tekstilnog kombinata *Dalmatinka* u Sinju, izvedena 1953. prema projektu Lavoslava Horvata.

Uz navedene arhitektonske i urbanističke odrednice, značaj tvornice s kontinuitetom uspješnog djelovanja više od 95 godina, u danas većinom deindustrijaliziranoj Hrvatskoj osobito dolazi do izražaja u socijalnom i gospodarskom kontekstu. „Temeljna djelatnost Grupe KONČAR je proizvodnja opreme i postrojenja za proizvodnju, prijenos i distribuciju električne energije, kao i opreme za primjenu u području transporta i industrije. Osnovan 1921., KONČAR danas u svom sastavu ima 17 ovisnih i 1 pridruženo društvo s oko 3700 zaposlenih. Godišnja prodaja iznosi oko 320 milijuna eura, a polovica je u izvozu. Tijekom godina proizvodi KONČARA izvezeni su u više od 100 zemalja na svim kontinentima. Strategija KONČARA je daljnji razvoj i povećanje proizvodnje u skladu sa zahtjevima tržišta, s posebnim naglaskom na vlastiti razvoj i društveno odgovorno poslovanje", naglašeno je na početnoj internetskoj stranici grupe KONČAR, koja ponosno ističe da 2016. obilježava 95 godina postojanja.[37] Manji broj industrijskih sklopova uspio je očuvati svoju djelatnost garantirajući gospodarsku opstojnost naše zemlje.

Kompleks *Končar* danas predstavlja neprepoznatu vrijednost industrijske baštine kao dijela kulture društva. Proizvodnja generatora u tvorničkom sklopu nadišla je sami artefakt te je cjelokupan moderni sklop tvornice u arhitektonskom, urbanističkom, društvenom i socioekonomskom smislu postao generator razvoj grada i društva. Na nama je da to valoriziramo, osvijestimo i očuvamo.

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SUMMARY

The industrial factory complex in Zagreb was built immediately after the Second World War, as part of the inital need for industrialization and electrification in a war-torn country. The work of the Zagreb architects Stjepan Kauzlarić and Mladen Gomboš (with engineers Vladimir Juranović and Otto Werner) won the first prize in a public competition. The architectural solution was based on the foundations of modern Croatian architecture between the wars, and the achievements of this modernist work is seen in a number of architectural awards given around the middle of the 20th century.

The magnificent industrial complex was built in the then western suburbs of Zagreb (in an area limited by, but also connected to the infrastructure). It anticipates the urbanity in the marginal area with modern architecture that includes exceptional constructive solutions. It became a central work area for the inhabitants of the city and its surrounding area. The construction of accompanying social contents and facilities around the industrial plot followed the construction of the factory complex; it included a number of schools and housing buildings, all built for the employees of the factory. It was a development activator in this area of the city, encouraging the infrastructural advancement as well as the social one.

The need for the construction of the complex of the industrial halls is the result of the transformation and industrialization, after which the existing production takes on a new form.

It is the logic of production, the making of a product from its beginning to its final form, which is the key to the specific organization of the factory plot inside the limited area, defined by the existing infrastructure. Solutions created in this complex are an expression of functional connections inside the industrial process, i.e. the process of production. The position and design of architectural elements are an affirmation to this process, but also to the role of industry in the development and design of the city and society. Urban, architectural and unique constructive solutions testify of radical changes in various areas as a result of industrialization.

In addition to these architectural and urban elements, there is a specific importance of continuity in the company's successful activity for over 60 years, especially in today's social and economic context in Croatia. The Končar complex presents an unrecognized value of industrial heritage as a part of the culture of society.

Keywords: *modern architecture, urban development of Zagreb, industrial complex, architects Stjepan Gomboš and Mladen Kauzlarić*

VALLEY OF AMMUNITION INDUSTRY IN SLOVAKIA (ONCE AND TODAY)

Dolina u kojoj se proizvodi municija u Slovačkoj (nekad i danas)

Miroslav Beňák*

SUMMARY

Up to this day, an infrastructure of three major ammunition concerns can be found in the valley of the river Váh in Slovakia. In the 20th century their production of weapons and components represented a substantial portion of the Slovak export goods – including components for the manufacture of torpedoes.

The production sites in the cities of Trenčín, Dubnica nad Váhom and Považská Bystrica were founded in the third decade of the 20th century and gained an important strategic position considering the situation in Europe at that time. The site in Dubnica nad Váhom was a particularly interesting complex partially situated underground, inside a mountain massif.

A network of additional infrastructure was built in this industrial area, which, as well as the above factories makes part of the Slovak industrial heritage. Thus, in connection with industry the architecturally valuable residential structure of Nová Dubnica was built from scratch as an entirely new settlement. Interventions like these have influenced the character of the region significantly and generated its genius loci. What is the current state of this system after the production has been scaled down? How can the relation of the residential structure and the preserved industrial heritage respond to the requirements of sustainable development? This report will introduce the processes of evaluation of available sites (their capacities), identification of their usable potential, and creation of visions for their active involvement in planning the sustainable development of this region.

Keywords: *ammunition industry, historical technical infrastructure, architectural and urbanistic values, sustainable development, production of torpedoes components in Slovakia*

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1. INTRODUCTION

Industrial heritage, related to the production of torpedoes, is located also in Slovakia. Ammunition factory in Dubnica nad Váhom was established in the '30s of the 20th century and was one of the most important industrial concern and producer of special equipment. During World War II, the plant was in full control by the Germans and by this situation the production of torpedoes components was transported here from a bombed German factory. Production Torpedo was not the only exceptionality of that ammunition factory. It was part of a comprehensive infrastructure of the ammunition industry in Slovakia, which had a significant impact on the settlements in its vicinity.

Defense against enemy and military influenced the settlement during each historical period, especially its shaping. Whether it was the construction of castles, fortified urban systems or ordinary barracks for soldiers, always it responded to techniques and methods of warfare of its time, as well as the terrain predisposition. The Industrial Revolution and the subsequent development of technology were well reflected also in weaponry and industrialization of arms production, which had again overlap in the manner of intervention in the affected sites.

Slovak ammunition industry has largely influent the economic development of Slovakia and development of sites. This was significant in the valley of the river Váh, which provides a safe place surrounded by mountains. The key factors for choosing this place were territorial predispositions of this area, its safety in view of the new phenomenon of warfare – air force and movement of fronts – and on another its good interconnectedness with other infrastructure systems like traffic. So by the political decision of the Czechoslovak Republic and the Ministry of National Defence they invested in the construction of the most important ammunition factories in Slovakia. This resulted in a growth of strong infrastructure that heavily influenced the economy and thus also the growth of some settlements for several decades ahead, nearly to the coup in 1989.

The growth of settlements and way of urbanization of the country relating to industrialization '30s of the 20th century, strongly linked to the arms, were the very specific phenomenon since development was directed to new premises and to "non-urban settlements" (Lipták, 2002). That way has created the factories in Dubnica and in Považská Bystrica, the most characteristic and the most important weapons factories at that time in Slovakia.

This relationship between site and factories and overlap each other when the site itself became a social infrastructure and housing infrastructure related to the factory is specific phenomenon of industrialization. Given the definition of industrial heritage, which says that industrial heritage is not only the production itself and their buildings, but the industrial heritage is also corresponding

infrastructure – transport, technical or social, so many more objects relating to manufacturing (TICCIH, 2003), these sites are also part of the industrial heritage of Slovakia. These structures have a significant architectural and urban qualities, what can be seen on the example of the site Nová Dubnica.

The infrastructure of the ammunition industry can be perceived more complex. Infrastructure – something like a network or system – is essentially a "carrier" of information and relationships between entities. They are material – such as roads, railways in between premises or technical infrastructure inside the area, or this system can be conceived as a network of relationships between factories each other and they impact to finalized product. Across the history of the armaments industry, this phenomenon is very significant, since the arms factory in Slovakia were created as branch plants other concerns, or manufacturing of the threatened concerns was relocated to them during the war. Moving of production was the way, how the factory in Dubnica nad Váhom started production of engines for the German torpedoes. Thus Factory is part of the industrial heritage related to this product.

What is the current state of this system after the production has been scaled down? How can the relation of the residential structure and the preserved industrial heritage respond to the requirements of sustainable development? The aim of the paper is to outline the rise and development of the armaments industry and the relationship of production and the site on case study of factories in Dubnica nad Váhom, Považská Bystrica and Trenčín. At the same paper will draft the impact of the degradation of the infrastructure exceeding till today and at the end way of looking at this infrastructure as a complex of values.

1.1. Literature Review

There have been several historical studies focused on the ammunition industry in the region of middle Považie. They represent an excellent base as a well done archival research. The ammunition industry in Dubnica nad Váhom and in Považská Bystrica before and during World War II was well elaborated in historical studies by Muráriková – Škoda´s Factories in Dubnica nad Váhom in 1938 – 1945 and Armament Industry in Slovakia in the 1930s, focused on history of these concerns during this period of time (Muráriková, 2014 and 2013). History of settlement Dubnica nad Váhom and Ammunition factory is described in monography Dubnica nad Váhom by several historical studies (Margetin, 1967; Zemena, 1967). A specific phenomenon is the "ammunition urbanization" or urbanization by ammunition industry or army, which assessed the impact of the armament industry, urban development, and urban planning. The relationship between the city and the ammunition industry in Slovakia was developed in the study "Defense industry and urbanization in Slovakia in the 19th and 20th centuries" (Lipták, 2002).

The study "The Socialist Town of Nová Dubnica: When Form Could Not Follow Function" discusses the subject of the settlement structure tied to the factories in Dubnica nad Váhom – Nová Dubnica and its values as a unique example of the socialist city (Haberlandová, 2013). This is a good example of industrial heritage with specific historical, architectural and urbanistic values related to a type of architectural style and a person of the architect at the same time. Another comparable housing complex for workers in Dubnica nad Váhom was described by Dulla and Moravčíkova (2002) and Alexy (2010).

There have been written several monographs focused on the history of these concerns (Vopat, 2000; Janas, 2009).

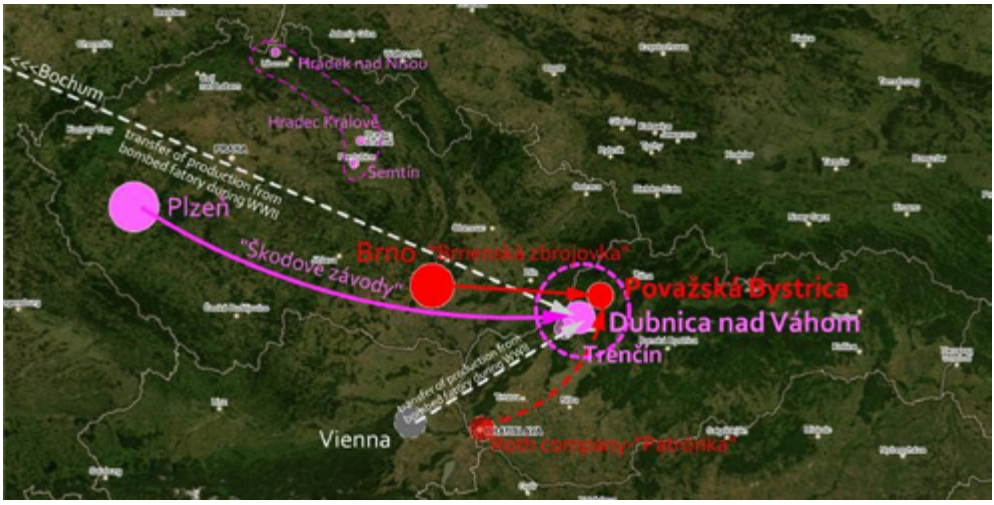
Literature, however, is focused mainly on the past of these concerns until 1989. The present and the impact of the fall of ammunition industry on the image of the city was captured by Abaffyová L. in "Looking to the Future and Back: the Image of an Industrial Town in the Last Decades of State Socialism and its Tendencies after 1989". The given issue represents specific phenomenon, which concerned other to industrial cities as well.

The historical continuum of development, life, and fall of these factories with impact on the present, the relationship between settlement and ammunition industry as a complex infrastructure and their common sustainable development are described partially in literature. This contribution is focused on evaluation of this preserved infrastructure as an industrial heritage regarding their history, present, and impact to settlement.

2. HISTORICAL CONTEXT − RISE OF THE SLOVAK AMMUNITION INDUSTRY IN 30th YEARS OF 20th CENTURY

The rise of the Slovak ammunition industry was described very well by Muráriková (2014): "The Czechoslovak Republic was one of the most important producers and exporters of ammunition and weapons during the interwar period. It had a leading position in the ammunition industry together with UK, France, USA, and Sweden. While most of the armament industry was located mainly in the territory of Bohemia and Moravia, the situation began to change at the turn of 20th and 30th years of 20th century. The reason for this was an increasing threat from Germany according to the increasing power of Nazism, and so a lot of factories moved to Slovakia, where they had a relatively safe "inland" position. In this period there were founded also two most important weapon factories in Dubnica nad Váhom and Považská Bystrica. Their common attributes that affect their establishment and growth was their position in the valley of the river Vah and the surrounding mountains." (Muráriková, 2014, pp. 23-24)

Concerns usually didn't set up their own companies, but they were a part of large national or international concerns. As for our ammunition factories, the



■ **Figure 1.** *Relationships between concerns in 30th and 40th years of 20th centrury, transfer of production duringh the World War II from bombed factories (resource: autor)*

factory in Dubnica nad Váhom was related to the concern Škoda Plzeň (Pilsen) and the factory in Považská Bystrica was Czechoslovak ammunition factory "Zbrojovka" Brno (Muráriková, 2014; Hešterová, 2015).

During the existence of the Slovak state, and the Second World War Slovak ammunition factories were objects of German interests. Factories were under German control, and their production was literally necessary for them. Both factories became part of Hermann Göring Werke concern (Hešterová, 2015).

2.1. The Factory in Dubnica nad Váhom

The factory in Dubnica nad Váhom was historically linked with the Škoda´s factory in Plzeň in the Czech Republic. The construction in Slovakia was planned because of military-strategic reasons, whereas the factory in Plzeň was in a disadvantageous position near the border with Germany. In accordance with the requirements of the Ministry of National Defense, the new Slovak factory was to be located in the middle of the Czechoslovak Republic, in the valley of the river Váh between Trenčín and Žilina. Finally, The chosen area was Dubnica nad Váhom. The contract for the construction of a backup factory for artillery material and munitions in Slovakia was signed on April 21, 1928 (Muráriková, 2013; Margetin, 1967).

Since 1934 the pace of construction has been significantly accelerated. It was caused by Hitler's rise to power in Germany and therefore the fear of military conflict. All machinery from the parent factory in Plzeň was moved to Dubnica nad Váhom. 2 January 1937 the production was launched, despite the factory had not been finished yet (Muráriková, 2013).

Ironically, while the accelerator of the construction of this ammunition factory was fear of Germany, finally the concern was handed over to the Germans without much resistance (Muráriková, 2013; Margetin, 1967).

The factory has gradually expanded into a huge complex. The production had taken place not only in the halls of the aboveground parts of the factory but for strategic reasons, most of the production was located in underground operations and to be protected from air attack and bombardment.

The factory was divided into two parts. The so-called. "Block" included objects with mechanical manufacturing, located in the aboveground and underground parts, and the so-called "Valley" with labor workshops. In the beginning, the factory had these departments – a cannon workshop (mechanical workshop III), munitions workshops (a mechanical workshop I) and a workshop for lighters (mechanical workshop II). Other departments were the toolroom and labour workshop in the "Valley".

The production was focused on a wide range of weapons and ammunition – from fortification cannons through anti-tank guns, complete guns, field howitzer. In 1943 was the of production 88 mm anti-aircraft cannon – Flak 41 was moved from the bombed German factory in Bochum to Dubnica nad Váhom. At the beginning of 1944, the Škoda's factories in Dubnica nad Váhom took over the production of propulsion engines for torpedoes GT 12 and the production of aircraft engines from the bombed factoríes in Vienna and Bochum (Muráriková, 2014; Margetin, 1967).

The infrastructure of ammunition industry was in this period completely interlinked between concerns, where the Škoda´s factories in Dubnica nad Váhom was the main processor and the final producer – it consists of material processing, fabrication of supplements and mainly assemblation and testing of finished products. Materials and semi-finished products were imported mainly from the Protectorate of Bohemia and Moravia from the parent factory in Pilsen (forging), from Hradec Králové (metal parts mountings) from Hrádek (material for molding shots) from the arms factory in Brno (material for lighters) from explosives factory in Semtín (explosives for filling ammunition) (Muráriková, 2013).

In 1941-1945, the arms factory was under direct German command. The Slovak industry was beginning to focus significantly on increase in the production of armaments and it reaches great dimensions given the situation in those times. The Škoda Works in Dubnica has gradually become the largest arms factory which produced for the needs of the German army. In late 1942, the construction of a new production hall – Hall II began, as there had been a need for a plant expansion, which at that time had already been at full capacity. In 1943, the construction of the Hall III was planned. Despite the fact that in 1944 the overall industrial production begins to decline in Slovakia, the armament industry had its greatest expansion (Muráriková, 2013).



Figure 2. *Škoda´s Ammunition factories in Dubnica nad Váhom – part called "Blok" (resource: repro from Vopaz: Konštrukta Trenčín, 2000)*

The importance of the factory in Dubnica was increased by its location. It was far away enough from the enemy's air bases and its underground operations were well protected from bombing attacks. German plants were worse off. The machinery was progressively transferred from the bombed German plants to the arms factory in Dubnica, which has grown to great dimensions at the end of 1943 and during 1944. From Bochumer Verein für Gussstahlfabrikation factory that had been bombed, the manufacture of torpedoes components for the Navy and Air Force – propulsion engine GT 12 and pressure vessel GT 12, was moved to Dubnica nad Váhom.

In September 1943, the production of artillery components and shipping ammunition was launched in Hall II. With expanding production the employment had risen as well, in late 1944, the factory employed up to 18 227 employees (Murárikova, 2013).

The plant was a target of airstrike twice, on July 7, 1944, by the Allied troops and on January 16, 1945, by the Soviets. Despite the bombing, the factory had not suffered serious damage, which shows the ingenuity of its construction.

But what harmed the plant more, was the evacuation of the factory in connection with the retreating German army. The plant was to be destroyed. Several departments of the plant were blown up, the most important machines were taken away, at the end the Germans completely undermined and destroyed the factory in Dubnica nad Váhom, unlike the ammunition factory in Považská Bystrica, which remained almost untouched (Murárikova, 2013).

2.2. Ammunition factory in Považská Bystrica

A decisive role in selecting a location for the second important concern in the valley of river Vah played transport connections to the Czech Republic, the planned rail link of Považská Bystrica through Puchov and Horní Lideč, and of course the safety aspects. The valley of Vah was surrounded on all sides by mountains, which made bombing by aircraft almost impossible in that time.

This factory was established, like the factory in Dubnica nad Váhom, as a detached company of existing production concerns. In this case, these were the two major companies – The Czechoslovak ammunition and metalworking works, acc. Al., Považská Bystrica, originally The Roth company, and the second one was The Czechoslovak ammunition factory – "Zbrojovka", based in Brno (Janas, 2009).

The foundation stone was laid on July 7, 1929, and in the first year of construction, the first operational building was built – a rolling mill, a pressing shop and a foundry, and later that year a plant for the production of detonators and fuses. In the first phase of construction, the most important metallurgical operations and subsequent treatment of metal sheets were gradually built up. The plant has expanded year by year. In 1930, started the construction of the boiler room, engine room, water tank, laboratories and other facilities like rolling mills for brass and other. The plant was put into full operation in 1932 (Janas, 2009).

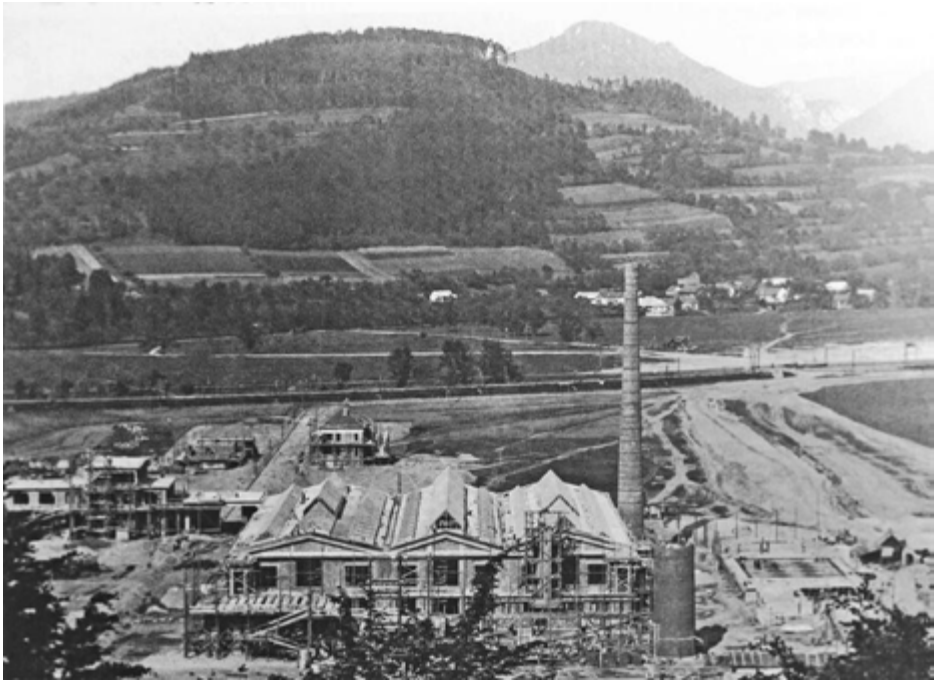


Figure 3. *Construction of the rolling-mill hall in Ammunition factory in Považská Bystrica (resource: repro from Janas: Engineering Works in Považie – from ammuniton factory to ZVL, 2009)*

The most important building of the ‘30s was the operation of foundries. Gradually, other important facilities and services were built up, like two new factory units, a private shooting range in the building, ammunition buildings and buildings for infantry ammunition, artillery cartridges and military guns production. By the end of 1937, a hardening room, forge, joiner workshop, and a power generator were build up. In addition to weapon production, the plant manufactured fulminates and mercury as well. Since 1934, the production of special ammunition has been introduced. The arms factory and the railway station were linked by a narrow-gauge railroad (Janas, 2009).

3. IMPACT OF AMMUNITION INDUSTRY ON THE SITES

3.1. The genesis of the impact of the army to urbanism and position of ammunition factories in the sites

What was the impact of ammunition factories on the towns? As Liptak (2002) claims – the army has always influenced the life and shape of the city. In the earlier periods, the influence of the military on the urbanism of cities was obvious and substantial – like settlements localization, building a fortification system, internal structure of the settlement. Later, some transformation of the cities – rise of suburbs was caused by the destruction of elderly fortification systems. In this period, barracks and training grounds have been moved to the city edges. Army phenomenon used to extend the settlements. The position of arms capacity depended on sources of materials and energy (what is comparable with positions of industrial areas) and on safety reasons. The phenomenon of ammunition industry used to dynamize development of the settlements, such as Plzeň in the Czech Republic, where was the mentioned concern Škoda, or Bratislava, which the second most industrialized town in former Hungarian Empire. But, following Liptak (2002), the ammunition industry still didn´t affect the structure of the industry so that we can talk about some more remarkable impact on urbanization. Production for the army was developed in older factories – mostly in older foundries and metalworking factories[1].

The First World War brought a lot of new aspects that affected the positions of ammunition production in Slovakia – the need to have sufficient production capacities located in a relatively safe place, due to the moving of front and aircraft. This accelerated in the ‘30s and caused that the industrialization tied to war had the most significant impact on the way of urbanization of the country (Liptak, 2002).

[1] Only one larger factory is known from the era of the First World War. It is the iron foundry and rolling-mill of the Coburg´s iron company in Trnava, Slovakia and is interesting, becouse as the first transfered the ironmongery from the traditional mountain environment based on sources of ore and wood to the “plane”. (Liptak, 2002) The position of this ironworks was more related to railtrack and the export of products to Bratislava and then by river Dunaj (Holec, 2010).

3.2. Impact on the social aspects of development and rise of social infrastructure

We have outlined many of the impacts in the text before. Factories provided access to employment for people from afar, significantly reducing unemployment in the region. Statistically – in April 1936, at the factory in Dubnica there were 650 people employed from the district of Ilava, 606 workers from the district od Trencin, 135 from the district of Puchov, 180 people from the district of Prievidza, 101 of Nové Mesto nad Váhom and another 420 from various parts of Slovakia (Muráriková, 2014).

With the increasing number of jobs, however, the need for accommodation and housing had risen, which was a big problem at that time, since Dubnica and Povazska Bystrica reported a shortage of vacant apartments. The arms factory in Považská Bystrica finally acceded to the construction of residential colonies for employees of the plant, dormitories for single employees, a new school, social house, sports stadium and also established a vocational school (Muráriková, 2014). Similarly, it was also in other cities where there were built barracks for workers, one-family houses and blocks of flats for specialists, as well as social infrastructure and sports facilities. Thus it continued to evolve and urban reshaping of village settlements to urban varied from small villages into real cities (Liptak, 2002).

3.3. The relationship between the ammunition industry infrastructure and the site Dubnica nad Váhom

Dubnica nad Váhom was a village situated on the southwest of Ammunition factory „Škodovka". Before the establishment of the armament factory, industry of the site was represented only by two distilleries and one brickyard, and since 1912 also sawmill and slaughterhouse. In the period after the First World War, the main employers were Domestic and Forestry Industries, and two mansions. Dubnica has been connected to the railroad since 1883 (Zemena, 1967) which was an important factor for the establishment and future development of the armory. Its establishment and construction was a breakthrough for the community and settlement, which caused its continuous development. As Zemena (1967) says – thanks to the factory, the population increased by one third and the number of homes doubled during 20 years of existence of the Republic[2] (Zemena, 1967).

During the war, the armory was the preferred concern, which also significantly impacted the development of the village. There was a brisk building activity. The new railway station was built in 1941-1942 because there was a need

[2] The number of inhabitants after the First World War was 2213 and the houses were 223. In the period before the end of Czechoslovakia in 1938 the inhabitants of Dubnica were 3308 and houses were 439 (Zemena, 1967).

for safe transport of a large number of workers from the armory. The sharp rise in population caused by the influx of labor force was causing housing hardship. It was mitigated first by the construction of the apartments for the employees of the hydropower plant in 1941. In the years 1942-1943, a colony of houses for "Škodovka´s" employees was built, which joined the village by a new way through the park (Zemena, 1967).

The colony itself, also called the "Kolonka", represents a valuable urban area of significant architectural and urban qualities, influenced by the German theory construction sites, which is based on the organic principle. The Colony respects the scale of the landscape, follow the contours, and bases itself strongly on the greenery (Alexy, 2010). It consists of two parts – a colony for officers consisting of 20 houses and workers colony, which is modest – consisting of 7 houses with two flats and 26 houses. Near complex, there was a sports stadion and apprenticeship house (Dulla, Moravčíková, 2002).

3.4. The relationship between the ammunition industry infrastructure and the site Považská Bystrica

The ammunition factory in Považská Bystrica had a specific share in the village formation and its gradual transformation to a city – a major industrial center for the whole of middle Považie. Despite the raging crisis in the '30s, the ammunition factory created many job opportunities in the site. Indirectly, the plant extended to other industries in the area. The local brickyard had expanded. At the turn of the '20s and '30s, four water mills supplied Považská Bystrica with flour. The ammunition factory expanded the board with additional auxiliary and non-production operations such as the distillery and an operation for soft drinks (Janas, 2009).

With the increasing number of employees in the factory, the need for housing increases obviously as well. It is the relationship between housing as an additional infrastructure to industry and the factory itself that has a major impact on the expansion of the site itself. At the site of a former manor, there was established a workers' colony, providing high standard accommodation in those times. Modern apartments, large parks, and first-class roads improved the quality of living, incomparable with the old part of Považská Bystrica. The expansive building up in the worker's colony connected the city with the plant, which was originally far from the village. This interconnection had a strong social and integrative character for the workers who were now able to feel like full citizens of Považská Bystrica. The Social House of the factory, architecturally very well done, fulfilled the role of the social superstructure. The industry had a strong social and cultural overlap in the site. It had its impact on education and sport as well. As a system with interest in its employees in almost the entire spectrum of saturation of their needs, it was comparable with the Bata company (Janas, 2009).

3.5. The relationship between the ammunition industry infrastructure and the site Trenčín

Before the wave of the ammunition industry in the '30s, the city of Trencin was different in comparison to the near Dubnica and Považská Bystrica. Trencin had the status of a city even before and by the way a one with long military tradition.

During the '30s, buildings such as the higher headquarters, warehouses, a large armory, barracks, etc. arose there. They planned to build a backup aircraft factory. However, military industry and its impact have mostly begun to develop later in the '50s. The traditional industrial culture had so moved to the "fourth sector". Trencin represents a town with significant military influenced urbanization. Whether it was the castle and fortification facilities in earlier periods, then the fall of influence in the 18th and 19th century, when the city expanded and the fortification system was destroyed in many places, later the crew with an impact on city life (Liptak, 2002).

3.6. Other operations in addition to ammunition industry – as a part of ammunition industry infrastructure

With the support of the Czechoslovak government, there were introduced other operations in addition to Skoda Works in Dubnica and arms factory in Považská Bystrica, that complemented the infrastructure of armament industry, that had been moved to the region of Považie. In Trencin, buildings for higher headquarters, warehouses, a large arsenal, and barracks were being built. In



■ **Figure 4.** *Opperations in addition to Ammunition factories (resource: autor)*

Kubrat-Záblatí they have started to increase military depots in Skalka at Trenčín constructing new underground warehouses for chemical warfare in the ruins of a monastery in Skalka at Trenčín. In Zlatovce, new barracks and workshops for anti-aircraft artillery were being constructed, in Nemšová barracks as well and in Istebník a military depot (Murárikova, 2014). These operations were far enough apart in terms of security but also sufficiently logistically interlinked.

Development of settlements headed mainly towards new premises, predominantly towards "non-urban settlements." A smaller part of military production was placed in existing factories, in other cases, it involved extensive modernization, or buildings long out of operation were used (Liptak, 2002), which today can be understood as the use of the available infrastructure capacity.

4. INFRASTRUCTURE OF AMMUNITION INDUSTRY DURING THE SOCIALIST PERIOD

4.1. Short intermezzo of "peaceful" production

After World War II, there had occured a kind of intermezzo in the arms industry with the beginning of socialism. With the "hard-won peace" and with the adjustment of the first five-year plan, most factories are passing to a sort of a replacement program. They converted their production capacity to other "peaceful" products. Big arms companies thus turned to production of structures needed for the reconstruction of the country, construction machinery. In Dubnica nad Váhom the factory transferred to the production of excavators, the factory in Považská Bystrica started to produce cans for milk in the mill cartridge, it replaced arms production by production of light motorcycles and introduces mass production of refrigerators for households[3] (Liptak, 2002; Janas, 2009). The aircraft factory in Trenčín tried to produce agricultural machines and fire extinguishers (Liptak, 2002).

The problem of most armament factories was their ineffective structure, high overhead costs and little experience with marketing, and so their production was inefficient. This led to the dismissal of employees. Attenuation in the arms industry and the search for alternative peace programs had a significant impact on the "armament urbanization" – the relationship to the sites and social conditions. Large proportion of the redundancies returned to the original peasant life.

Therefore, factories were glad to get rid of their alternative peace production anf later they returned to the original focus, which indirectly affected other cities as well – for example, shift of the production of refrigerators from Považská Bystrica helped the growth and development of Zlaté Moravce (Liptak, 2002).

[3] Something similar happened also in Coburg foundries in Trnava, which had also dealt with armament production. They produced here washing machines and other household appliances. There were some operations producing iron stoves, parts of cars, etc. too.

After a short peace intermezzo infrastructure of ammunition industry was once again gaining strength. The employment rate in some factories reached close to the war peak.

4.1.1. Trenčín

As it was already mentioned, from the '50s the arms industry in Trencin had begun to develop most particularly with regard to its research and development component, especially Konštrukta company, pushing the industry to the "fourth sector" (Liptak, 2002). The development of the city covering the arms industry has focused, in this case, on the site Sihoť.

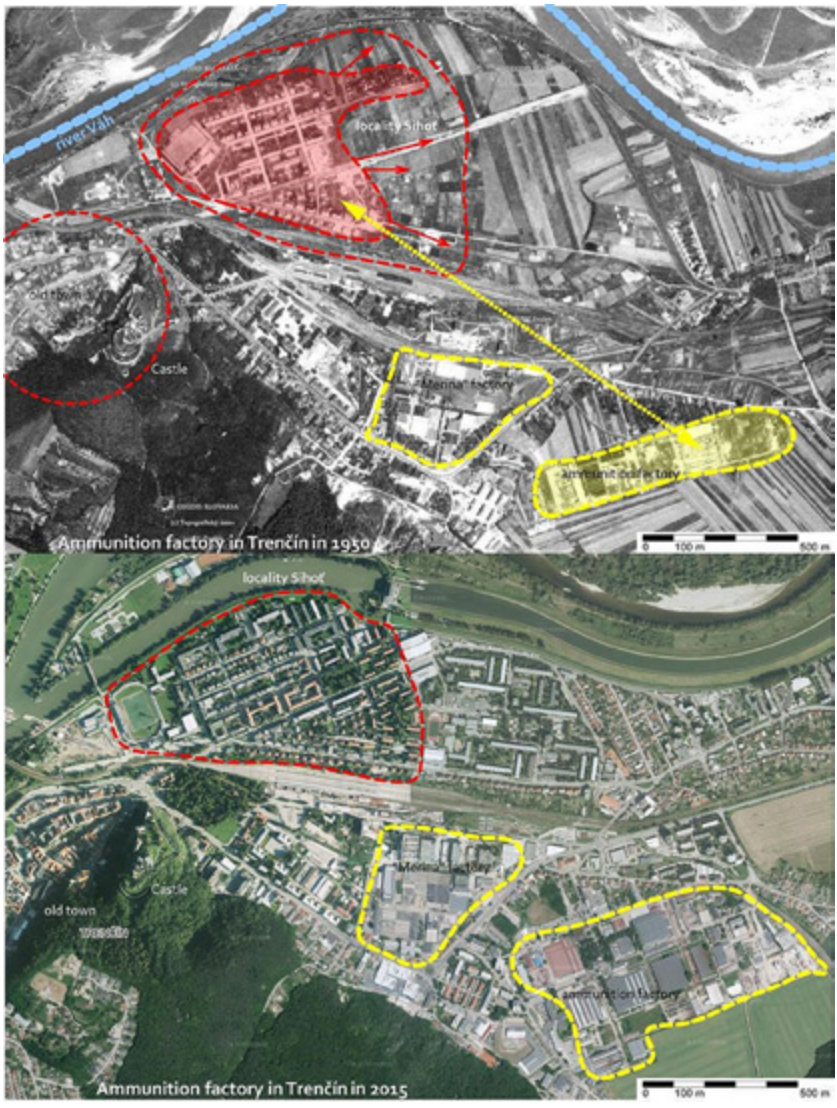


Figure 5. *Ammunition factory in Trenčín and the site Sihoť (resource: autor)*

4.1.2. Dubnica nad Váhom

In the ‘50s, the trend of production development in Dubnica was in line with the concept made during the war at the Group Hermann Göring Werke. The factory in Dubnica was divided organizationally into ZTS (Concern of heavy engineering) and ZVS (Concern of general engineering). With the production expansion, the number of employees had been gradually increasing, in 1978 reaching 12 156 in ZTS and 3483 in ZVS (Liptak, 2002). It is interesting that on the topographic map from 1955, the entire section of the plant “Block” thus ZTS is drawn as housebuilding, a park with swimming pool, a castle and a research institute in the northern part.



Figure 6. *Ammunition factory in Dubnica nad Váhom in 1950 (source: autor)*

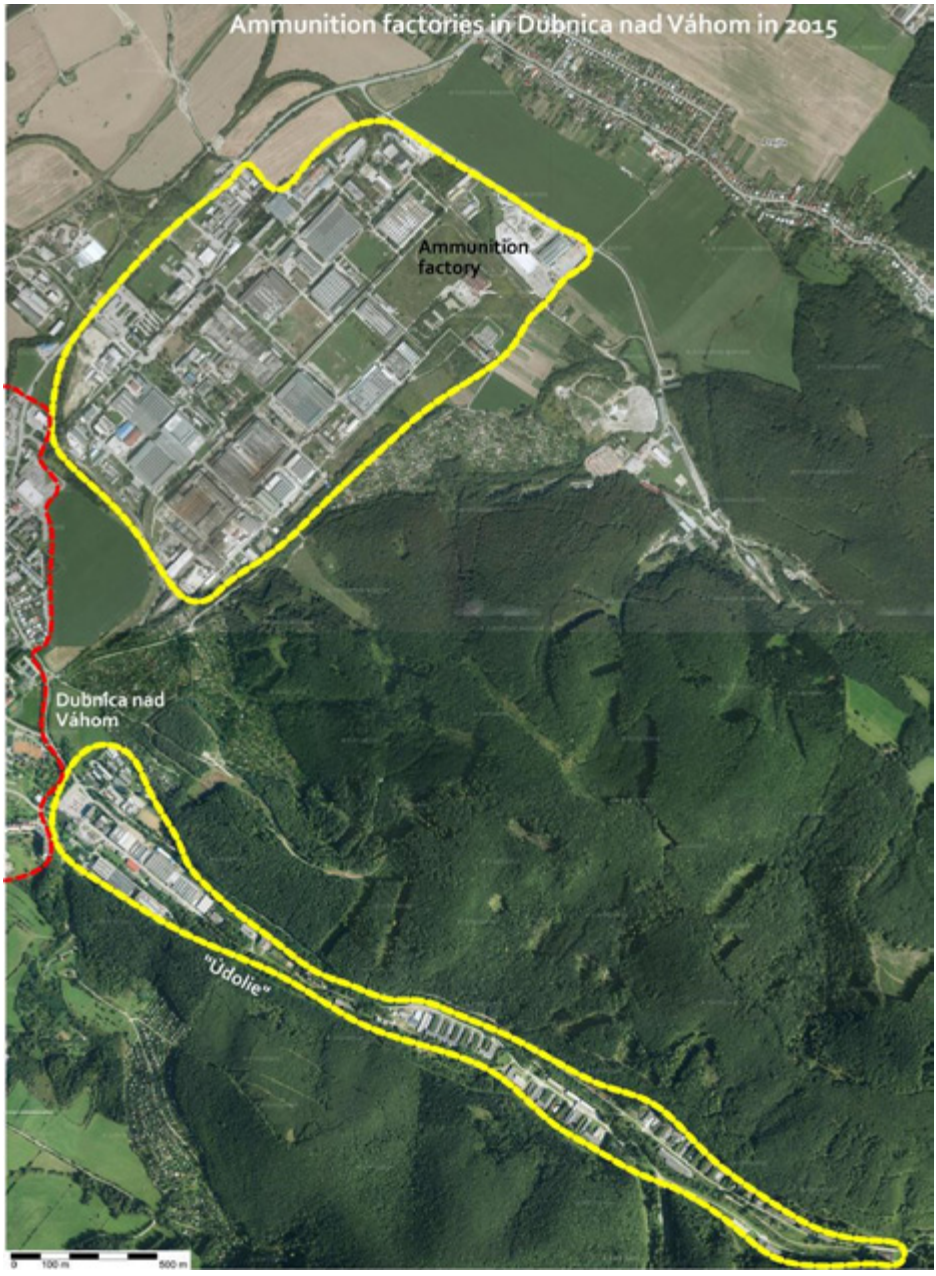


Figure 7. *Ammunition factory in Dubnica nad Váhom in 2015 (source: autor)*

4.1.3. Nová Dubnica

The plants of KJ Voroshilov – the new name for the original Škoda Works in Dubnica employed many people from the surrounding villages and from the circle of 50 km. The production expansion and ever-increasing number of employees and related housing needs have led to the emergence of Nova Dubnica – residence in the territory of 3.5 km south of Dubnica. It was built between 1951 – 1957. Its main specifics is that it was built in non-urban environment. It can be considered as a model example of the socialist type of city since the construction of the site did not have to build on the existing settlement structure (Liptak, 2002).



Figure 8. *Nová Dubnica – Settlemen structure built according to Ammunition factory in Dubnica nad Váhom (source: autor)*

The author of urbanism and architecture of Nová Dubnica is architect Jiří Kroha (along with Ivan Ciporanovom), who was also previously engaged with other colleagues in the question of social housing. The residential area has its tremendous qualities in the architectural and urban aspect. It is an important representative example of socialist realism in Slovakia (Haberlandová, 2013).

In connection with the arms factory, it represents a complementary type of "housing infrastructure" related to the main factory production, which was the largest employer in the Považie. Dubnica nad Váhom and Nová Dubnica too never became the administrative center of the district even compared to Považská Bystrica. In principle, both – Dubnica nad Váhom and Nová Dubnica too were well-equipped factory housing estates (Liptak, 2002).

4.1.4. Považská Bystrica

Považská Bystrica and its surroundings became a developed industrial region, with the contribution of the ammunition factory, or called with the new name in the socialist spirit – Concern of Clement Gottwald. Ever increasing population, connection to higher education, high attention was paid to culture. There was a new factory club, in 1968 there were set up secondary schools for workers. In 1946, there was a new swimming pool built next to the sports field, by reconstruction of a pit for capturing water in case of fire caused by airstrikes. In this example, a kind of conversion of some technical infrastructure of the plant to "peaceful" feature can be seen as well (Janak, 2009).

As for the factory itself, in 1950 the mill building was extended by another 3 fields, the construction of other buildings began. The overlap of the factory to the site was again important. The factory built a new heating plant for the town, it participated in the electrification and gasification of new parts of the city. The transfer of railway line from Puchov to Považská Bystrica was important (Janas, 2009). Since the beginning of the company construction in 1929 until 1998, the number of citizens had increased more than tenfold, and there was no other significant industrial concern near the ammunition factory (Liptak, 2002).

During the "peaceful interlude" special (armaments) production had some attenuation, as mentioned above. After war, the concern never produced only weapons, manufacture of motorcycles was introduced. With the return to production for the army, the concern achieved a high level of qualifications in special production, in 1981, the production of aircraft aggregators (Janas, 2009), engines for training and light combat aircraft of the Warsaw Pact armies was shifted here. Paradoxically, the results of this investment, which should work around 2,000 specialists, brought the first goal – the air motor – until the end of 1989, which given the subsequent political development in Czechoslovakia was relatively late (Liptak, 2002). The Towers for testing air motors are still preserved.

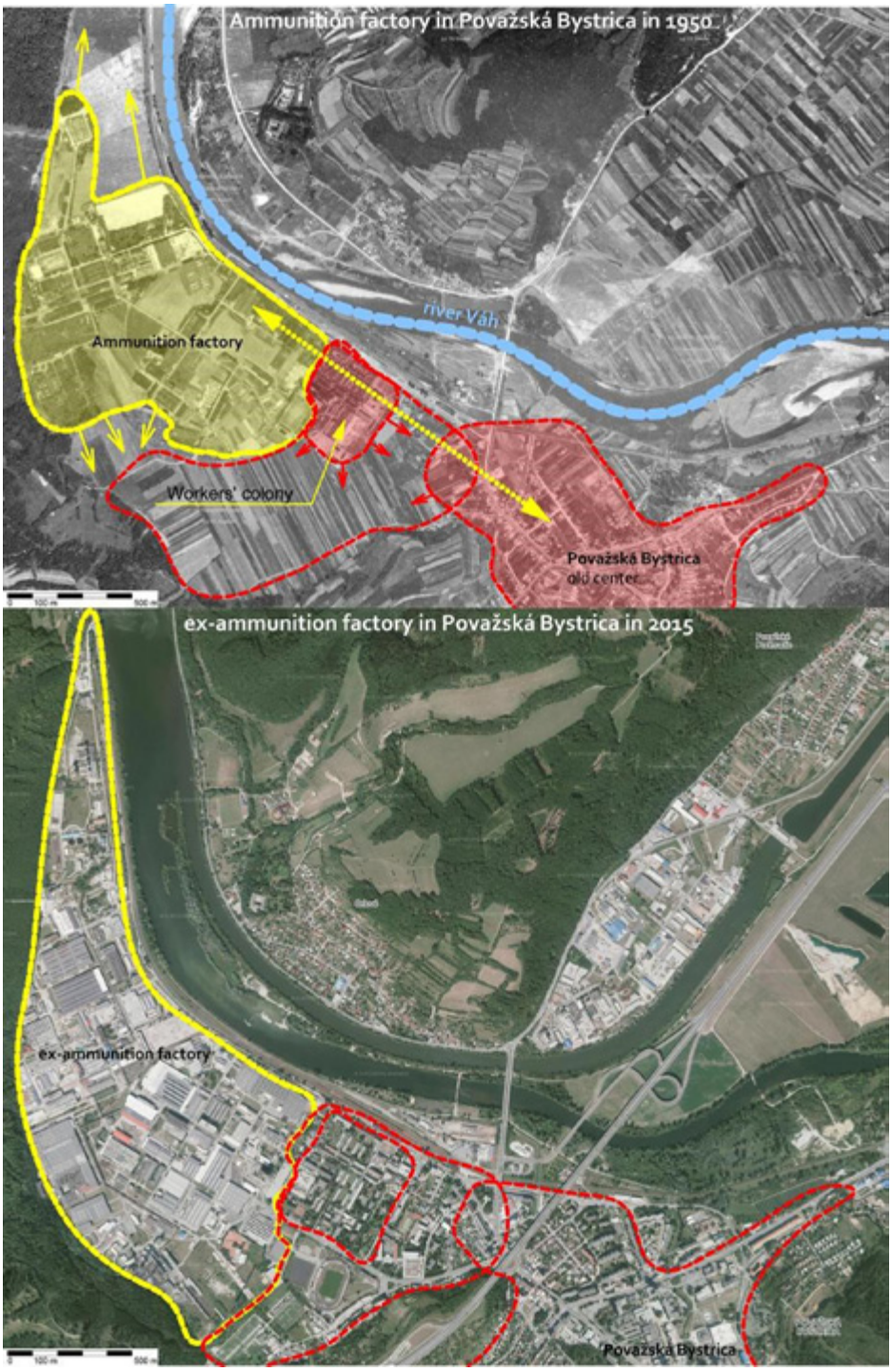


Figure 9. *Relationships between Ammunition factory in Považská Bystrica and settlement structure. Figure shows development of settlement structure according to factory (source: autor)*

With the gradual growth of the city, some restructuring and modernization also affected the historic town center and other parts, which, however, were related to armament production only indirectly (marginally). It was rather a typical reconstruction in the spirit of modernism and modernization of places itself in the period of socialism, what we find in other cities too. To some extent, it was the effort of creating a representative "of modern industrial and the socialist city", which significantly interfered in urbanism of the cities. Not all plans were implemented. Today, most of these modernizations of the '60s to the '80s are perceived more negatively because of interference in the original historic structures and standardized – impersonal construction of housing estates (Abaffyová, 2014).

Overall, in almost all cities connected with the ammunition industry, in particular of the Middle Považie, all life in urban centers was concentrated around the company. This effect, of course, was not uncommon in relation to other "monocultural" industrial cities. In case of armaments industry, however, this bond of the city and company was stronger and it specified also other relations, such as the link with the state bodies of power and ideology (Liptak, 2002). For cities and their residents employed in armament factories, it brought in a large number of benefits and strengths of social benefits – high wages, the

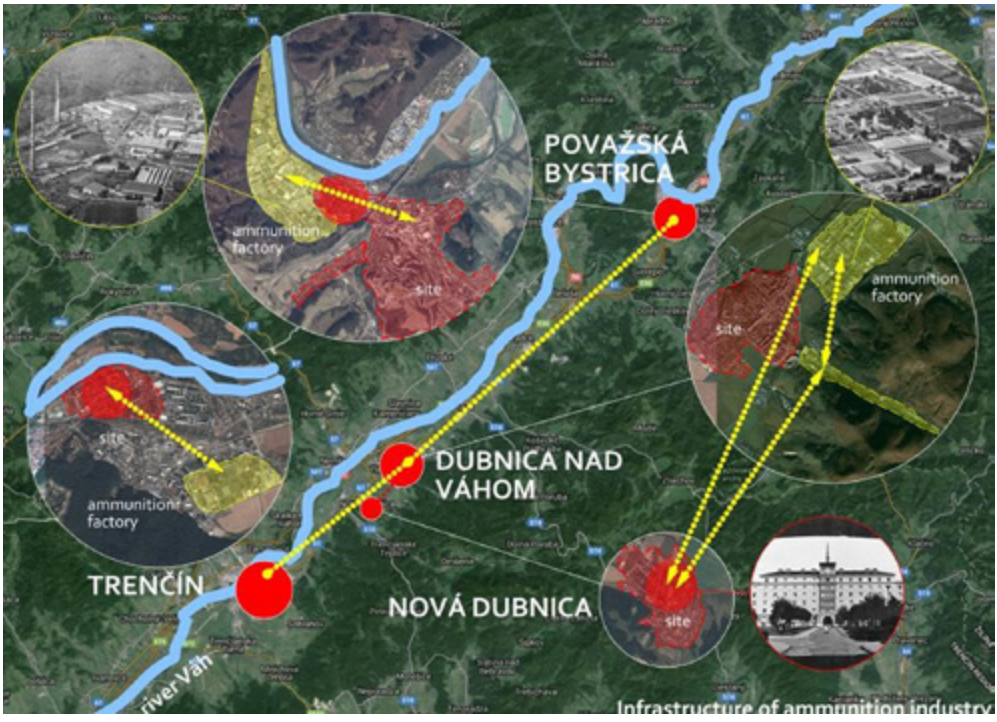


Figure 10. *Infrastructure of ammunition industry in middle Považie – relationships between factories and sites (source: autor)*

establishment of vocational schools, luxuriously appointed cultural facilities, recreational facilities, advantages in supplying and preference in short supply and so on.

Due to the length of the "third wave of armaments" (as Liptak called it, 2002), which lasted almost 40 years, these bonds engraved quite deeply into the lives of the employees. Almost the entire generation was raised on armaments production and its benefits and security. The link between the company and its certainties was obvious in many families. The deeper was the psychological trauma during later on (after the fall of communism in the late '80s), attenuation of armaments production to a complete stop caused tremendous trauma (Liptak, 2002). In context of sustainable development and its pillars or aspects, we can speak about social aspect or pillar, which was disturbed by decreasing of production.

5. PRESENT OF AMMUNITION INDUSTRY INFRASTRUCTURE IN THE VALLEY BASIN OF THE RIVER VAH

Attenuation of the defense industry has already started to show in the early eighties. International disarmament contract before the wrath in 1989 led to a substantial reduction in production or to a re-transformation of production to peace production. The subsequent political upheaval, the transition from planned to market economy, cutting off state subsidies to industry, all this significantly reduced the ammunition production. The fact that military production in Slovakia accounted for 2/3 of the national production had a significant impact on industrial-cities associated with armament production (Liptak, 2002), which was significantly reflected in the employment rate. In terms of development potential the stage of "armament urbanization,", as Lipták called the phenomenon of urban development linked to ammunition factories in his text, finally ended (Liptak, 2002). The former strong ammunition industry infrastructure is decaying and falling apart further not only on the national scale but also within the plant itself. Attenuation of production or a total stop of production caused sell-off and fragmentation of areas and buildings to small independent businesses and operations. Other problems which Slovak industry had to contend in general, was the era of privatization and globalization of the market, which many factories sank completely.

It can be said that almost all of the three plants in the valley of the river Vah basin have undergone the same transformation process and the partial attenuation of production. For the very areas, it meant that they did not use their full space capacity. The plants often fragmented into smaller pieces and separate businesses, many objects and buildings remained unused.

Trenčín, whose plant Konštrukta remained dedicated to the production of weaponry, probably turned out best. Similarly, the plants in Dubnica also continued with the production of weapons and ammunition in at least some parts of the area. After the revolution, the companies remained divided into two plants, as it had been before. Practically, both areas are used by different companies with different production orientation, although many areas remain vacant and unused.

5.1. Loss of industrial identity and it´s reanimation

The worst of it is likely to be the former engineering plants in Považská Bystrica that practically since 1989, have begun to decline. In 1998 came the slump in business (Janas, 2009) and in 2000 a definitive bankruptcy. At present, the area is, like the other, fragmented into more companies. A substantial part of the premises remained unused and dilapidated. Several valuable objects were destroyed in recent years. The engineering production, around which was almost the entire city life concentrated and adjusted its local infrastructure, such as transport and social, is gradually disappearing from the city's identity. In the past, the engineering plants were the main theme portrayed in promotional materials, but gradually in the '90s, they have started to fade out (Abaffyová, 2014). The event "Považské StrojArtne" (word-play "Machine-art in Považie") (2011) tried to sort of remind of this identity, it was organized by the association Pbblog which is active in the city of Považská Bystrica. The



Figure 11. *Towers for testing jet engines in Považská Bystrica (author: Andrej Sarvaš, 2016)*

event was held in one of the production halls of the engineering plant, where there was an exhibition of works of art linking art and industry, workshops and musical performances.

5.2. Relationship between settlement structure and the surviving industrial heritage in connection with the sustainable development of these settlements

Although the identity of the armament industry is gradually disappearing from these places, in principle there is no risk of decline in these cities as it was the case with other industrial areas that were dependent only on industrial production. In addition, the plant in Trencin and Dubnica still provide a number of jobs for the region. Taking the advantage of the location and transport connections into account, these areas still represent attractive locations. The position of these places strengthens as well their position on the development axis of the first instance, namely Považská development axis Bratislava – Trnava – Trenčín – Žilina. Dubnica nad Váhom, Nová Dubnica are cities of the third group and are characterized as the sites of regional even supraregional significance. Považská Bystrica is in the second group of settlements and is characterized as sites of supraregional even national significance, mostly supported with specific functions of international significance (Conception of Spatial development of Slovakia, 2001).

5.3. Industrial heritage

The case of the very preserved technical infrastructure of armament factories as the industrial heritage of sites is worse. The values of these sites are unquestionable, but currently declining production of some sites, abandoned buildings, brownfields creation and subsequent pressure on the development of these sites threatens tangible substance of this heritage. They are seen more as the availability of space and are minimally evaluated as industrial heritage or a monument.

On another side, there are colonies and housing complexes, connected to armament factories – such as "Kolonka" in Dubnica nad Váhom, or whole settlement Nová Dubnica. As the part of social infrastructure connected to the ammunition industry, we can talk about them as industrial heritage. Both are highly valued urban structures and protected monuments., with a specific architecture.



Figure 12. *Typical house of workers colony "Kolonka" in Dubnica nad Váhom (author: Andrej Sarvaš, 2016)*



Figure 13. *Workers colony "Kolonka" in Dubnica nad Váhom (author: Andrej Sarvaš, 2016)*

Given the range of values above, whose owners are such infrastructure of the ammunition industry, it would be more than appropriate to begin to think conceptually to assessing the possibility of transformation of the structure. This would minimize the loss of this heritage and it would be actively involved in the concept of development of this site. It is reinvigorated identity of these sites due to their industrial heritage and presents it. Just relationships of this infrastructure are the carriers of information which can be given for today's huge potential for further development in this context. Industrial heritage, there is evident not only in a material substance structures, whether sites or their own settlements, but also in the products that are produced in these armament factories, among others, the parts in the German torpedoes, which, given the globality of the historical circumstances and the actual military conflict It represents a unique artifact. This artifact is currently preserved factory and its infrastructure.

6. CONCLUSION

The infrastructure of the ammunition industry, mainly in the middle Považie, since its onset in the 30s was continuously developed until the coup in 1989. The sudden change in the political system and the economy meant that the realization of many planned things failed. As well as political decisions arose this type of industry, by political adjustments and changes it gradually wore off as was the case in other industries too. While arms factory in Dubnica nad Váhom and Považská Bystrica stood the bombing during World War II and a small intermezzo of "peace" production, it was much harder to bear the coup, stopping subsidies and privatization of estates during the last years.

Today, although the plants are used not at all their capacities. Even the factories in Dubnica and Trencin are able to maintain a continuum of the defense industry, their preserved structure still faces the pressure of development and inadequate protection. Significant is the case in Považská Bystrica, where much of the spaces are unused and original huge area is used only partially. Just settlements development, that was accelerated in past just by those factories, is some threat to these areas today. They are viewed more as the only flat for development without any values of industrial heritage.

The military is a kind of archetype of the "boy's fascination". Top technology with an almost existential and "fatal" consequences, emotions associated with military history, all this creates strong potential attractors that can be further developed.

Industrial heritage linked to the ammunition industry in Slovakia is a strong phenomenon with overlays in the development and urbanism of many places, all this is a reason for thoroughly exploring, mapping, preservation and function conversion of this kind of heritage. Just conversion based on active use

of the availability and potential of these structures, not only tangible but also intangible contained in the population, leads to the continued sustainable development based on the identity of the site. The phenomenon of sustainable development, in this case, is based on the sustainability of the material structure of this heritage as the preservation of Genius loci and its subsequent presentation. At the same time balances the trauma caused by the sudden loss of "the breadwinner" of the region as well as the collapsing identity.

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SAŽETAK

Infrastruktura triju glavnih proizvođača municije do današnjih se dana nalazi u dolini rijeke Váh u Slovačkoj. U 20. stoljeću njihova proizvodnja oružja i sastavnih dijelova predstavljala je znatan udio u izvozu roba Slovačke, uključujući i dijelove za proizvodnju torpeda.

Proizvodni pogoni u Trenčínu, Dubnici nad Váhom i Považská Bystrici izgrađeni su u trećem desetljeću 20. stoljeća. Zadobili su važan strateški položaj, uzevši u obzir stanje u Europi u to vrijeme. Proizvodnja u Dubnici nad Váhom bila je smještena u posebno zanimljivom kompleksu, djelomice pod zemljom, unutar planinskog masiva. U ovom industrijskom području bila je izgrađena mreža dodatne infrastrukture. Poput prije navedenih tvornica, dio je slovačke industrijske baštine. Zahvaljujući toj proizvodnji izgrađeno je sasvim novo naselje, arhitektonski vrijedna rezidencijalna struktura Nová Dubnice. Intervencije poput ove bitno su utjecale na karakter regije i stvorile njezin genius loci.

Koje je sadašnje stanje tog sustava nakon što se proizvodnja smanjila? Kako odnos između rezidencijalne strukture i očuvane industrijske baštine može odgovoriti na zahtjeve održivog razvoja? Ovo izvješće predstavit će procese vrednovanja raspoloživih lokacija (njihove kapacitete), identifikaciju njihova iskoristivog potencijala i stvaranje vizija za njihovo aktivno uključivanje u planiranje održivog razvoja regije.

Ključne riječi: *proizvodnja municije, povijesna tehnička infrastruktura, arhitektonske i urbanističke vrijednosti, održivi razvoj, proizvodnja dijelova za torpedo u Slovačkoj*

WHITEHEAD AND THE IMPLEMENTATION OF TORPEDO IN SCANDINAVIA 1875 – 1914

Whitehead i upotreba torpeda u Skandinaviji 1875. – 1914.

Hans Christian Bjerg*

SUMMARY

In the paper I will give an account of the purchase of Whitehead torpedoes by Sweden, Denmark and Norway in 1875. I will present how the Scandinavian Navies got in contact with Robert Whitehead, why they were interested in purchasing those torpedoes, and how they decided to buy them in the same packet.

For small navies the torpedo was a revelation. Following the philosophy of la jeune école*, it was a weapon which could match the big ships of the great sea powers. Furthermore, I will present how it was in different ways that they implemented torpedoes in their respective navies, partly in small boats partly on big surface warships. Each of the countries also bought the right to produce and repair torpedoes of the Whitehead model. Due to this reason, the development was a little different in the mentioned Scandinavian countries.*

The paper will also present in what way the three countries planned to use torpedoes both in the strategic and tactical way. The described development will be followed up to the year 1914.

Keywords: *Whitehead torpedoes, Scandinavian Navies, la jeune ecole, strategic and tactical use of torpedoes*

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SAŽETAK

U ovom radu opisat ću kako su Švedska, Danska i Norveška kupile Whiteheadova torpeda 1875. Prikazat ću kako su skandinavske mornarice stupile u kontakt s Robertom Whiteheadom, zašto ih je zanimala ta nabava te kako su odlučili kupiti ih u istom paketu.

Za male mornarice torpedo je bio otkriće. Slijedeći strategiju la Jeune École*, bilo je to oružje koje se moglo suprotstaviti velikim brodovima značajnih pomorskih sila.*

Prikazat ću kako su se te skandinavske zemlje na različite načine koristile torpedima u svojim mornaricama, dijelom na malim brodicama, dijelom na velikim ratnim brodovima.

Svaka od tih zemalja kupila je pravo da sama proizvodi i popravlja torpeda Whiteheadova modela. Zahvaljujući tome razvoj torpeda bio je u svakoj malo drukčiji.

U ovom ću radu prikazati i na koji su se način te tri zemlje namjeravale koristiti torpedima, i strateški i taktički. Opisani razvoj slijedit ću sve do 1914.

Ključne riječi: *Whiteheadova torpeda, skandinavske mornarice, „nova škola", strateška i taktička upotreba torpeda*

THE P-913 ZETA SUBMARINE IN THE COLLECTION OF THE PARK OF MILITARY HISTORY IN PIVKA (SLOVENIA)

Podmornica *P-913 Zeta* u zbirci Parka vojne povijesti u Pivki (Slovenija)

Janko Boštjančič*

SUMMARY

The submarine service along the Eastern Adriatic coast has a long and rich tradition, which began with the launch of the first two submarines of the Austro-Hungarian navy in 1909 in Pula and, despite countries coming and going and borders constantly moving back and forth, continued until the turn of the millennium. After almost one hundred years, the submarine service tradition was brought to an end due to the changes in society and in the safety conditions; the preservation of the historical memory and rich heritage thus lies in the hands of museum institutions. In 2011, the Park of Military History, the main military-historical museum institution in the Republic of Slovenia, managed to obtain one of the former Yugoslav submarines – the P-913 Zeta, today's most exciting exhibit in the Park's collection.

The P-913 Zeta belongs to the generation of the youngest Yugoslav submarines, the 911-type; between 1983 and 1988, six of these submarines were constructed. These are commando submarines, named after one of the rivers from each of the six socialist republics: Tisa, Una, Zeta, Soča, Kupa and Vardar. They were designed at the Zagreb Naval Institute (Brodarski inštitut Zagreb) and the Brodoprojekt Company from Rijeka, and constructed at the Special Vessels Shipyard (Brodogradilište specijalnih objekata) in Split.

The Yugoslav commando *submarines were powered only by electricity. The batteries were recharged at the base or at other vessels as they did not have their own power generators. Consequently, they were hard to detect, they were extremely quiet, magnetically neutral, and relatively autonomous underwater. They were designed for operation in shallow seas with the capability of laying mines close to the enemies' ports. The submarines were specifically intended for the transport and deployment*

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of naval commandos; apart from four crew members, they could accommodate six additional naval commandos together with four underwater scooters and other equipment.
The Park of Military History obtained the P-913 submarine as a donation of the Republic of Montenegro and transported it to Pivka with the help of the donor. With the obtainment of the submarine, its renovation and the preparation of the museum exhibition on submarine tradition, the Park of Military History managed to preserve an important part of the technical and historical heritage, which revives a valuable historical memory.

Keywords: *submarine, submarine service,* commando *submarine, Park of Military History, historical memory*

SAŽETAK

Podmorničkа služba duž istočne obale Jadranskog mora ima dugu i bogatu tradiciju koja je počela porinućem prvih dviju podmornica austrougarske vojske 1909. u Puli te je usprkos vladavini ovih ili onih zemalja nastavila djelovati do kraja stoljeća. Nakon gotovo stotinu godina tradicija podmorničke službe privedena je kraju zbog promjena u društvu i sigurnosnih uvjeta, a očuvanje sjećanja na povijest i bogato nasljeđe u rukama je muzejskih institucija. Godine 2011. Park vojne povijesti, *glavni institucionalni vojnopovijesni muzej u Republici Sloveniji, uspio je dobiti jednu od podmornica bivše Jugoslavije, odnosno podmornicu* P-913 Zeta, *danas najuzbudljiviji izložak u zbirci* Parka.
P-913 Zeta *pripada generaciji najmlađih jugoslavenskih podmornica, 911-tipa. Između 1983. i 1988. izgrađeno je šest takvih podmornica. To su* commando *podmornice, od kojih je svaka nazvana po jednoj od rijeka šest socijalističkih republika:* Tisa, Una, Zeta, Soča, Kupa *i* Vardar. *Projektirane su na zagrebačkom Brodarskom institutu i u Brodoprojektu u Rijeci, a izgrađene u Brodogradilištu specijalnih objekata u Splitu.*
Jugoslavenske commando *podmornice pokretale su se isključivo na struju. Baterije su se punile u bazi ili na drugim plovilima jer nisu imale svoje generatore. Slijedom toga, bilo ih je teško otkriti, bile su veoma tihe, magnetski neutralne i relativno samostalne pod vodom. Projektirane su za djelovanje u plitkim morima, s mogućnošću polaganja mina u blizini neprijateljskih luka. Podmornice su bile posebno namijenjene za prijevoz i razmještaj mornaričkih komandosa; uz četiri člana posade mogle su primiti šest mornaričkih komandosa, zajedno s četiri podvodna skutera i drugom opremom.*
Park vojne povijesti *dobio je podmornicu P-913 kao donaciju Republike Crne Gore i prevezao je u Pivku uz pomoć donatora. Dobivanjem te podmornice, njezinim obnavljanjem i pripremom za muzejsku izložbu o podmorničkoj tradiciji,* Park vojne povijesti *uspio je sačuvati važan dio tehničke i povijesne baštine kojom se obnavlja vrijedno sjećanje na povijest.*

Ključne riječi: *podmornica, podmorničkа služba,* commando *podmornica,* Park vojne povijesti, *sjećanje na povijest*

HOLLANDROUTE – A HERITAGE NETWORK IN THE *AMSTERDAM METROPOLITAN AREA*

HOLLANDROUTE – Mreža povijesne baštine u *Amsterdam Metropolitan Area*, regiji grada Amsterdama

Hildebrand de Boer*

SUMMARY

The touristic heritage network "HollandRoute" links Dutch heritage sites of trade, productivity, engineering, industry, water management and infrastructure, within the European Route of Industrial Heritage (ERIH).

Historic mills, pumping stations, factories, fortresses and estates have shaped the face of Holland for centuries. Now they are tangible reminders of the long industrial history of the Amsterdam Metropolitan Area. Many route points in the HollandRoute *already enjoy protection due to their high cultural value: the old canals of Amsterdam, as well as the fortresses around the capital city (The Defence Line of Amsterdam) have been named UNESCO World Heritage Sites. For these sites, as well as many other exciting route points found in the HollandRoute, this means the start of a new life as cultural hotspots and tourist attractions. Thousands of tourists discover the Amsterdam Metropolitan Area using the* HollandRoute *with its core 7 anchor points selected by ERIH (European Route of Industrial Heritage), and no less than 47 especially selected route points.*

Aside from the HollandRoute*, there are more than 60 theme routes available throughout the region. With over 700 kilometres of cycling routes and over 200 kilometres of walking routes, these theme routes offer further insights in various themes and areas. The theme routes are available for free on the* HollandRoute *website and app.*

The more than 60 walking-, cycling- and waterroutes, form the perfect addition to the HollandRoute *and guide the visitors along another 1000 waypoints and areas brimming with special history and unique character. The 140-kilometre* HollandRoute *is furnished with standardized signage for motorized vehicles. These*

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signs will not only guide to the many anchor points and route points, but also along spectacular views and deep polders on the way there. The compact nature of the Amsterdam Metropolitan Area, however, also allows for easy access to all route points by public transport.
In 2015 for the first time the Industrial Heritage Festival was organized, within the network of the HollandRoute*. It is decided to continue this festival in the HollandRouteProgramme for 2016 and the following years.*
Hildebrand de Boer will present how the HollandRoute *was established, and in which broader European context of touristic heritage networks the HollandRoute may be considered. Besides the presentation, a special workshop might be organized about the genesis and aspects of touristic heritage regional networks.*

Keywords: *industrial history, cutural value, Amsterdam,* HollandRoute*, anchor points, ERIH*

SAŽETAK

Turistička mreža povijesne baštine pod nazivom HollandRoute *(Holandska ruta) povezuje holandska mjesta povijesne baštine vezana za trgovinu, proizvodnju, tehniku, industriju, upravljanje vodom te infrastrukturu, a dijelom je europske rute industrijske baštine (ERIH).*
*Povijesni mlinovi, pumpne stanice, tvornice, utvrde i veliki posjedi stoljećima su oblikovali lice Holandije. Sad su opipljiva sjećanja na dugu industrijsku povijest regije grada Amsterdama (*Amsterdam Metropolitan Area*). Mnoge su točke na ruti pod nazivom* HollandRoute *zbog svoje velike kulturne vrijednosti već zaštićena mjesta, a stari kanali u Amsterdamu, kao i tvrđave oko glavnoga grada (Obrambena linija Amsterdama) proglašeni su UNESCO-vim mjestima svjetske povijesne baštine. Za ta mjesta, kao i za mnoge druge zanimljive točke na toj ruti, to znači početak novog života kao iznimno popularnih kulturnih odredišta i turističkih atrakcija. Tisuće turista otkriva regiju grada Amsterdama koristeći se tom rutom, s njezinih sedam sidrišnih točaka koje je odabrao ERIH (Europska ruta industrijske baštine) te čak 47 posebno odabranih točaka na njoj.*
Osim HollandRoute*, postoji više od 60 tematskih ruta u cijeloj regiji. S više od 700 kilometara biciklističkih i više od 200 kilometara pješačkih ruta, te tematske rute nude dodatni uvid u razne teme i područja. Tematske rute mogu se dobiti besplatno na internetskoj stranici* HollandRoute *kao i putem aplikacija.*
Više od 60 ruta za pješačenje, vožnju biciklom, kao i vodene rute, savršen su dodatak HollandRouti *i vode posjetitelje duž tisuću drugih točaka i regija prepunih posebne povijesti. 140 kilometara duga* HollandRouta *opremljena je standardiziranim znakovljem za motorna vozila. Ti znakovi ne samo da vode do mnogih glavnih sidrišnih točaka na ruti, već to čine duž mjesta sa savršenim pogledom i dubokim polderima. Zbog zbijene prirode regije grada Amsterdama do svih točaka na toj ruti može se lako doći javnim prijevozom.*
Godine 2015. prvi je put organiziran Festival povijesne baštine unutar mreže HollandRoute*. Odlučeno je da se taj Festival nastavi održavati kao dio programa te rute i 2016. te u sljedećim godinama.*
Hildebrand de Boer prikazat će nastanak HollandRoute *i pokazati u kojem se širem europskom kontekstu može promišljati ta ruta. Osim same prezentacije mogla bi se organizirati posebna radionica o genezi i aspektima regionalnih turističkih mreža povijesne baštine.*

Ključne riječi: *industrijska povijest, kulturne vrijednosti, Amsterdam, Holandska ruta, točke sidrenja, ERIH*

WORKSHOP: REGIONAL TOURISTIC HERITAGE NETWORKS & HOLLANDROUTE – A PRACTICAL APPROACH OF ASPECTS AND BUILDING STONES

RADIONICA: Regionalne turističke mreže povijesne baštine i *Hollandroute* – Praktičan pristup i postupci

Hildebrand de Boer*

SUMMARY

The purpose of the Regional Touristic (Industrial) Heritage Networks is to make people aware of the historical value and importance of their (industrial) heritage, through provision for tourism and other leisure activities. These active networks can emerge to economic valuable platforms of cooperation in the field of industrial heritage preservation, presentation and promotion. During the workshop we will look at relevant ingredients and procedures. Also some effects of existing regional networks are paid attention. Ingredients of Regional Touristic Heritage Networks are attractions, routes, communication and the network of participants. Relevant attractions are the ERIH Anchor Points, Route Points (also Settlements), Rest Points (restaurants, cafes and hotels on heritage sites), Viewpoints, historic infrastructure and Industrial Tourism Sites. A Main Route and eventually a Main Water Route is provided, together with Theme Routes for biking, hiking and water sports. Effective communication and promotion is indispensable. Helpful tools are websites, apps, and last but not least printed media and heritage cards. Further an active and responsible network of collaborating site parties, i.e. in the field of cross marketing, is essential in order to guarantee a sustainable achievement. The procedures to establish the Regional Touristic Heritage Network will vary regionally strong, but there might be some basic procedure lines recognizable, which have to be filled in. In this respect we can consider the aspects of preliminary investigation, Master Plan, implementation, preparation of the official start, management and further development of the network.

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All in all, the realization of a sustainable Touristic Heritage Network is a huge challenge and at the same time a valuable economic investment. Fortunately we can make use of experiences with regional networks in different European countries.

Keywords: *Industrial Heritage, ERIH, Visitor networks, Rijeka*

1. SHARED HERITAGE

The history of industry is an important part of our European heritage. Nothing has influenced the European continent more than 200 years of 'Industrial Revolution'.

The story was similar across Europe: working and living conditions differed little between countries during the industrial era – a miner in the German Ruhr Area or in the valleys of South Wales dug the same coal, used the same tools and experienced the same conditions. These miners migrated across Europe in their search for 'black gold'. Industrial history is therefore a heritage shared by all European people: it forms part of our common European identity.

2. HERITAGE SHAPES FUTURE

Today, across Europe, communities value their industrial heritage and many former industrial sites and areas are protected and maintained as symbols of a bygone era.

However, these are not just reminders of our technical achievements and social history; they also help to define the identity of communities and individuals – they influence who we are and they shape our future. The future of these former industrial regions is an important issue across Europe, and many of these areas still have a role to play in providing work.

Over the past twenty years, former industrial sites have often become symbols of change and have adapted to new uses. Some have become museums or been transformed into housing. Others have become a focus for new industrial uses including the 'Creative Industries'. 'Regeneration through Heritage' has become a popular theme.

3. ATTRACTIVE FOR THE PEOPLE

Also, across Europe, many of the 'cathedrals of work' have become major attractions of cultural tourism attracting millions of visitors a year. This demonstrates that industrial heritage tourism is no longer a niche market but has grown into a major tourism sector.

The maintenance and interpretation of former industrial sites is often a challenge which needs innovative solutions. They need not be regarded as a



Figure 1. *Attractive heritage for people, ERIH Anchor Point Landscape Park Duisburg-Nord [D], 2017 (Photo: Hildebrand de Boer).*

burden because experience has shown that such sites can often be transformed into attractive and lively areas which make a positive contribution to our cities.

4. EUROPEAN ROUTE OF INDUSTRIAL HERITAGE – THE MASTER PLAN

Funded by the European Union, the ERIH network (the European Route of Industrial Heritage) was established to encourage the appreciation, understanding, protection and promotion of our common European history and to facilitate this by the exchange of experience and by joint marketing.

ERIH has become a voice for industrial heritage sites and a champion for industrial heritage tourism with the aim of improving the image and the economic wellbeing of ERIH sites and former industrial areas. ERIH has become established as a Europe-wide brand for industrial heritage and industrial heritage tourism.

The first stage was the preparation of a Master Plan (2000-2001) [1] which identified specific proposals and activities to develop the marketing of industrial heritage tourism within Europe. In 2005, the first part of the 'European Route of Industrial Heritage' was launched in North-West Europe. Since then the network has gradually expanded so that by today it includes most European countries.



Figure 2. *ERIH Annual Assembly, ERIH Anchor Point Brewery Pilsen [CZ], October 2015 (Photo: Hildebrand de Boer).*

5. EUROPEAN ROUTE OF INDUSTRIAL HERITAGE – THE ASSOCIATION

In 2008 a legal association was set up which now manages the organisation of the network.

Central point of the association is the website [2], consisting comprehensive information about 1.750 sites all over Europe, as well as 105 high level Anchor Points and 18 regional route networks of industrial heritage. Further information blocks relate to 15 European Theme Routes about the different branches of industry, history of 15 industrial branches, industrial history of 38 countries, 162 biographies, an event database, a best practice database and more than 3000 links.

ERIH is a quality benchmark that celebrates our industrial heritage as a major element of European culture. The result is an exciting and varied range of visitor attractions, many of them in former industrial areas, but all with a common seal of excellence. ERIH stands for the very best in European industrial heritage and sustainable tourism, identifying destinations and assuring the visitor of a high quality experience when they get there.

Today ERIH can be considered to be the most comprehensive European cultural network [3].

6. REGIONAL INDUSTRIAL HERITAGE NETWORKS

The ERIH purpose of the Regional Industrial Heritage Networks is to make people aware of the historical value and importance of their (industrial) heritage, through provision for tourism and other leisure activities. These active networks can emerge to economic valuable platforms of cooperation in the field of industrial heritage preservation, presentation and promotion.

Ingredients of Regional Industrial Heritage Networks are attractions, routes, communication and the network of participants. Relevant attractions are the Anchor Points (also Settlements), Rest Points (restaurants, cafes and hotels on heritage sites), Viewpoints, historic infrastructure and Industrial Tourism Sites. A Main Route and eventually a Main Water Route is provided, together with Theme Routes for biking, hiking and water sports.

Effective communication and promotion is indispensable. Helpful tools are responsive websites and printed media. Further an active network of collaborating site parties, i.e. in the field of cross marketing, is essential in order to guarantee a sustainable achievement.

The procedures to establish the Regional Industrial Heritage Network will vary regionally strong, but there might be some basic procedure lines recognizable, which have to be filled in.

In this respect we can consider the aspects of preliminary investigation, Master Plan, implementation, preparation of the official start, management and further development of the network.

All in all, the realization of a sustainable Industrial Heritage Network is a huge challenge and at the same time a valuable economic investment. Fortunately we can make use of experiences with regional networks in different European countries.

Meanwhile, on the European scale of ERIH seventeen regional networks for industrial culture originate in Belgium, Germany, the Netherlands, Austria, Poland, Spain and United Kingdom. Regional networks are being prepared or developed in various European countries.

7. ERIH HOLLANDROUTE IN THE AMSTERDAM METROPOLITAN AREA

The aforementioned ERIH Master Plan provided in 2001 for, among other things, the establishment of regional networks for industrial culture. This resulted in an industrial heritage network in the Amsterdam Metropolitan Area, which could be expanded further as 'HollandRoute' from 2009 – thanks to cooperation within the regional tourism promotion program 'Visit Amsterdam, See Holland', supported by European ERDF resources. The HollandRoute was



Figure 3. *ERIH HollandRoute, Steam Pumping Work Halfweg [NL], 2011 (Photo: Hildebrand de Boer).*

officially opened on 1 July 2011 by the King's Commissioner in the Province of Noord-Holland.

The HollandRoute links Dutch heritage sites of trade, productivity, engineering, industry, water management and infrastructure, within the European Route of Industrial Heritage (ERIH).

Historic mills, pumping stations, factories, fortresses and estates have shaped the face of Holland for centuries. Now they are tangible reminders of the long industrial history.

Many route points of the HollandRoute already enjoy protection due to their high cultural value: the old canals of Amsterdam, as well as the fortresses around the capital city (The Defence Line of Amsterdam) have been named UNESCO World Heritage Sites. For these sites, as well as many other exciting route points found in the HollandRoute, this means the start of a new life as cultural hotspots and tourist attractions. Thousands of tourists discover the Amsterdam Metropolitan Area using the HollandRoute with its core seven anchor points selected by ERIH (European Route of Industrial Heritage), and no less than 47 especially selected route points.

Aside from the HollandRoute, there are more than 60 theme routes available throughout the region. With over 700 kilometres of cycling routes and over 200 kilometres of walking routes, these theme routes offer further insights in various themes and areas. The theme routes are available for free on the HollandRoute website [4] and app.

The more than 60 walking-, cycling- and water routes, form the perfect addition to the HollandRoute and guide the visitors along another 1000 waypoints and areas brimming with special history and unique character.

The 140-kilometre HollandRoute is furnished with standardized signage for motorized vehicles. These signs will not only guide to the many anchor points and route points, but also along spectacular views and deep polders on the way there. The compact nature of the Amsterdam Metropolitan Area, however, also allows for easy access to all route points by public transport.

As with ERIH on a European scale, here too the European commitment on a regional scale has led to a sustainable result. Meanwhile, the HollandRoute network – consisting of Anchor Points, Route Points, Rest Points, View Points, signposted main route, and theme routes for walking, cycling and boating – has been added an annual event called 'The Week of Industry' [5], with a multitude of cultural events and company visits. Without the participation of the European Union, this result would not have been achieved.

8. EUREGIONETWORK INDUSTRIAL CULTURE

Inspired by the results of the 'HollandRoute' and the 'Route der Industriekultur' in the Ruhr area, in 2013 a project group started the preparation of a Euregional network for industrial culture in the East Netherlands and West Münsterland (Germany), chaired by EUREGIO.

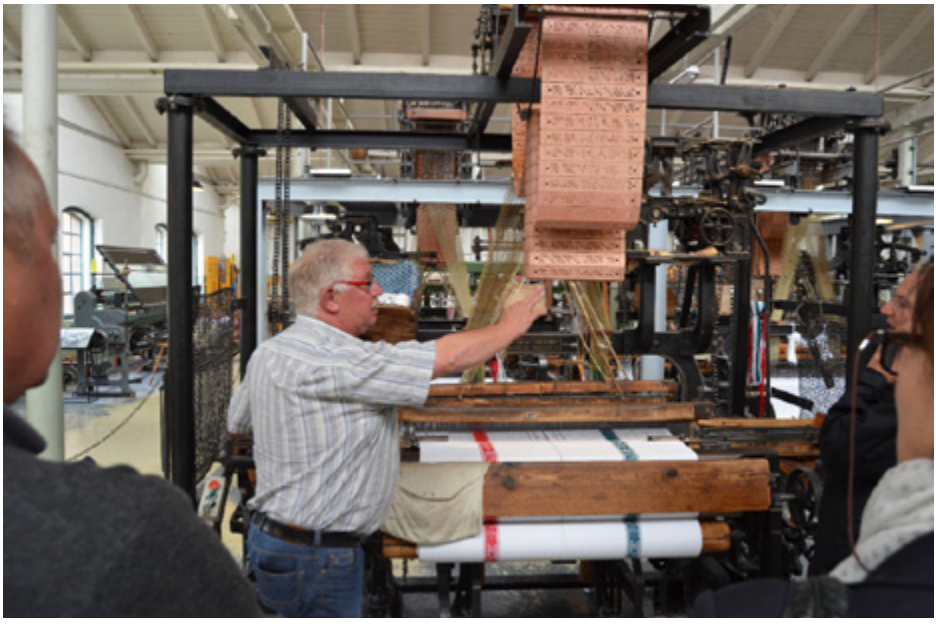


Figure 4. *EuregioNetwork Industrial Culture, ERIH Anchor Point TextilWerk Bocholt [D], 2015 (Photo: Hildebrand de Boer).*

Thanks to an INTERREG-4 contribution, the project group was able to instruct the HollandRoute Foundation to conduct a feasibility study into such a Euregional network [6]. The feasibility study was presented in 2015 and the project 'EuregioNetwork Industrial Culture' is now being implemented [7]. This network will become a combination of industrial heritage sites and modern innovative industries.

9. OPPORTUNITY: AN ERIH REGIONAL INDUSTRIAL HERITAGE NETWORK IN RIJEKA AND KVARNER

Time is scarce. Tourists and holidaymakers wish to make the most of their vacation and least possible waste of time selecting, preparing and weighing alternatives. Products where they know in advance what they will get, are growing in popularity. Increasingly, there is a need for original, unspoiled and authentic elements that the tourist and holidaymaker can identify. Regional identity is an important motif for a visit. There are new opportunities for Rijeka.

Rijeka's regional identity is European. You become fascinated by the tangibility of centuries of European history and ongoing geopolitical changes over the last 150 years, under the influence of Austria, Hungary, Italy, Yugoslavia and Croatia. Rijeka was called alternately St. Veit am Flaum, Szentvit, Fiume and Reka. This is also echoed in Rijeka's European Capital of Culture 2020 concepts of 'Port of Diversity'.



Figure 5. *Torpedo Launching Test Station, Rijeka, 2016 (Photo: Hildebrand de Boer).*

In the past centuries, the port of Rijeka (Fiume), developed into an important industrial and maritime center. Affecting industrial production, there was (military) need of ships and weapons, and the (civil) demand for products for which the raw materials could easily be supplied overseas and by rail.

Imagine products such as rope, leather, canned fish, oil refining, sugar, paper, tobacco, brandy & spirits, cocoa & chocolate, pasta & rice, soap, furniture and playing cards. A large amount of maritime- and rail-related warehouses and storage buildings arose. Utilities supplied drinking water and electricity. Rijeka from 1866 onward, was the industrial cradle of the torpedo, as one of the most innovative weapon systems in modern history, thanks to the collaboration between the naval Captain Giovanni Luppis [1813-1875] and industrial entrepreneur Robert Roger Whitehead [1823-1905].

Of all these diverse industrial activities, their remains are stil very much apparent in Rijeka, despite the enormous historical dynamics that befell the city. In 2014, attention was paid to Rijeka's industrial past, with an exhibition by the City Museum of Rijeka. Ema Anicic wrote for this purpose an excellent publication with a thorough overview of the remaining industrial heritage [8]. It is now important to go and tell the European story of Rijeka's industrial history and unlock the key industrial heritage for tourism, visitors and education.

10. THE CORE OF THE RIJEKA-KVARNER NETWORK

The Rijeka Kvarner Network of Industrial Culture brings tourists, holiday-makers and youth to heritage sites of harbor landscape, industry manufacturing, engineering, commerce, utilities, infrastructure and housing.

Important priorities of Rijeka Kvarner Network Industrial Culture are:

- An active network of heritage sites (Anchor Points, Route Points, Rest Points)
- An active network of companies which provide industrial tourism
- A network of View Points
- A marked or electronically accessible Main Route
- Theme trails for biking, hiking and boating
- Guide Map
- Responsive Website
- A network of Information Points
- An educational program about the Rijeka Kvarner Industrial culture

Rijeka Kvarner Network Industrial Culture	
ROUTES	**ATTRACTIONS**
Main Route	**ERIH Anchor Points**
Main Naval Route	**Route Points**
Theme Routes	**Rest Points**
LD-Routes	**View Points**
Educational Program	**Industrial Tourism**

At the core of the Rijeka Kvarner Network Industrial Culture should be a permanent exhibition of the history of torpedo invention, production and purpose. Currently, the historical Railway Warehouses near Zabica Square house a splendid exhibition about 150 years of torpedo invention and production [9].

Ideally in the future, the Whitehead Torpedo Factory could become a historical centre to house the current exhibition, as well as showcase the history



Figure 6. *Exhibition Torpedo 150, Rijeka, 2016 (Photo: Hildebrand de Boer).*

of the factory and establish a related Austro-Hungarian maritime history archive. There are Whitehead family relations interested in spearheading this project in collaboration with the broader Industrial Heritage vision.

Also in the core of the network, both City and Maritime Museums are indispensable for the reflection on the industrial and maritime history:

- *Exhibition Torpedo 150*, Railway Warehouses, near Zabica Square
- *City Museum of Rijeka*, Muzejski trg 1/1
- *The Maritime and History Museum*, Muzejski trg 1

11. THE SIX AREAS OF THE RIJEKA-KVARNER NETWORK

- Industrial Zone of the Centre *(Port Warehouses, Cranes, Bridges, Lighthouse, Railway Station, Factories)*
- Skoljic and Vodovodna Street *(Tram Depot, Tannery, Factories, Foundry, Slaughterhouse, Power Plant)*
- Mills on the Rjecina River and Ruziceva Street *(Industrial Mills, Ice House)*
- Western Industrial Zone *(Rice Mill, Oil Refinery, Hotel Emigranti, Metal Foundry and Villa Robert Whitehead & Co., Third May Shipyard, Chemical Industry)*
- Eastern Industrial Zone – Susak *(Factories, Laboratories, Lazaretto)*

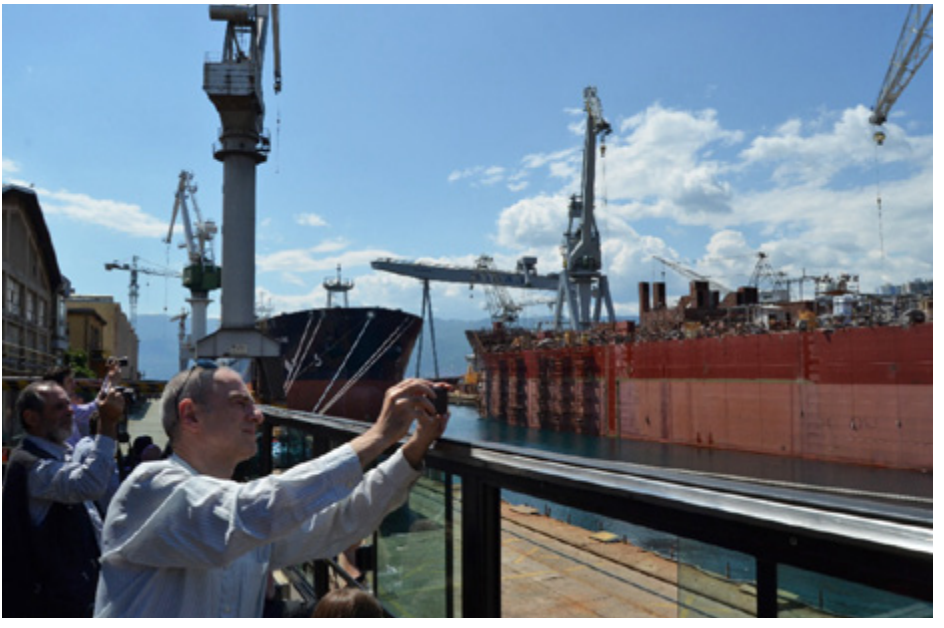


Figure 7. *Third May Shipyard, Rijeka, 2016 (Photo: Hildebrand de Boer).*

- A sixth area could be identified as the *Kvarner regional surroundings of Rijeka*, especially the sub-areas of Kraljevica, Vinodol, the island of Krk and the island of Cres. It might need further research to identify the relevant industrial and maritime heritage in these sub-areas.

The impressive list of industrial heritage sites that has survived, contains more than sufficient substance for to achieve the Rijeka Kvarner Network Industrial Culture.

Current: A part of the industrial heritage can already be visited today, or can possibly be made accessible in the near future.

Future Trails: Another part of the industrial heritage can be experienced from the public roads and thus allows viewing access, for instance as part of developing industrial heritage discovery trails, in the areas of the network.

Other Sites: In addition, other sites of industrial culture will appear in the network, for instance – workers housing, funeral monuments, statues, market places, etcetera.



Figure 8. *Market Hall, Rijeka, 2018 (Photo: Hildebrand de Boer).*

Past/Present: The condition of the industrial heritage covers a broad spectrum, from real industrial archaeological sites in the Rjezina River Area, to the modern full functioning enterprises of the Oil Refinery and the Shipyard 3. Maj. These full functioning industrial sites deliver an opportunity, together with other modern industrial activities in Rijeka, to develop a network of companies with facility for industrial tourism. That means, the focus of the project is not only to look back into history, but also to look forward into the modern and future industrial innovation in Rijeka and Kvarner.

Both, industrial heritage tourism and industrial tourism are linked in this way. Beyond that, the project comes to life with an educational program, about the industrious and maritime past, and contemporary industrial activities, technics, research, etcetera.

Coherent Key Elements of the Network:

- Aimed at both the local population and visitors from outside the project area
- Educational program focused on industrial culture and innovative future
- Industrial tourism highlights the tremendous economic and technical performance delivered by the industry today
- Collaboration and cross-marketing by the participating network partners
- Promoting the tourism economy as a motor for the strengthening of cultural heritage.

12. SEIZE THE MOMENT

An Action Plan – as the first phase of the Rijeka Kvarner Network of Industrial Culture – could be officially presented in 2020, when Rijeka is the cultural capital of Europe. This event would bring the further realization of the Rijeka Kvarner Network into an effective perspective.

Collaboration is the key concept in all European activities, in order to make the European Treasures of Industrial Culture accessible to a broad, regional and international audience. It always is a privilege to be able to contribute to this, together with many dedicated colleagues in a beautiful joint European cultural area full of historical connections and innovative lines to the future.

Rijeka and Kvarner should not be missing!

Let us continue to build, together, for each other, because Europe is much more than the sum of its parts!

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SAŽETAK

Približiti ljudima povijesnu vrijednost i značenje njihove (industrijske) baštine pružanjem turističkih i ostalih zabavnih aktivnosti, cilj je regionalnih turističkih mreža (industrijske) povijesne baštine. Te aktivne mreže mogu postati gospodarski vrijedne platforme suradnje u očuvanju industrijske baštine, njezine prezentacije i promocije. Na radionici ćemo razmatrati relevantne elemente i postupke. Obratit ćemo pozornost i na neke učinke postojećih regionalnih mreža. Atrakcije, rute, komunikacija i mreža sudionika spadaju u elemente regionalnih turističkih mreža povijesne baštine. U relevantne atrakcije spadaju sidrišne točke Europske rute industrijske baštine (ERIH), ostale točke rute (kao i naselja), točke za odmor (restorani, kafići i hoteli na mjestima baštine), točke s pogledom, povijesna infrastruktura i mjesta industrijskog turizma. Daje se glavna ruta, možda i glavna vodena ruta, zajedno s tematskim rutama za vožnju biciklom, pješačenje i vodene sportove.

Nužna je učinkovita komunikacija i promocija. Među pomoćna sredstva spadaju internetske stranice, aplikacije te, ne manje važni, tiskani mediji i karte s povijesnom baštinom. Potrebna je i aktivna i odgovorna mreža suradnje među mjestima povijesne baštine, kao u području cross marketinga *kada je nužno jamčiti održivo ostvarivanje zadanih ciljeva.*

Pri osnivanju mreže regionalne turističke baštine doći će do većih regionalnih razlika u postupcima, međutim naći će se i neke prepoznatljive crte postupaka koje treba zadovoljiti. U tom smislu možemo razmotriti neke aspekte preliminarnog istraživanja, glavni plan, provođenje, pripremu službenog početka, upravljanje i daljnji razvoj mreže.

Sve u svemu, realizacija održive mreže turističke povijesne baštine golem je izazov, a istodobno i vrijedno gospodarsko ulaganje. Srećom, mogu se iskoristiti iskustva mreža iz raznih europskih zemalja.

Ključne riječi: *baštinska mreža, industrijska baština, slobodne aktivnosti, očuvanje baštine, reginalne mreže, Rijeka*

FANCIFUL SPECULATION OR GEORGE READ MURPHY AND THE *VICTORIA* TORPEDO

Maštovita špekulacija ili George Read Murphy i *Victoria* torpedo

Denis Cahill*

SUMMARY

Despite the fact that George Read Murphy (1856-1925) spent most of his working life in Victoria, we have very little in the way of information regarding his relatively short stay in London between 1889 and 1890. It was during this period that he was said to have written his first novel and invented the Murphy torpedo that was later, renamed the 'Victoria' torpedo.

The Murphy or 'Victoria' torpedo was a modified Whitehead torpedo, in which the direction of travel and the speed was controlled via an insulated three-core cable dispensed from the torpedo and the ship or shore station from which it was launched. Giovanni Luppis (1813-1875) had anticipated the need for directional control in his designs for the "Salvacoste" which he had submitted to Robert Whitehead in 1864. However, Whitehead discarded directional control in favour of a 'fire and forget' weapon that theoretically travelled in a straight line and at a predetermined depth.

The Victoria Torpedo Company Limited was formed in 1890 to exploit Murphy's Patents, and ensure the company's rights to the manufacture, maintenance and repair of the Murphy or 'Victoria' torpedo. Following the British Admiralty's failure to adopt the Murphy or 'Victoria' torpedo, the company ran into financial difficulties and in 1891 and there were reports that it was to go into voluntary liquidation. The Murphy or 'Victoria' torpedo never went into full-scale production and remains a nineteenth century engineering oddity.

Keywords: *Controlled torpedoes, Luppis, Murphy, Victoria, Whitehead*

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SAŽETAK

Usprkos tome što je George Read Murphy (1856. – 1925.) proveo većinu svoga radnog života u Viktoriji*, malo je informacija o njegovu razmjerno kratkom boravku u Londonu između 1889. i 1890. Kažu za njega da je u to vrijeme napisao svoj prvi roman i izumio Murphyjev torpedo kojemu je poslije promijenjeno ime u* Victoria *torpedo.*

Murphyjev ili Victoria *torpedo bio je izmijenjeni Whiteheadov torpedo na kojem se smjerom putanje i brzinom upravljalo pomoću izoliranoga trodijelnog kabla koji je dolazio iz torpeda i broda ili stanice na obali s koje je bio lansiran. Giovanni Luppis (1813. – 1875.) predvidio je potrebu za upravljanje smjerom u svojim nacrtima za* Salvacoste *koje je predao Whiteheadu 1864. Whitehead je, međutim, odbacio takvo upravljanje u korist „ispali i zaboravi" oružja koje je u teoriji putovalo u ravnoj liniji i unaprijed zacrtanom dubinom.*

Godine 1890. osnovana je tvrtka Victoria Torpedo Company Limited *koja je trebala iskoristiti Murphyjeve patente i osigurati prava na proizvodnju, održavanje i popravak Murphyjeva ili* Victoria *torpeda. Nakon što britanski Admiralitet nije prihvatio Murphyjev ili* Victoria *torpedo, tvrtka je zapala u financijske poteškoće tako da se 1891. govorilo da je samovoljno otišla u stečaj. Murphyjev ili* Victoria *torpedo nikada se nije proizvodio u širim razmjerima i ostaje inženjerska neobičnost 19. stoljeća.*

Ključne riječi*: torpeda upravljana s obale, Luppis, Murphy,* Victoria*, Whitehead*

WISDOM AND ART OF THE STATE: THE TESTIMONIALS OF INDUSTRIAL HERITAGE AND FRAMEWORK OF LAGOON OF VENICE

Mudrost i vrhunska tehnologija – svjedočanstva industrijske baštine i okosnica Venecijanske lagune

Gaetano Cataldo*

SUMMARY

The essay deals with the relationship between three symbolic sites realized throughout the history of the Republic of Venice, characterized by great historical and architectural importance and landscape and all with a particular target of naval and military production.

These three sites, the historic and impressive Arsenale, magnificent example of industrial archeology that has incessantly changed his appearance until it has remained an active place of production, the industrial area of St. Giobbe intended to Silurificio Schwartzkopff *and the Island of* Vignole*, subject to changes related to the military activity, were intimately connected and are the tangible result of that Wisdom and Art of the State that has characterized all interventions designed by the Venetian Republic.*

By means of historical documentation and archives we have attempted to reconstruct the common elements that united these architectural structures and have characterized the material life, bearing in mind the more the concept of relationship to architectural object isolated.

This results in the conviction that, today, you might experience the absence of an overall political project other than that of the forced cohabitation of military installations, cultural, scientific and that you can groped to write their future beyond, in addition to express the elements of a coherent project also made of transformation and change.

Keywords*: Arsenal, Silurificio, Island of Vignole, S. Giobbe, Botanical Garden, Galeazze, Gaggiandre, Corderie, Michele Sanmicheli, forts, castles, octagons, batteries, Whitehead, Navy, Idroscalo*

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1. WISDOM OF THE STATE: THE ARSENAL OF VENICE IN THE LAGOON PLANNING AND DEFENSE

It is above all the beginning of the Sixteenth century, in the context of the strategic urban and territorial transformations that the image of the *Serenissima* becomes a vehicle for a Wisdom of the State demonstrated by the number and prominence of the century achievements, driven primarily by political motives. A wisdom that has characterized the centuries-old political and military life, achieved through a strict and functional structure of the territorial government by the oligarchy that has approached, in administrative action, to achieve utopia formalized in the *Idea of Venice*: It is a civilization that has been expressed in a long period, anticipating much modern bureaucratic organization through the creation of Delegates *Magistrature* and the appointment of *Provveditori*, *Officiali*, *Savij* and *Governatori* for the most delicate areas of land management and public affairs. The political and administrative system of the Republic was able to ensure political stability for centuries thanks to its composition and structure that have created the myth: in the Sixteenth century, only a patrician at the end of his career he would be able to explain the complexity of the Venetian political machine necessary to ensure their internal balance and avoid adventurist forces with reversals of dominant positions.[1]

A different city-state from all the other and located at the center of a vast commercial empire with military connotations, made up of satellite towns both at sea and on the mainland: these last placed at the base of the expansion of the myth even on the most stable territorial bases necessary to create, with the optical of good governance, a wide protective band around the capital by the Great European military Powers.

But at the same time they are frustrated the ambitions of the State of the mainland, the Republic, closing in on itself, produces the most important urban and regional *renovatio* throughout its millenary history. The renewal is based essentially on the new *Forum Publicum* of St. Mark's square, incardinated on *sansoviniane* architectural hinge, it becomes a place of epiphany of power to start the new role assumed by the *Porta da mar*: the two columns of the protector Saints[2] are the true gateway urban that introducing the symbolic space of the square, and suggest that the privileged perspective axis, tangent the Ducal Palace and St. Mark's Basilica, it introduces into the Codussi's arch under the clock and from here, to the Rialto commercial heart. The Place of Minerva is interrelated to the Place of Mercury, ruled by another wisdom.

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[1] In order to avoid coups d'ětat or personal ambitions, even the behavior of the Doge was judged monthly by three patricians members of the Consiglio dei Dieci, the sovereign Venetian governing body.

[2] The Byzantine S. Todaro and the Christian S. Marco.

Another wisdom also characterizes the third pole of the Sixteenth-century urban triangulation, the Place of Vulcan, the city of art understood as *bonae artes*, location of the capabilities of to do the *Homo Faber*, to design and manufacture: the *Arsenale*, a strategic place of Venetian naval power, realized in the current area[3] from the first half of the Thirteenth century, as evidenced by documents of 1223-1224[4] and continuously expanded and reorganized,[5] in 1500 is configured as an exceptional feature of the town and for the role by dimensions.[6]

The *Arsenale Novissimo* is not only the place of the an *ante-litteram* industrial production, factory symptomatically already famous and prematurely described in admiration by Dante Alighieri[7], who compares him to a hellish place like smoky factory, among the most active in Europe «Quale nell'arzanà de' Viniziani/bolle l'inverno la tenace pece/a rimpalmare i legni lor non sani, […] chi fa suo legno nuovo e chi ristoppa/le coste a quel che più vïaggi fece»:[8] as it is crowded in the hellish pit, much like the *Arsenale* is crowded with sailors and calkers who take advantage of the winter break to repair the hulls. But it is also considered by the Senate of the Venetian Republic as a real machine intended «in bona parte la conservation del stato nostro si terrestre come marittimo».[9] Not only the consolidation tool of the Venetian State, but also for expansion and offense «uno apparato di acquistare i Regni, et le Provincie» as written by Daniele Barbaro,[10] in 1556, Patriarch of Aquileia, humanist and studious.

But the *Arsenale* preconized by Daniele Barbaro, location of the naval production, will be hidden from view of the most and, although the third cornerstone of urban renewal, without *Decor* as a factory: the state secrets should fall on productive activities that must remain unknown and only to a small area, that of the *Bucintoro* and deposits of the artillery, where they show *Venustas* and *Vis*, access is allowed to the illustrious guests. A place with no face

3 With the gradual dismantling of the small Arsenale di Terranova near S. Marco decommissioned in the early 1300s.

4 «Que sunt ex altera parte arsane versus Castellum» in Ennio Concina, L'Arsenale della Repubblica di Venezia, Milano, Electa 20063, p. 12.

5 Above all between 1303-1325 and after 1473.

6 Even today it is identified as one of the dimensionally significant areas of the city, with an area of about 320,000 square meters of which 90,000 of water, able to compete by extension with the tourist harbour of Tronchetto.

7 Who visited the Arsenale in 1312.

8 Dante Alighieri, La Divina Commedia, Inferno, Canto XXI, vv. 7-12, a cura di Natalino Sapegno, Firenze, La Nuova Italia 1993IX, pp. 236-237.

9 Manfredo Tafuri, «Sapienza di Stato» e «Atti Mancati»: Architettura e tecnica urbana nella Venezia del '500, in Architettura e Utopia nella Venezia del Cinquecento, Catalogo della mostra a cura di Lionello Puppi, Venezia Palazzo Ducale, luglio-ottobre 1980, Milano, Electa 1980, pp. 16-39.

10 Ibidem.

that manifests its magnificence only with the triumphant entry of the *Porta di Terra*, already present from the previous century,[11] but integrated, repeatedly, until 1571.



Figure 1.

The grandiose works of enlargement and monumentalization, implemented between the end of the Fifteenth century and the next, took shape in the «concentrazione di manifatture navali man mano organizzate […] nel più grande complesso produttivo preindustriale dell'età moderna»,[12] characterizing the Republic, especially between the fall of Constantinople and the victory of Lepanto, as a defense wall of Christianity: it is during this phase that are made extraordinary *Corderie* and with monumental triumphal doors, columns and ashlar stone of Istria, the theories of arches and trusses that were to confirm the role of Venice as the Queen of the seas.

A place of monumentalised work, undoubtedly strategic for the political fortunes of the Venetian State, which goes hand in hand with that *Idea* of Venice preconized and can only be explained in this context with a structure

[11] Made in 1460 under the Doge Pasquale Malipiero; the terrace in front of the allegorical statues dates from 1682, while the lions were sent by Morosini in 1687 after the victorious military campaign of the Peloponnese.

[12] Filippo Maria Paladini, Arsenale e Museo Storico Navale di Venezia. Mare, lavoro e uso pubblico della storia, Padova, Il Poligrafo 2008, p. 13.

completely surrounded by a high perimeter wall with battlements, only one capable foreclosure of the prying eyes of the military strategies. Intervention beginning in the first decades of the '500 as part of *Renovatio*, as witnessed by the perspective view of Venice engraved by Jacopo de' Barbari in 1500[13] in which the large factory is still very far from rigorous subsequent manufacturing organization.

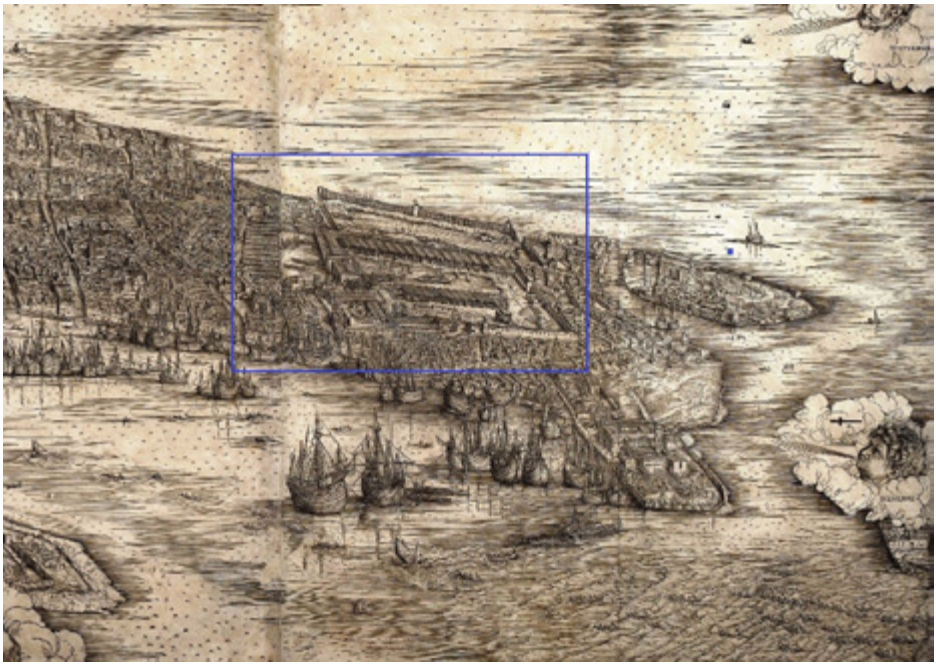


Figure 2.

It recognizes the entrance with triumphal arch and the drawbridge before the two crenellated towers, completed in 1574,[14] which will serve as a reference to the boundary wall still unrealized.

[13] Jacopo de' Barbari, VENETIE M.D., xylograph cm 132,72x277,50 in six sheets printed in 1500 by Anton Kolb, copy kept at Minneapolis Institute of Art, The John R. Van Derlip Fund (2010), da http://collections.artsmia.org/art/111219. It bears an inscription around the image of Mercurio, up: VENETIE. M.D. /MERCVRIVS PRECETERIS HVIC FAVSTE EMPORIIS ILLVSTRO; and a cartouche hanging from the trident of Nettuno, down: AEQVORA TVENS/PORTV. RESIDEO/HIC NEPTVNVS. The Collegio Notatorio granted on 30 October 1500 to the German printer Anton Kolb, active in the city, the privilege for four years to print and sell exclusively in the Serenissima territory the view of the city of Venice, in A.S.V., Collegio Notatorio, registro 15, c.28r.

[14] A year after the realization of the Gaggiandre, the two great water yards, covered by trusses of light above 23 meters straight on the paraments with arched arches supported by stone columns; they overlook the large internal basin and were built between 1568 and 1573 on a project attributed to Jacopo Sansovino: they testify to the constructive mastery of the Venetian carpenters for the ample light of the roofs and can be conceptually assimilated to a modern three-dimensional structure.

The interior of the docks is not yet well defined and has underground areas wider than the current, including the dock towards the *Galeazze* canal and the northern lagoon is not yet practicable. The fence is not crenellated and is discontinuous compared to the current with many houses facing the construction site areas, the docks are not connected together in an organic whole and are characterized by a large number of moorings covered by canopies: all this shows a disorganized creative casualness far from the image of efficiency typical of an industrial structure that will acquire in the following centuries when it will be a closed place in a city that is substantially without walls and which delegates the defensive physical limit to the lagoon.

The place, identified as the epicenter of science and naval-military technique, is transformed into a territorial level driving structure, not only urban, of the processes of economic development of the Veneto region, the *Stato di Terra* that was ratified in 1556 with the constitution of the new *Provveditorato sopra i Luoghi Inculti*.[15] A territorial consolidation that is opposed to the unstable *Stato da Mar* while maintaining as a pivotal balance the City, which has its strength in the *Arsenale*, a military institution at the top of the complex network of naval bases spread throughout the Veneto Sea: a reserve of warships always on alert, from the Adriatic to the eastern Mediterranean, for war emergencies.

At the same time when the Arsenal widens with the *Darsena Novissima* the Venetian Republic realizes the fragility of the lagoon territorial defenses, whose absence came from the awareness that the isolation given by the presence of water was a guarantee of invincibility. The latest testimony was the occupation of Chioggia by the Genoese fleet in 1379-80, which imposed the blocking of the canal directed to the basin of S. Marco and the construction of isolated towers on the neighboring islands, such as that of Poveglia.

The simplified map of the *Stato de' Porti di Venezia e di S. Erasmo* of 1410[16] testifies the first organic interventions on the port mouth of the Port of Venice, the most important and close to the Arsenal, which is defended by two castles, the tower of the *Castelvecchio*, on the tip of the *Lido*,[17] and *Castelnuovo*, on the opposing tongue of land that will generate the Island of Vignole: around this last bulwark, on the design of Michele Sanmicheli,[18] from 1543, the Forte di S. Andrea will be built. The imposing war machine, strong of forty cannons arranged on an arched front, will be completed fifteen years later becoming, as

[15] Tafuri, *Op. cit.*, p. 32.

[16] Described in the Drawing of B. Zendrini e Z. Zuliani del 1811 (A.S.Ve.)

[17] Already existing in 1350, as evidenced by a similar design referring to the same year of B. Zendrini e Z. Zuliani, 1811 (A.S.Ve.) and before the war with Genoa.

[18] He is also the author of a Report on the state of the lagoon fortifications sent to the Consiglio dei Dieci sent on 21 January 1535.

well as symbolic cornerstone[19] of the Venetian sea defense, landmark and true urban city gate[20] together with the nearby Fort of St. Nicolò.

The defensive program proposed by Sanmicheli also involved the other two port mouths of the lagoon, Malamocco and Chioggia, the latter already the object of hostile acts[21] that were realized with the construction, in 1384/85, of the *Castello della Lova*.[22] This intervention, prior to the Sanmichelian program, had already been added, in the Fifteenth century, to the construction of the sturdy square tower of *Punta della Dogana*,[23] now destroyed, in 1414, and the aforementioned *Do Castelli* of the Lido.

The architect's plan surpassed the proposal by *Antonio da Castello*, formulated in 1509,[24] to encircle the island *clodiense* with a walled ramparts[25] to the advantage of the construction of the Fort of *St. Felice*,[26] built in 1541 by Antonio Cappello and Michele Sanmicheli[27] who conferred, also in this case, the facies of the city gate on the lagoon façade. After the fortification of the upper lagoon entrances, S. Nicolò, and lower, Chioggia, in the following century the Senate approved, in concomitance of the war of Candia against the Turks, also that of the central entrance, Malamocco, with the construction in 1646[28] of the of the third entry into the Lagoon marked, as well as the fort of the Alberoni, from that of S. Pietro in Volta: these are bastion structures located at the beginning of the Malamocco canal, often used, even if farther from the city, as access during the sand clearing of the upper part of the Lido.

The Senate entrusts the *Provveditore alle Lagune e ai Lidi* the task of reorganizing the defensive system of the lagoon territory in a permanent manner: with the addition of octagons, batteries and *ridotti*[29] made especially between

19 In reality from the Forte of St. Andrea, so armed, no cannon was ever fired until the twilight of the Serenissima when on April 20, 1797, almost swan song and a few days before the capitulation to Napoleon, it was sunk in the harbor mouth the French vessel "Le Liberateur d'Italie" which had not respected the arrest order.

20 Designed on the model of the urban gates of Verona (1535-1557), with arched openings in rustic ashlar wall, as the main urban door, in 1571, there was the commemorative epigraph of the victory of Lepanto: NE QUID URBI NATURA OMNIUM MUNITISSIMAE DEESSET/ HAEC PROPUGNACULA DECEMVIRI POSUERE/ALOJSIO MOCENIGO PRINCIPE/ANNO MAGNAE NAVALIS VICTORIAE.

21 The aforementioned Genoese siege of the 1379/80.

22 Or of the Lupa.

23 Strategic point of confluence between the Canal Grande and the Canale della Giudecca.

24 In full crisis against the League of Cambrai.

25 Pietro Marchesi, Fortezze veneziane. 1508-1797, Milano, Rusconi 1984, p. 184.

26 Opposite to the fort with embankment of Brondolo

27 Marchesi, *Op. cit.*, p. 189.

28 Ibidem.

29 At the end of the interventions the system was integrated by the octagons of Poveglia, Campana, Alberoni, S. Pietro, Malamocco and Ca' Roman; the ridotti of S. Angelo della Polvere, St. Erasmo,

the 1600s and 1700s, located along the canals punctuated by the smaller islets of the Lagoon, the reticular system of the Lagoon defense is completed, integrated into the mainland with the fortified cities of Palmanova[30] and the terrestrial forts completed under the Napoleonic dominations, first, and Austrian, after, as the Forte Marghera and the Maximilian Tower of *St. Erasmo*: in this period many lagoon batteries are restructured and integrated. With the Kingdom of Italy the network thickens, especially in the mainland, with the strong placed at the crown of the Lagoon City.

There is no doubt that the heart of this vast system, since the Fifteenth century, was and remains the *Arsenale*, a place where the ambitions of the Serenissima were realized and where the connection with the fortresses of the State was established. The multisecular naval activity, organized inside the minor basins, before, and in the large docks, afterwards, remains substantially unchanged until 1810 when the production potential is further increased with the construction of three other dry docks, outside the wall enclosure but in the immediate vicinity, in front of the Certosa Island.

But the war machine of the *Arsenale Novissimo*, after the symbolic but ephemeral triumph of Lepanto, comes into crisis synchronously with the decline of the Serenissima. It is a story of continuous crises started in the Seventeenth century, aggravated in the following century and continued in the Nineteenth century, notwithstanding the modernization and the attempts to relaunch the production also implemented under the rule of Austria.

In the Nineteenth century the continuity of French and Austrian domination also concentrated on the *Arsenale* which was affected by systematic structural and technological redevelopment, with a not indifferent effect on the entire *Sestriere* of *Castello*, traditionally related to the productive structure: in the decade of domination Napoleon, 1805-1815, reinforced the role of the city in the control of the Adriatic, essentially in an anti-Hapsburg, and of the Mediterranean with profound transformations of the same architectural structure and an innovative location in the contradalchable and residential network; a «moderno sapere tecnico navale e idraulico»[31] was also introduced in the military manufactory, which substituted the artisanal knowledge imparted orally.

Testa di ponte di S. Erasmo e della punta di S. Erasmo, Malamocco di S. Filippo, Monte d'Oro, Cortellazzo, Cavallino, Tre Porti and Palada de S. Zulian; the internal batterie of S. Giorgio in Alga, S. Secondo, Lazzaretto, S. Francesco del Deserto, Fisolo, Poveglia, Campana, Trezze, Campalto, Tesséra, Carbonera, Buel de Lovo and Anconetta; the coastal batterie of S. Maria Elisabetta, Casa Bianca, Terre Perse, S. Leonardo, Rocchetta and S. Pietro.

30 To which are added the main fortified cities of the Veneto State already subject to interventions, such as Bergamo, Brescia, Verona, Vicenza, Padova e Treviso and the minors like Cittadella, Castelfranco etc.

31 Paladini, *Op. cit.*, p. 22.

But it was the longest Austrian domination, 1815-1866, to affect even more deeply with a wide campaign of restoration, enlargement and modernization of the structure and the surrounding areas, also converting religious and civilian *contermini* artifacts, with a view to a new maritime role conferred by the Empire on the Adriatic quadrant. The process stopped abruptly immediately after the brief revolutionary parenthesis of 1848 in which the eight thousand *arsenalotti* had a strategic role in the revolt anticipating the same Daniele Manin: the imperial reaction was obviously punitive right against the establishment with a strong downsizing of its role in the a more general and necessary re-elaboration of the maritime military strategy of the Lombardy-Veneto region and of the Adriatic itself which hinged the new military and arsenal axis on the cities of Trieste and Pola, interrupting any new initiative on the Venetian area.

The crisis persevered until the Unification of Italy with the stagnation of the activities both on the minor shipbuilding and on the greater *arsenalizia*: only after twenty years since the revolt, in 1867, in the Royal *Arsenale* the propeller corvette *Vettor Pisani* was launched, the first vessel for the Italian Navy, despite the common technological backwardness, in reality, to the whole new Kingdom in which the innovations of the industrial revolution had come late. So much so that in the accompanying report for the Naples International Exposition of 1871 the glorious past of the Arsenal was reduced to *archeologia industriale*.[32]

In the following decade, 1871-1881, the arsenalitic structure was reactivated by integrating several projects and creating two new large basins of *raddobbo* and new quaysides; the two docks, the *Nuova* and the *Novissima*, were unified, as they are presented today, and the uncovered areas that exceeded those covered were increased; the factory was motorized and machinery for steam maritime locomotion was introduced.[33] The difficulties in updating the workforce were real because by 1879 only «quattro piroscafi, […], un incrociatore ad elica a scafo di legno, un lancia-siluri, due avvisi e una torpediniera finalmente in ferro o acciaio. […] Grandi emozioni furono quindi destate nel 1885 dalla costruzione all'Arsenale di un incrociatore (non corazzato) come l'Amerigo Vespucci, a propulsione mista ma dotato di un imponente apparato motore di 3.340 CV».[34]

The decline of the *Arsenale*, hidden behind the hagiography of the myth of Venice, has an ephemeral revival in the last twenty years of the '800 with the attempt to relaunch the shipyards of the new Kingdom of Italy, operated with mixed public-private funding and the establishment of branches of foreign

[32] L'industria navale e le sue industrie attinenti l'Esposizione internazionale marittima di Napoli (1871). Relazione del professor Alberto Errea e del professor Gian Antonio Zanon delegati dal Municipio all'Esposizione, Venezia, G. Longo 1872, in Paladini, *Op. cit.*, p. 32n.

[33] Positive technical datum but that led to the closure of the Corderie, now useless, transformed into productive areas.

[34] Paladini, *Op. cit.*, p. 36.

multinationals: this is the phase that coincides with the establishment in 1887[35] of the *Schwarzkopf* Torpedo Factory and whose launch tests were carried out in the artificial canal of the nearby Island of Vignole; the test activity in the *Siluripedio* of the island continued until 1901, when the factory was closed and the hydrofoil test basin was transformed into a base for seaplanes.

Between 1906 and 1908 the production of torpedoes was transferred to the factory of S. Bartolomeo di La Spezia, already active for naval productions since 1880:[36] this broke the last hopes of recovery from a crisis not only productive but also economic and social extended to all the city, eliminating that role of social shock absorber. The last activities of the only Italian monumental arsenal were the realization, within the first decade of the Twentieth century, of five submarines of the small class *Glaucus,*[37] while the project of rebirth of the structure that should have happened with the construction of the new large battleship *San Marco* it vanished with the transfer of military activity to Castellammare, near Naples, highlighting all the limits, even dimensional, of the historical structure.

2. THE ARSENALE AS A TYPOLOGICAL *UNICUM*

The precise role of the architectural artefacts destined to the production of warships, in relation to the traces still existing today and necessary for a monumental and landscape recognizability in an extremely delicate context such as the Lagoon, confirm the uniqueness of the Venetian Arsenal within the architectural typology: in terms of size and organization it is a unique example in the world, in good condition until today, unlike the other great arsenals of the past such as the largely disappeared *Kondoskalion* of Constantinople, or the arsenals of Barcelona, Toulon and Chatham near London.

But the Venetian *Arsenale* is unique also for the particularity of the architecture, for the elegance of the structures, the rationality and the figurative parsimony of the imposing factories, in spite of the Nineteenth century devastations: the complex has never lost its morphological order, that «particolare equilibrio tra edifici e bacini maturato in quattro secoli sino alla metà del Cinquecento e da allora mai più messo in discussione».[38] The most significant expansions, which still today characterize the *Arsenale's* morphological structure, were built between 1866, after the annexation of Veneto to the Kingdom of

[35] Peter Hertner, Industria italiana degli armamenti a capitale straniero. Il silurificio Schwarzkopf di Venezia,1887-1901, in Venetica, n.8 luglio-dicembre 1987, Abano Terme, Francisci 1987, pp. 65-93.

[36] Benito Petrucci, WASS 133 anni di storia. Al servizio delle Marine del mondo: passione e tecnologie avanzate, Volume I (1875-1945), Wass Whitehead Sistemi Subacquei Finmeccanica, Roma, Ciuffa 2008, vol. I, p. 75.

[37] The five submarines made in Venice between 1903 and 1905 Glauco, Otaria, Narvalo, Squalo e Tricheco were the first example of series construction of these still experimental units.

[38] Paola Gennaro, L'architettura delle fabbriche dell'Arsenale, in L'Arsenale riordinato. Nuovi progetti per Venezia, catalogo a cura di P. Gennaro, Venezia, Arsenale 1987, pp. 13-28.



Figure 3.

Italy, and 1900, and can be clearly identified by comparing the lithographed map drawn up after 1824,[39] or the more simplified design of the same period,[40] with the current digital cartography. The interventions took the form of expansion, towards the north, of the operational area with the burial of the *Canale della Bria* and the nearby Jewish swamp to create, in 1875, the 1st new dry dock and, three years later, the 2nd new and larger basin.[41]

To the east, towards *S. Pietro di Castello*, will be added the *Giardino delle Vergini*, physically connected with the landfill of the *Rio della Guerra*; the three aquatic sheds in the *Darsena Novissima Grande* dock were buried in 1544 and the *Isolotto* was dismantled, which divided the aforementioned dock from the *Darsena Nuova*, also eliminating the whole series of sheds, to create the current large central basin in an attempt to convert production naval towards the new large steel boats. In this sense the map of the city, designed in 1857 by Giuseppe Habnit[42] and in which the structure of the complex with *Isolotto* in the center is clearly illustrated, is decisive.

39 Piano dell'Arsenale di Venezia e suoi contorni per servire alla di lui storia, Prem. Lit. Kier A.B. inc., Biblioteca Museo Correr, Venezia, Ms Cicogna 2823.3 02.

40 Drawing in pen on paper, Biblioteca Museo Correr, Venezia, Ms Cicogna 2823.3 01.

41 The nearby third dry dock, larger than the first two, will be built in 1914.

42 Pianta della Città di Venezia nuovamente disegnata pubblicata da Giuseppe Habnit Negoziante di Stampe, d'Oggetti di Belle Arti e di Cancelleria in Piazza S. Marco Procuratie Vecchie al Tiziano Vecellio N°102, 1857, Biblioteca Fondazione Scientifica Querini Stampalia, Venezia, Cart. III 25 B.

To build the headquarters of the new Arsenal Management were demolished the *Magazzini Generali* located south-west of the *Darsena Nuova*, while along the *Canale delle Galeazze*, to the north-west, a part of the *Squadratori* building was demolished to create the two new marble ports of the *Novissimetta*. Here other *fondamenta* will be built with new embankments and further modifications to the aforementioned buildings.

On the side towards the *Fondamenta Nuove*, to the north, the sixteen sheds facing the *Darsena Novissima* are shortened with the elimination of the view over the water and the construction of the *fondamenta*. Other architectural changes will affect the buildings on the eastern side of the complex, the fronts of the *Magazzini Marittimi* south of the *Darsena*, the building facing the internal road *Stradal Campagna*, always the *Galeazze* on the south and west sides and the artifact of the *Squadratori.*

At the end of the Nineteenth century the *Arsenale* was fully active in the construction of warships, employing, on the date of January 15, 1896,[43] at the Naval Construction Department 2753 workers and at the Artillery and Armaments Division 1144 employees with a total of 3897 dependents.

Further additions, but smaller, will be implemented in the first half of the 1900s, including the reinforced concrete bunkers of the Second World Conflict still visible today.

The substantial changes allow, however, to be able to identify even today the functional geometric matrix that generated the complex and which is identified in the elementary module, iterated, of the shipyard born from the practice of shipbuilding and expanded, modularly, with the increase dimensional of the ships. The original medieval module is organized on the dimensions of 46.00 meters in length, 16.50 meters in width and 7.00 meters in height.[44]

In the Sixteenth century, keeping the height unchanged, the length will extend up to 54.00 meters and the width to 18.70 meters: it should be kept in mind that the ships and galleys were being hoisted and equipped outside the arsenal fence to allow their maneuverability. In exceptional cases, as for *Gaggiandre* and *Galeazze*, you will reach larger sizes between 24.00 meters in width, 60.00 meters in length and 14.00 meters in height. From the module are separated the two specific artifacts of the *Corderie*, 317.00 meters long and punctuated by large columns in Istrian stone proportioned in Tuscan order, and that of *Squadratori*, along 140.00, the last great figurative effort, almost an illuminist project that attempts to recall the great historical past.

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[43] Cesare Augusto Levi, Navi da guerra costruite nell'Arsenale di Venezia dal 1664 al 1896, Venezia 1896, Presso l'autore pp. 182-183.

[44] Romano Chirivi L'Arsenale Veneziano – Un itinerario monumentale, in Romano Chirivi, Franco Gay, Maurizio Crovato, Guglielmo Zanelli (a cura) L'Arsenale dei Veneziani, Venezia, Filippi 1983, pp. 5-34.

It follows that the artefacts of the *Arsenale*, in their specificity, can not be assimilated to architectural types being devoid of both the fixity typical of the models and the figurative constancy; these are space devices able to meet two fundamental requirements, «la massima luce libera raggiungibile con capriata lignea e il minimo ingombro trasversale dei muri portanti»,[45] making it an exceptional example for the time.

3. THE PRODUCTION OF TORPEDOES IN VENICE

In spite of the centuries-old military and maritime experience of Venice, no productive structures were installed in the modern marine war methodology, which saw in the torpedoes a revolutionary novelty, still widely used today.

It should be remembered that the *Whitehead* of Fiume, since the 70s of the Nineteenth century, had the temporary world monopoly of this new and effective weapon with contracts with the main world military marines: in that decade the first tests with torpedoes carried out in Italy were made by the technicians of the *Arsenale* of Venice,[46] at that time still characterized by a specialized workforce of the highest level, a legacy of centuries of professionalism in the field.

The prototype torpedo that the Italian Navy received in 1873 from the *Whitehead* of Fiume[47] was assigned to the hybrid corvette with sail and engine *Ammiraglio Caracciolo*, which assumed the function of School Ship of Torpedo Boats to train operators specialized in the new weapon. At the same time, confirming the competence of the Venetians, the first torpedo workshop was set up at the *Arsenale*, placed under the direction of the Artillery Direction, directed by the captain of the vessel Gustavo Tilling, first true expert in underwater weapons of the Italian Navy.[48]

The arsenalist structure played a secondary and supporting role, firstly, in the assistance for the use of torpedoes purchased from the *Whitehead* of Fiume and, later, in the field of technical tests on the Island of *Vignole* on behalf of the competitor *Schwartzkopff* which, diversifying the production, made of phosphor bronze alloy torpedoes, stainless steel compared to those of *Whitehead* steel: this feature conditioned the Italian military choices that opted for the German product, however, conditioning production in Italy.

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45 Gennaro, *Op. cit.*, p. 16.

46 Hertner, *Op. cit.*, p. 66.

47 Petrucci, *Op. Cit.*, p. 74. Also not to be forgotten is the figure of the frigate captain Roberto Mazzinghi, a profound connoisseur of this weapon, to whom he dedicated several publications, including Note ed appunti sul siluro.

48 Ibidem.

Venice, therefore, at the express request of the Government for almost three decades, from 1887 to 1901, was a center for the production of torpedoes *Schwartzkopff* that realized, at its own expense in the face of important contracts already stipulated,[49] a factory in the area of *S. Giobbe*: the report to the shareholders of *Berliner Maschinenbau-Actien-Gesellschaft vormals L. Schwartzkopff* for the financial year 1886-1887, confirming the important contract acquired, communicated that the company had already «iniziato a costruire a nostre spese degli stabilimenti a Venezia»[50] at that time strategic Italian maritime city, still relevant in a Kingdom linked to Austria and Germany by the Triple Alliance Treaty.[51]

On May 3, 1887, in the presence of the King and Queen of Italy, the Prime Minister Francesco Crispi, the Minister of the Navy Benedetto Brin and other authorities,[52] the foundation stone was laid for the new *Silurificio* in the ex-garden area botanist of *S. Giobbe*, in *Cannaregio*, near the railway station. The factory was inaugurated on December 15, 1888, immediately starting a large-scale production necessary to avoid the dependence of Italy from abroad of strategic supplies such as military.

The area of the former *Orto Botanico*, established under the Napoleonic dominion[53] as a support to the courses of Botany and Agriculture of the first non-confessional high schools, was created by the chemist Francesco Duprè in the vineyard of the *Minori Osservanti Francescani di S. Giobbe*, suppressed in 1806 and from 1810 the seat of the *Imperial Regio Liceo Convitto di S. Caterina*:[54] soon, thanks to the work of the Bavarian gardener Giuseppe Ruchinger, it became one of the most important in Italy[55] for rare species and exotic plants cultivated[56] here and unobtainable in others national viridials. Symptomatic is the precise description of the botanical garden made by Ruchinger[57] in 1847,

[49] There was already a contract of 4.4 million marks, equal to about 5.5 million italian lire to build torpedoes in Venice by 1893, a sum that, today revalued, is equal to about 23 million euro.

[50] Hertner, *Op. cit.*, p. 65.

[51] Stipulated in Vienna on 20 May 1882 and by virtue of which the German company Schwartzkopff had been supplying torpedoes to the Italian Navy for some time.

[52] Including the Chairman of the Supervisory Board, Conrad, and the General Manager Kaselowsky, son-in-law of L. Schwartzkopff.

[53] By decree of March 14, 1807, in Renato Vecchiato, Gli speziali a Venezia. Pagine di storia, Venezia, Mazzanti Libri 2013, p. 84.

[54] Giuseppe Maria Ruchinger, Cenni storici dell'Imp. Regio Orto Botanico in Venezia e catalogo delle piante in esso coltivate, Venezia nell'I.R. Priv. Stabilimento Antonelli, 1847, p. V.

[55] Covering an area of 18,672 square meters including buildings it was equipped with hot and warm greenhouses and had a small grassy hill at the center made with the ruins of the demolished monastery from which you could see the Lagoon and the Colli Euganei, in Ruchinger, *Op. Cit.*, p. XII. The text describes with great precision the original structure of the Botanical Garden, which today is unrecognizable.

[56] From the original 500 cultivated species in 1818, more than five thousand of 1847 were reached.

[57] Ruchinger, *Op. Cit.*, pp. X-XIII.

the only memory, unfortunately not visual, before its destruction occurred the following year.

Its end coincided with the Austrian bombing carried out by the mainland during the siege against the Republic of *S. Marco*[58] and lasted 24 days with an average of one thousand artillery shots a day: finding the area in the position closest to the lagoon, it suffered irreparable damage and the progressive abandonment of unsustainable costs until it was transformed, in 1887, into sediments for the *Silurificio*. Work began on March 26, 1887 with «la vanga e l'accetta [che] sbarbicavano piante, tagliavano alberi, distruggevano la Natura viva per fondare in suo luogo una officina di stromenti di guerra. […] Venezia col *Silurificio* ha perduto il suo *Orto Botanico*, che forse poteva essere conservato, anche senza allontanare da se quello stabilimento».[59]

The importance of the site is confirmed by the surviving architectural vestiges coinciding essentially with the Fourteenth-century church of *S. Giobbe Profeta*[60] and a single built wing of one of the two original cloisters to which some factories of the *Silurificio* were juxtaposed.[61] The church was enlarged under the Doge Cristoforo Moro and completed with the magnificent lunette portal made by Pier Lombardo.[62]

The structural organization of the religious complex is summarily described in the map[63] drawn after 1464, which identifies the church and the hospice in a simplified facies and with much of the area still occupied by water. The *Veduta di Venezia* engraved in 1500 by Jacopo de' Barbari describes the area of *S. Giobbe* clearly delineating both the architectural complex and the gardens overlooking the lagoon at the time and fenced by wooden palisades.

The map of the Napoleonic Cadastre,[64] drawn between 1807 and 1813, describes the complex of *S. Giobbe* still in its entirety with the church buildings,

58 Promoted as an attempt to free itself from the Austrian domination by Daniele Manin who was its president from 1848 to 1849.

59 Bartolomeo Cecchetti, A ricordo dell'Orto Botanico di Venezia, in Archivio Veneto, T. XXXIV, p. I – 1887, Venezia 1887, pp. 1-7.

60 Built in 1380 by Giovanni Contarini originally S. Agiopo, protector of silk merchants, alongside the homonymous hospice built two years earlier.

61 After the factory closed, the area was sold to S.A.D.E. Società Adriatica Di Elettricità founded in 1905 by the Venetian count Giuseppe Volpi di Misurata, sold in 1962 to E.N.E.L. Ente Nazionale Energia Elettrica; today it is owned by the real estate company San Giobbe S.r.l. which acquired it in 2007 from the electricity company to build a residential complex on an area of 25 thousand square meters of which 10 thousand for urban park.

62 Sculptor and architect of Ticinese origin, author, with his sons Tullio and Antonio, of the Venetian Renaissance linguistic renewal.

63 Riportata in Francesca Romana Liguori, Il complesso di San Giobbe profeta e San Bernardino e l'Orto Botanico di Venezia, in Bollettino d'Arte, s. 7, n. 8 (2010), Roma, IPZS 2010, pp. 45-76.

64 The rigid subdivision of the Historical Catasti in Napoleonico (1807-1813), Austriaco (1846-1852) and Austro-Italian (1852-1866) does not make much sense because, in reality, it is a unique process of drawing up and updating the maps developed from the early Nineteenth century until 1938. The

the two cloisters and the *addenda* located on the canal and towards the interior of the area. From this period there is a detailed metric survey drawing[65] of the two floors of the structure drawn up in 1810 by the *Ufficio dell'Ingegnere alle Fabbriche del Demanio e alla Cassa di Ammortizzazione* Alessandro Ganassa, with modifications by Giuseppe Roncan, which precisely identifies the destination and size of individual environments. In the drawing drawn up by the Belluno painter Pietro Paoletti,[66] active in Venice in the first quarter of the 19th century, the area of the Botanical Garden of *S. Giobbe*, still devoid of vegetation and bordered, in the lower part of the west, by the *Rio di S. Giobbe*, is described , to the north by the *Cannaregio* canal, to the east by the wall and to the south by the *Rio della Crea* which, currently, borders the railway area: the *Campo di S. Giobbe* is clearly identified with the nave of the church jutting out to delimit the first cloister, now partly surviving; beyond the construction parallel to the nave we can recognize the second cloister, now disappeared, and a single building almost in the middle of the free area destined to a botanical garden.

In the drawing it is not yet visible the wall diaphragm that, joining the factory parallel to the nave with the *Rio di S. Giobbe*, will house the ashlar portal of access to the Garden: the drawing, though not exhaustive, records the situation of the complex after the 1821, the year in which the demolition works of the unsafe factories started in April of the same year, coinciding with some of the oldest parts. This is the result of the more summary drawing, drawn up again in 1821 by Giuseppe Roncan, active in the *Ufficio dell'Ingegnere alle Fabbriche del Demanio e alla Cassa di Ammortizzazione*:[67] it describes the area now modified for the establishment of the botanical garden, with according to the cloister and the building facing the *Rio di S. Giobbe* already destined for demolition to be united to the «Orto Bottanico».

The interventions of the Botanical Garden begin immediately, so much so that a plan[68] of the same 1821 clearly identifies the buildings saved and outlines the *Giardino Bottanico*, included between the lagoon and the *Rio della Crea* and

map of the Catasto Napoleonico F° 00005 S. Giobbe (1807-1813) reported is kept in original at the State Archives of Venice and can be consulted via the web at the link: http://geocataloghi.iuav.it/cat_prod_nap/gestione_jpg.php?elem_jpg=000005.jpg.

65 State Archives of Venice, dall'Ufficio dell'Ingegnere alle Fabbriche del Demanio e alla Cassa di Ammortizzazione (1815-1847), Primo blocco, B. 70, fasc. 240 bis – Alessandro Ganassa con modifiche di Giuseppe Roncan, in Liguori, *Op. cit.*, p. 59.

66 Belluno 1801-1847, active painter in Venezia, Milano, Padova (Caffè Pedrocchi), Roma (villa Torlonia e Vaticano) e Montecassino.

67 State Archives of Venice, Ufficio dell'Ingegnere alle Fabbriche del Demanio e alla Cassa di Ammortizzazione (1815-1847), Primo blocco, B. 70, fasc. 240 bis - Giuseppe Roncan: Pianta dell'Orto botanico dopo la demolizione delle fabbriche del Convento (1821), in Liguori, *Op. cit.*, p. 65.

68 Redatta da Gian Battista Paganuzzi, Iconografia delle trenta parrocchie di Venezia, Venezia 1821, Tav. XVIII.

Rio di S. Giobbe, with precision the design of a rigidly partitioned Italian garden and the few surviving religious buildings: the Ruchinger project, intended for amateurs of the green, is divided into main and secondary avenues that are borrowed from the rows of tall trees and espaliers of hedges; there is a *Canal Salso*, a *fossa* desinated to the cultivation of the lagoon alchemis, and a grassy hill built using the ruins of the convent not awarded to the public auction. Do not miss the classic cave, hosting a stone effigy of *S. Giobbe*, and a second lookout towards the *Rio della Crea* and the gardens of the *Convento di S. Lucia*, not yet demolished to make room, a few years later, at the railway station. The plan is, in any case, the only existing graphic testimony of the botanical garden's functional organization[69] because the *Folio* number 003252 of the Austrian Land Registry,[70] drawn up in a period between 1826 and 1852, describes the area of the garden free with the simple written *Orto Botanico* and no buildings other than religious, not having censorship relevance. The same representation is shown in the map of Venice published by the *Congregazione Municipale* in 1847: the area of *S. Giobbe* is not described beyond the words *Orto Botanico.*

The access to the botanical garden was guaranteed by a neoclassical curtained portal, subjected to a simplified trabeation, with rosettes at the ends, supported by pillars with rustic ashlar on plinths that close the opening at the sides, still *in situ* today; at the State Archives of Venice there is the design of the *Nuovo ingresso all'I.R. Orto Botanico a S. Giobbe*, drawn up in 1854 and attached to the technical testing of 1858,[71] characterized by a different configuration: here the portal is architraved, with a flat lintel marked by a leonine epithome, and the rustic-shaped pilasters come to the ground; on the trabeation there is a disk *acroterio* joined with volutes.

The situation reported by the map of the Austro-Italian Cadastre[72] is quite different, which corresponds to a transition period that ends in 1886 with the promulgation of the law of *Messedaglia*:[73] the graphic relief of the terrain dates back to the end of the 80s of the Nineteenth century because of the vegetable garden botanical has now disappeared and the area already presents the works of the *Silurificio* with reference to constructions partly existing even today.

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69 Not detailed because described in the publication of the Paganuzzi of 1821 having other purposes.

70 The map of the Catasto Austriaco F° 003252 S. Giobbe (1846-1852) reported is kept in original at the State Archives of Venice and can be consulted via the web at the link: http://geocataloghi.iuav.it/cat_prod_aus/gestione_jpg.php?elem_jpg=003252.jpg.

71 State Archives of Venice, Genio Civile, B. 786, fasc. 17f, Tipo dimostrante il Nuovo ingresso all'I.R. Orto Botanico a S. Giobbe Allegato al Collaudo (1858), in Liguori, *Op. cit.,* p. 66.

72 The map of the Catasto Austro-Italiano F° 008643 S. Giobbe (1852-1866) reported is kept in original at the State Archives of Venice and can be consulted via the web at the link: http://geocataloghi.iuav.it/cat_prod_ita/gestione_jpg.php?tnerlem_jpg=008643.jpg.

73 Approved on March 18, 1886, reorganized the land tax, surpassing the stable census and leading to the new Catasto.



Figure 4.



Figure 5.

Comparing the map with the aerofotogrammetric,[74] much clearer than satellite zenithal photography because it is devoid of vegetation, we can date back to that period the two industrial buildings still existing today on the edge of the *Rio della Crea*, below to the right; there is also a large building located on the left side of the area along the *Rio di S. Giobbe* which is enlarged towards the church in the aero-photogrammetric; the other building located at the center of the original botanical garden is, instead, partly demolished in the current situation.

The aerial photography of the *Silurificio*[75] area is of help: the original project of the *Silurificio Schwartzkopff* of 1887 is not easy to find and the map of the Austro-Italian Cadastre is the one closest to the original situation of the factory.



Figure 6.

A reminder of the original structures is the *Memoria sul silurificio di Venezia*[76] written by the director of the *Opificio* Rosellini in September 1898, three years after its closure: the factory occupied besides the original sedime of the Botanical Garden (16,500 square meters) on to which 4,000 square meters of buildings insisted, also a vast contiguous land of 8,200 square meters where the

[74] Foglio 127161_1 consulted via the web at the link: http://mapserver.iuav.it/website/dbgt/dbgt.html.

[75] visible on www.googleearth.com.

[76] Hertner, *Op. cit.*, Appendice n. 3, pp. 90-93.

executive offices and the managers' quarters were built. From the planimetry, exposed to the Exposition of Turin, attached to the original *Memoria*[77] was the presence of «3 vasti, solidissimi fabbricati isolati, ciascuno servito da appositi motrici, nei quali si trovano la Fonderia (ca. 1600 mq.) la Fucina coi magli a vapore (ca. 400 mq.) e la Torneria (ca. 2000 mq.) con aggiustatura e montatura».[78] It is practically the situation illustrated faithfully in the map of the Austro-Italian Cadastre and recognizable in the aerial view[79] that identifies, far better than any photograph, the three buildings of the original *Silurificio*: in the lower right corner the shed on the *Rio della Crea*, made of *terracotta* bricks without plaster, with centinate openings and a raised central body; on the left the other building, morphologically coeval, today incorporated into a building of the second half of the 20th century; in the center, behind the trees, the tripartite shed, always in bricks.

At the end of 1888 a member of the Ministry of the Navy visited the workshops of S. Giobbe describing them as follows: «Il Silurificio Schwartzkopff […] occupa uno spazio di terreno abbastanza grande, piuttosto isolato, che confina con due canali, ed è prossimo alla stazione della ferrovia. Gli edifizi ad uso di officine costruiti dalla Ditta, sono costituiti da un pianterreno e un primo piano. […] L'officina più importante e la sola finita allorché visitai lo stabilimento, è quella congegnatori. Essa è ben fornita di macchine utensili tutte provenienti dalla Germania, in generale piuttosto piccole, salvo poche, dei migliori tipi noti. […] L'officina forge è discreta e non ultimata, contiene 5 fucine, sei piccoli magli. La fonderia era in corso, aveva un solo *cubilot* e mancava ancora di forni a crogiuolo e forni a riverbero per bronzo, è munita di grue che possono sollevare sino a 15 tonn.».[80]

The structure was completed by the middle of the following year, occupying at the beginning 76 workers then going to 200 in the period of maximum production. From the Report to shareholders of *Berliner MAGv L. Schwartzkopff* for the financial year 1889/90, it is an evident appreciation for the Venetian branch of the company that «ha operato in modo decisamente soddisfacente. Sono state superate le difficoltà comportate dall'addestramento di nuovo personale straniero ancora inesperto nel nostro ramo specialistico;[81] gli operai italiani si sono rivelati abili e capaci al punto tale che è stato possibile richiamare gli operai tedeschi inviati a Venezia come istruttori. […] Oltre ad alcuni cannoni, lavori di fusione ed altri piccoli lavori, Venezia ha fornito 100 siluri…».[82]

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77 In Hertner's essay the Memoria is not attached but is kept in Rome at the Central State Archives, Marina Militare, Direzione Generale d'Artiglieria ed Armamenti, 11a Divisione: Armi subacquee e materiale elettrico, pacco 154.

78 Hertner, *Op. cit.*, p. 91.

79 By Google earth®

80 Hertner, *Op. cit.*, p. 67.

81 Most likely they were not specialized workers like Arsenalotti.

82 Hertner, *Op. cit.*, p. 68.

Among the torpedoes produced in Venice, mention should be made of the *Siluro* type B57, now today exposed at the *Museo Tecnico Navale de La Spezia*,[83] *Salone Armi Subacquee,* built in the *Silurificio Schwartzkopff* of Venice in 1887: has the diameter of 356 mm and length of 4.620 mm, weight of the bursting charge in Kg. 57 and propulsion with reciprocating engine with compressed air pistons; the offensive speed/distance was 26 – 28 knots/800 meters.



Figure 7.

It was the second type of torpedo purchased by the Italian Navy in 645 units made at the factory's Venetian headquarters. The weapons were intended for use on ships of the type *Italia*, *Etna*, *Calabria* and *Iride.*

Symptomatic is the vicissitude, punctually described in the cited essay by Peter Hertner, of the problems arisen, after only a few years, on the quality of the torpedoes produced in Venice that led to a decline in orders from the Italian Navy with consequent losses in the turnover of the company for the year 1897/98. The decline in orders was due to the «non sempre eccellente qualità dei prodotti del Silurificio di Venezia»: as early as August 1893, the captain of the frigate Vialardi, sent by the Ministry of the Navy to the company's headquarters in Kiel, reports the unsatisfactory result of the tests carried out on the new torpedoes also due to the «non voler spendere sugli esperimenti, e l'avidità del molto guadagno [che] li porta a screditare anche il materiale, prova ne siano le costruzioni a S. Giobbe, dove da qualche tempo i serbatoi, sebbene rispondino alle condizioni di accettazione non sono più come quelli di una volta».[84] The military attaché also registers the surprise of the general manager of the company for the decline to the minimum terms of the orders obtained, now, only minimally from the Italian Navy and «marine di 3° o 4° ordine, quali la Norvegese, la Olandese»: adding, in its report, the qualitative appreciation for the new torpedoes produced by the *Whitehead* of Fiume.

It is the early beginning of the end of the Venetian factory which, in the same year, already leaks into the results of the Marine Ministry's Torpedoing

[83] I thank the Director of the Museum, Captain of Vascello Roberto G. Palì, for the documentation provided.

[84] Hertner, *Op. cit.*, p. 68.

Commission, which must point out the continuous difficulties in testing new production torpedoes: in reality these did not have anything innovative, but there were slight improvements to the first torpedo produced in Venice, the aforementioned B57, absolutely not comparable with the new torpedoes made in Fiume.

Until 1889 the production of *S. Giobbe* fluctuates without a precise program supported by orders now quantitatively distant from those of the beginning,[85] so that part of the staff, providing for the dismantling of the plant, was transferred to the Arsenal of Taranto. Even the choice of the Berlin General Management to entrust the conduction of the factory to former Italian naval officers did not reverse the trend and even the new torpedo B90,[86] despite repeated tests, did not seem to satisfy the reliability demands of an extremely strategic product in case of conflict. On the one hand, the lack of investment in research and innovation, on the other hand the ever smaller margins imposed by the Italian Navy on the purchase of torpedoes, reported by the director of the *Opificio* Captain Rosellini,[87] author of the aforementioned *Memoria sul silurificio di Venezia*, produce a sharp decline of turnover and heavy liabilities[88] that lead to the definitive closure of the company, despite the political pressure of the Venetian deputies on the Italian government.

The report to the shareholders of *Berliner MAGv L. Schwartzkopff* of the year 1900/1901 is symptomatic: «dopo essere giunti alla convinzione che è impossibile sperare in una sufficiente attività nei prossimi tempi, nel gennaio di quest'anno [1901] abbiamo sospeso l'attività nel nostro stabilimento di Venezia ed abbiamo deciso la liquidazione».[89]

Decisive for the closure of the opificio were the innovations introduced by the competing company *Whitehead* of Fiume that were appreciated by the technicians of the Italian Navy, overcoming the advantages of the first German bronze torpedoes: the German naval attaché in Rome confirmed in its reports that «l'arma sottomarina delle navi e imbarcazioni è il siluro Whitehead. I siluri sono acquistati, ora, solo dalla Whitehead».[90]

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[85] The production average ranged from 54 to 60 annual torpedoes of the new 450 mm model, with a workforce of only 120 workers.

[86] Produced in 86 copies.

[87] Hertner, *Op. cit.*, p. 71.

[88] The liabilities of the fiscal year 1897/98, not recorded in the financial statements, were closed with reserves of all the companies of the group such as those of the following financial years from 1898 to 1901 which soon passed from -2,000 German marks to - 72,000 German marks, in Hertner, *Op. cit.*, Appendice n. 2, p. 89.

[89] Hertner, *Op. cit.*, p. 72.

[90] Ibidem. The main innovations concerned the increase in the volume of the tank, still in steel but tinned, and its loading pressure, indispensable for the increasing needs of speed increase and route.

4. THE SILURIPEDIO OF THE *VIGNOLE* ISLAND

The monumental testimonies of the Arsenale remain of the historic maritime and military activity of the *Serenissima*, today still awaiting a destination that is truly consistent with the size and the morphology of the structure. Of the architectural evidence of the short season linked to the construction of torpedoes in Venice as almost nothing remains, with the exception of the three artifacts in serious degradation, located in a strategic area for the city and waiting to redefine its destiny: this short season, however, remains a testimony of great landscape that can not fail to attract the interest of those who care about the fate of the Lagoon, the *Siluripedio*/*Idroscalo* of the Island of *Vignole*.

The large and regular geographic cut along 800 meters is unique in the labyrinthine and organic structuring of the great environmental ecosystem[91] that has as its pendant only the modern piers of the Tronchetto marina, an artificial element forcibly added in 1960 to the western sector of the city; the *Idroscalo*, instead, is a regular cut in a largely existing island and compares its geometric rigor with the irregularity of the island edges.

The role, within the production of torpedoes, of the functional trinomial *Fabbrica di S. Giobbe*/ *Arsenale*/*Isola delle Vignole* summarizes and anticipates a concrete interaction between private industrial capital and public institutions related to a synergy that has produced great results: if on one side the private industry invested[92] to create productive products, on the other the Venetian Municipalities and the Navy provided advice and state-owned areas of support. Only in this perspective can one understand a great territorial transformation like that of the realization of the *Siluripedio*[93] on the Island of Vignole, a sparsely inhabited area, very close to the Arsenale and connected to S. Giobbe by the *Fondamenta Nuove* canal.

The area was not chosen by chance but it is obviously the result of pondered decisions, inheritance of that Wisdom of the State that had distinguished the long history of the Republic: that of the Vignole Island has always been considered as an area with a military vocation for the strategic position of main access to the basin of S. Marco, defended by the first half of the 1500s by the two Castles of *S. Andrea* and *S. Nicolò del Lido*.

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91 Consisting of canali, ghebbi, velme and barene.

92 The nefarious outcomes of public industrial production are known, tragically bankrupt especially in Italy due to political interference.

93 With a length of about 800 meters, a width of 50 meters and a depth of 8 meters, it is also suitable for the testing of large B90 torpedoes calibrated for a 600 meter stroke against floating targets placed just before the end of the canal.

The close and privileged relationship between the Arsenale and the Vignole is already confirmed by the map drawn by Andrea Fisaro in 1570,[94] which depicts the northern embattled wall circuit of LARSENAL [with the number 23] up to the *Rio della Tana*, with the direct entrance through a new channel [CANAL TARADO FIN QUI] in the wide *Canale dei Marani*: this channel is intercepted by the prolongation of the aforementioned canal that enters directly into the *Canale delle Vignole* on which the *Castel Novo di S. Andrea* faces. So a direct link between the Arsenal and the Island has always been in the strategic programs of the Republic and it becomes natural the settlement of the late '800 of a *Siluripedio* to sanction and confirm the close link.

The territorial construction was consolidated also in the following century when the *PORTO DI VENETIA*, always closed by the *CASTEL NOVO* and the *FORTEZZA VECHIA* as you can see in the map of 1676, is reorganized by connecting the Island of Vignole to the Fort of S. Andrea with the *ARZERE DELLA GARZINA* which becomes an ordering element in an area subject to strong hydrodynamic actions. In all subsequent maps the Fort is always connected to the aforementioned embankment that transforms it from the original insular element into the peninsular.[95]

For the hydrodynamic action of marine and lagoonal currents, the embankment will be buried by the *barene*, becoming the area for the viticulture of two important families of the Venetian patriciate, the Marcello and the Diedo. The archive map[96] of the Eighteenth century describes very clearly the expansion of the Island of Vignole from the *Arzere della Garzina* onwards: the embankment has now extended to the *Cavana fatta a discaricar Burchielle* that identifies the boundaries of the *VIGNA DA CA' MARCELLO* together with the *ghebbo* that *Serve discaricar Burchielle*, located near the Port of S. Erasmo; at the entrance of the access channel to the *cavana*, which borders the borders of the *Vigna da Ca' Diedo*, the Sixteenth century *CASTEL NOVO* by Michele Sanmicheli is clearly present with an axonometric representation.

A determination of the configuration of the Island and the consistency of the assets affected by the defensive role can be found in the documents of the Austrian Land Registry of 1846, conserved at the State Archives of Venice: on p. 30, of the Register[97] among the assets excluded from the outside there are, obviously, strategic military installations including the *Fort di S. Erasmo*, various forts and, to the letter *G*, the *Forte delle Vignole* which has a surface of

[94] Randomly drawn a year before the Victory of Lepanto.

[95] Always maintaining the narrow water defense defensive moat still present today.

[96] State Archives of Venice, Genio civile I s ds 24.

[97] State Archives of Venice, Catasto dei Terreni e Fabbricati del suddetto Comune Censuario di S. Erasmo con Vignole approvato dall'I.R. Giunta del Censimento con Decreto 7 gennaio 1486. Provincia di Venezia, Distretto di Venezia, Comune Ammnistrativo di Murano, Comune Censuario di S. Erasmo con Vignole, A.S.Ve, Censo Stabile Attivato (1846-1929), Registro n. 795, p. 30.

pertiche 22,70.[98] On pages 31 and 37 relating to the year 1852, at letter *E: Laguna* is present, without changes in consistency, the «casa ad uso della Guardia di Finanza costrutta di nuovo nella spianata del forte» of the surface of *pertiche* 00.20. It is the barracks of the *Guardia di Finanza* that is cited as a topographical reference in the following two documents reported here. With the same coldness of accounting are listed, in the land registry updates, all the changes made to the aforementioned assets until the year 1929.

The territorial developments that have affected, among other things, the Island of *Vignole* are proven by the *Carta Topografica della Laguna di Venezia* of 1847[99] engraved by G.B. Garlato: near the *Porto di Lido* the *argine della Garzina* has been greatly expanded to house the batteries that have, in the head, the Fort of St. Andrew, strangely connected with a short isthmus to the Island of *Certosa*. This situation is roughly identical to that described in the *Idrografia* drawn by the engineer Giuseppe Muller in 1874 attached to the *Progetto di regolarizzazione del porto di Lido* of the engineers Matì and Contin.[100] Of greater interest, and much more faithful, is the map of Estuario Veneto da Venezia a Chioggia,[101] drawn up in 1886 under the direction of Captain of Vascello Gian Battista Magnaghi and published in Genoa 2 years later: it is a very precise nautical chart, which reports the isometric seabeds of the navigable canals, in which the *Siluripedio delle Vignole* is described for the first time; the long and regular canal, with a constant depth of 7.40 meters, is recently built and coeval with the construction of the *Schwartzkopff Silurificio di S. Giobbe*. In addition to the fort of S. Andrea, the barrack of the *Guardia di Finanza* cited below and, in the northern sector, a powder magazine; another powder magazine is hosted on the nearby Island of *Certosa*.

The presence of a torpedo repair workshop is mentioned in the description of the same area prepared for the geodetic operations fundamental for the relief of the city and the lagoon of Venice, carried out in the first decade of the 20th century, when the Island of *Vignole* is used as telemetry strongpoint; the description made by the technicians is symptomatic: «Il luogo scelto per la misura della base appartiene ad una isola contigua a quella della Certosa ed è precisamente l'argine gettato fra la Caserma della Guardia di Finanza, di rimpetto al castello di S. Andrea, e l'officina di riparazione dei siluri in prossimità delle Vig-

[98] Equal to about 2,371,40 square meters.

[99] Carta Topografica della Laguna di Venezia e del territorio conterminante fino a 37 chilometri di distanza dalla città con cenni descrittivi del gran ponte sulla Laguna, 1847, in basso: G.B. Garlato inc. Venezia Prem. Lit. G. Kier, Biblioteca Fondazione Scientifica Querini Stampalia, Venezia, Cart. III 25 B.

[100] Tommaso Matì – Antonio Contin, Relazione sulla regolarizzazione del porto di Lido, Venezia, Antonelli 1874, tav. I.

[101] Estuario Veneto da Venezia a Chioggia, rilievi eseguiti sotto la direzione del Capitano di Vascello G.B. Magnaghi Comandante il R. Piroscafo Washington, scala 1:30.000, 1886, pubblicata a Genova nel Settembre 1888 dall'Ufficio Idrografico sotto la direzione del Capitano di Vascello G.B. Magnaghi e venduta da Ulrico Hoepli, Milano, Collezione Privata.

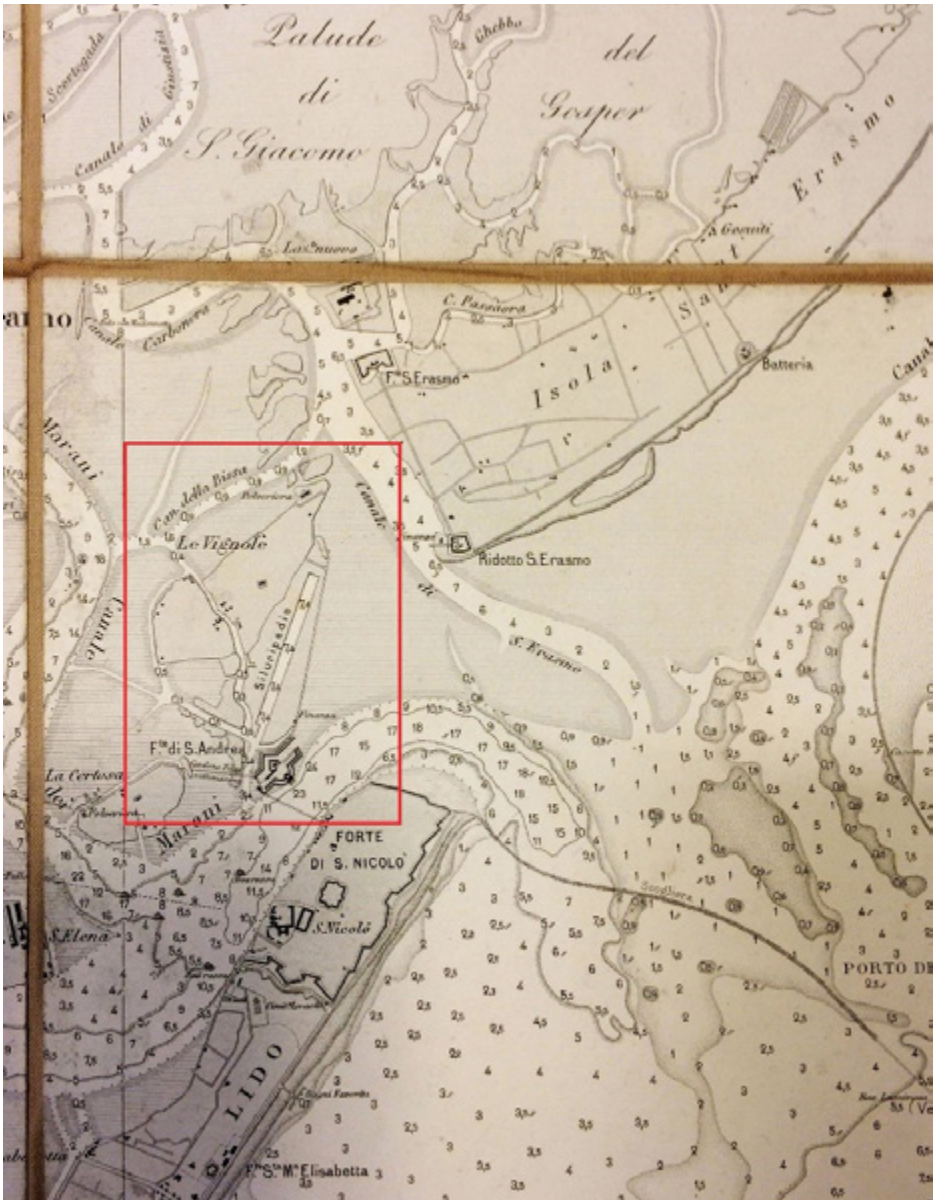


Figure 8.

nole. L'argine menzionato assume uno sviluppo quasi rettilineo nel senso del meridiano fra la laguna, ad Est, ed il canale appositamente scavato per il lancio dei siluri, ad Ovest, ed è quindi, in sostanza, quanto di meglio potevasi desiderare per lo scopo che si vuole conseguire».[102]

[102] Giovanni Piero Magrini, Luigi De Marchi, Tullio Gnesotto, (a cura) Operazioni geodetiche fondamentali per il rilievo della città e laguna di Venezia, in Ricerche Lagunari, n. 11, Reale Istituto Veneto di Scienze Lettere Arti, Venezia, Officine Grafiche Ferrari, 1908, p. 9.

This geographical reconnaissance will be fundamental for the subsequent arrangement of the Port of *Lido* designed in 1905 by Eng. Erminio Cucchini, of the *Genio Civile di Venezia*, who in his publication[103] illustrates the situation and the evolution of the main lagoon port: the first hydrography of 1882 shows a simple connection between the northern sector of the Island of *Vignole* and the *Forte di S. Andrea*, the *argine della Garzina*, which in the subsequent map of 1887 has already been enlarged for the transformation into *Siluripedio*. In the other hydrographic maps of the years 1892, 1898 and 1900 the situation of the *Vignole* remains substantially unchanged with changes only to the depth of the access channels to the lagoon.



Figure 9.

It is known that after the closure of the Schwartzkopff factory, the canal was redirected to *Idroscalo* for the seaplanes of the Italian Air Force and, therefore, based on the *Lagunari di S. Marco*[104] that still today use the area for the storage of dinghies and amphibious landing craft.[105]

The long basin of the *Vignole* Island, after its use as a *Siluripedio* and the transformation into an *Idroscalo* for seaplane was still used for the technical testing of war weapons, confirming the role played by the staff of the *Arsenale* in the past and the desire to exploit the know-how still present.

[103] Erminio Cucchini, La sistemazione del porto di Lido nella laguna di Venezia/memoria, Milano, Tip. L. di G. Pirola di E. Rubini, 1905.

[104] Selected body of commandos of the Fanti da Mar of the Venetian Republic.

[105] I thank Brigadier General Arturo Nitti and Lieutenant Colonel Gianpaolo Lisi of the Serenissima Lagunari Regiment for allowing me access to the military base and for the collaboration.

Among the uses it should be remembered the profitable period in which General Alessandro Guidoni, mechanical engineer and war hero, between 1916 and 1917 covered, with the rank of lieutenant colonel, the role of head of aeronautical construction department at the *Idroscalo di S. Andrea*:[106] in 1917 he began his studies on the resistance of the *sopracquee* structures against bombs and projectiles and on the resistance of the ship's hull to the submarine explosions of mines and torpedoes.

In the same year he designed, with Gaetano Arturo Crocco, a gyro-guided telebomba, called *Crocco-Guidoni* which, launched by a dirigible or an airplane, could hit a target twenty kilometers away, conceptually anticipating modern drones. Of this futuristic *telearma*, for which the Navy was very interested, gave all the rights deriving from the patents related to it free of charge to the Italian State. Also in this field, he designs a parachute torpedo to be launched in ports to block naval traffic and an aerotorpedo that sums up the aerodynamic and hydrodynamic capabilities of the weapon.

The basis for torpedo aircraft, called *Aeroporto di S. Andrea da Varriale*, played a very active role during 1st World War due to its strategic proximity to the battlefront and was used, as well as by the Italian Air Force, also by the Royal Navy as a base for M.A.S.[107] alias Anti Submarine Motorboats and torpedoes, agile and fast means ideal for raids in the Austrian ports of the Upper Adriatic: the new destination is shown in the map of the Island, drawn up in 1914,[108] which shows the area included between the *Bacino del siluripedio* e l'*Argine della Garzina di proprietà della Guerra* a series of buildings in addition to the piers along the Idroscalo.

On the opposite side there are other buildings in addition to the historic *Polveriera Vignole*. Two years earlier, the new *Regia Scuola di Aviazione di Venezia* had been set up at the *Arsenale*, which in 1913 led to the first flight experiments on seaplanes with the first Seaplane Squadron commanded by the Lieutenant of vessel Giuseppe Miraglia, a war hero[109] who which is still dedicated the barracks of the *Lagunari*. An extensive photographic documentation of the time testifies to the structuring of the base that will be equipped with a large series of hangars and buildings for military use, largely replaced, in the '50s, by modern buildings of the barracks.

The only surviving testimonies of the *Siluripedio* are the structure built at the head of the canal with the central turret control tower and at the sides the large observation balustrade terrace resting on concrete pillars founded directly

[106] http://www.aeronautica.difesa.it/archiviovetrine_news

[107] In 1915 Gabriele Dannunzio was also hosted there.

[108] Ufficio Autonomo del Genio Militare per la Regia Marina Venezia, Disegno n.144 del 15.7.14, annesso al n. 2766, Ufficio Storico della Marina Militare.

[109] Fallen in battle on December 21, 1915



Figure 10.



Figure 11.

in the water which, originally, housed in the intrados sector the torpedo launch systems, now disappeared; and the shed, located near the terrace, characterized by arched openings and neoclassical facies that once housed the torpedo repair workshops.

5. CONCLUSION

What has been said up to now requires some conclusive reflections: one concerns the irreversibility of disused industrial areas that, compared to natural ones, will never be able to return to the previous naturalization level, as for example in the case of the nearby Marghera industrial area the degree of pollution of land and water is so dramatic that it compromises the whole lagoon ecosystem. In the case of the *S. Giobbe* area, environmental reclamation operations have already been carried out, necessary for the installation of new residences that will be integrated with the remaining green residuals. It will be necessary to assume a reuse of the three historical artifacts that have hosted the *Schwartzkopff Silurificio*.

The other concerns the structural characteristics of Italian industry, linked to a capitalism that has historically distinguished the interventions activated essentially by foreign capital and which now, after the conclusion of the state welfare, is returning to the foreign hands of large financial and banking groups .

In the case of the *Arsenale*, today a magnificent testimony of industrial archeology able to change its *facies* unceasingly until it has remained an active place of production, today there is the absence of an overall political project that is not that of forced cohabitation of military, cultural, scientific, and minimally productive installations that have led to substantial transformations of the artefact with demolitions, arbitrary reconstructions for anastylosis or a presumed original style, disrespectful or irreverent restoration interventions.

These are realities that often come into conflict under the silent gaze of the still present industrial archaeological evidence, like the large Armstrong tower crane[110] present as a beacon on the *darsena Novissima Grande*, and which have nothing of the original organic structure of the complex in which, historically, intervened keeping in mind more the concept of relationship than that of an isolated architectural object.

We are convinced that the three testimonies of the Wisdom of State analyzed here, the *Arsenale*, the area of *S. Giobbe* and *Vignole* Island, will require an architectural and landscape rewriting intervention that is not limited only to the preservation of the testimonies or the restoration of the structures, but who has the courage to write *al di là*, to express the elements of a coherent project also made of transformation and change.

[110] Currently affected by a restoration.

SAŽETAK

Istraživanje odnosa između industrijske arheologije i strukture Venecijanske lagune koje traje već neko vrijeme, ali posebno namijenjeno Konferenciji u Rijeci, od početka 2015. bavi se arhivskom dokumentacijom, kartografijom i bibliografijom proizvodne strukture ratne mornarice u Veneciji, obuhvaćajući razdoblje od druge polovice 19. do prvih desetljeća 20. stoljeća. Cilj je objasniti i definirati monumentalne prostore za proizvodnju vojnog oružja, počevši od slavnih stoljeća Mletačke Republike do razdoblja prevlasti Habsburga i Kraljevine Italije.

Prikazat će se ključna uloga venecijanskog Arsenala, jedinog brodogradilišta u Veneciji i sjedišta prestižnih brodograditelja, s posebnim naglaskom na proizvodnju vojne opreme, i tradicionalne i inovativne poput torpeda, u vremenu nakon ujedinjenja i u okviru novog ustrojstva talijanskih centara za vojnu proizvodnju.

S obzirom na tragove koji danas još uvijek postoje, definirat će se i precizna uloga arhitekture u proizvodnji vojnog oružja, kojoj je potrebna prepoznatljivost kao spomenika i krajolika u krajnje osjetljivom kontekstu kao što je Venecijanska laguna, s posebnim naglaskom na izložbenu funkciju Arsenala / otoka le Vignole u okviru Venecijanskog bijenala, te dati prikaz svih tehnoloških potencijala, tržišno usmjerenog i pomorskog iskustva koje je Veneciji dugi niz godina osiguravalo prevlast na morima.

Ključne riječi: *Venecija, Arsenal, brodograditelji, laguna, industrijska baština, krajolik*

LUPPIS I WHITEHEAD – GRAĐANI RIJEKE, GRAĐANI SVIJETA

Luppis and Whitehead – citizens of Rijeka, citizens of the world

Ines Cerovac, Evgenia Arh, Jana Krišković Baždarić, Branka Pemper

SAŽETAK

Organizacijom izložbe publikacija iz svoga fonda pod nazivom Luppis i Whitehead – građani Rijeke, građani svijeta *Sveučilišna knjižnica Rijeka uključila se u obilježavanje 150. obljetnice izuma torpeda i 7. Međunarodne konferencije o industrijskoj baštini koja se održava u Rijeci od 19. do 21. svibnja 2016. Izloženom građom iz fonda Sveučilišne knjižnice ostvaren je pokušaj simulacije osobnih riječkih knjižnica Ivana Luppisa i Roberta Whiteheada predstavljanjem izbora knjiga, časopisa i novina dostupnih u Rijeci u njihovo vrijeme. Izložbom se željelo ukazati na bogatstvo izvora za proučavanje industrijske baštine u Rijeci, s posebnim naglaskom na tehničko područje i područje torpedistike koje posjeduje Sveučilišna knjižnica Rijeka.*

Osim s temama iz torpedistike, posjetitelji će se kroz novinske članke imati prigodu upoznati i s kronikom događanja u Rijeci u vrijeme suradnje Luppisa i Whiteheada pri usavršavanju izuma torpeda koncem 19. stoljeća. Putem navedenih izvora pokušao se opravdati i sam naziv izložbe zbog njihova izuma oružja svjetskog značenja za čije je usavršavanje i dovršavanje, nakon odbijanja podrške austrijskih vlasti i vojnih krugova, tadašnja Rijeka pružila sve potrebne uvjete i podršku.

Osim simulacije osobnih knjižnica Luppisa i Whiteheada, projekcijom najnovijih znanstvenih radova dostupnih u digitalnom obliku u internetskim bazama podataka na koje je pretplaćena Sveučilišna knjižnica Rijeka, nastojat će se dočarati i stručna knjižnica na temu torpedistike kako izgleda danas.

Izloženim izvorima o navedenim temama i ovom izložbom Sveučilišna knjižnica Rijeka dala je svoj doprinos očuvanju i promicanju bogate lokalne industrijske baštine i poticaj za daljnja istraživanja.

Ključne riječi: *Luppis, Whitehead, Sveučilišna knjižnica Rijeka, internetske baze, torpedistika*

* Sveučilišna knjižnica Rijeka, Hrvatska, e-mail: icerovac@svkri.hr, earh@svkri.hr, jkriskovic@svkri.hr, bpemper@svkri.hr / Rijeka University Library, Rijeka, Croatia

SUMMARY

On the occasion of the 150th anniversary of Torpedo and the 7th International Industrial Heritage Conference, the University Library Rijeka got involved by organizing an exhibition of publications from its collection entitled "Luppis and Whitehead – citizens of Rijeka, citizens of the world".

Through the exhibited materials from the University Library collection, a simulation of Luppis and Whitehead's personal Rijeka libraries has been realized by presenting a selection of books, periodicals and newspapers available in Rijeka in their day. The exhibition aims to point out the abundance of sources available for research of industrial heritage in Rijeka, with a special emphasis on those concerning the technical sector and torpedo engineering owned by the University Library Rijeka.

Apart from becoming acquainted with topics concerning torpedo engineering, visitors will get an opportunity to familiarize themselves with a record of events which took place at the time during which Luppis and Whitehead collaborated on the project of perfecting the invention of torpedo at the end of the 19th century. These sources will stand to justify the exhibition title "Luppis and Whitehead – citizens of Rijeka, citizens of the world" due to the world-wide significance of the weapon for the perfection and final realization of which the then Rijeka offered all the necessary conditions and support, after the Austrian authorities and military circles refused to do so.

Apart from the simulation of Luppis and Whitehead's personal libraries, we will try to present a specialized torpedo engineering library in its present form through a projection of the most recent scholarly work on that topic available in digital form through the Internet data bases to which the University Library Rijeka is subscribed. Through the exhibition of sources on the aforementioned topics, the University Library Rijeka will make its contribution to the preservation and promotion of the rich local industrial heritage and provide an impetus for further research.

Keywords: *Luppis, Whitehead, Rijeka University Library, internet data bases, torpedo engineering*

THE SUBMARINE *PERAL*, THE STRATEGIC IMPORTANCE OF THE WHITEHEAD TORPEDO IN THE INVENTION OF THE SUBMARINE

Podmornica *Peral*, strateška važnost Whiteheadova torpeda u izumu podmornice

Juan Ignacio Chacón Bulnes, Diego Quevedo Carmona, José Manuel Chacón Bulnes

SUMMARY

This weapon was conceived by Captain Luppis of the Austrian Navy, and improved by Mr. Whitehead, a British engineer of the factory in Fiume, who gave his name to this system of torpedoes or locomotive torpedoes. In 1871, Germany bought the patent of this torpedo and advanced them by making them in phosphor bronze, saving thus on maintenance and extending their operating life avoiding corrosion. In 1880, the Spanish Armada sent a commission to examine both torpedoes, and chose the torpedo of Whitehead type, buying 100 units from the arms manufacturer Schwartzkopff. In 1888, Armada Lieutenant Isaac Peral launched his submarine, which was equipped with the Schwartzkopff torpedo tube having a capacity of three torpedoes of the Whitehead type. The previous existence of the locomotive torpedo allowed the inventor of the submarine to have the perfect weapon for these ships.
The submarine Peral *was the first submarine in history to shoot torpedoes. On March 21st in 1889, it launched one on the surface, while in immersion on January 16th in 1890. That same year, on June 7th, Peral made the first immersion navigation in history, 10 meters underwater. Isaac Peral was the first to load aboard torpedoes in a submarine and his system remains today in modern combat submarines. He also designed the system to launch up to 3 torpedoes underwater without losing its stability. Despite the success of the tests, the Navy rejected the project and the submarine dismantled, abandoned and forgotten for more than forty years in the same Arsenal of La Carraca (Cadiz), where she was launched in 1888. Some forty years later, it was towed by sea to Cartagena where it was first exhibited at the Arsenal of that city and then as a source motif for the next 80 years. Since 2013, it has been restored and displayed as the most important piece of the Naval Museum of Cartagena, thus regaining his place in naval history.*

Keywords: *Armada, Submarine* Peral*, Isaac Peral, Whitehead, Cartagena*

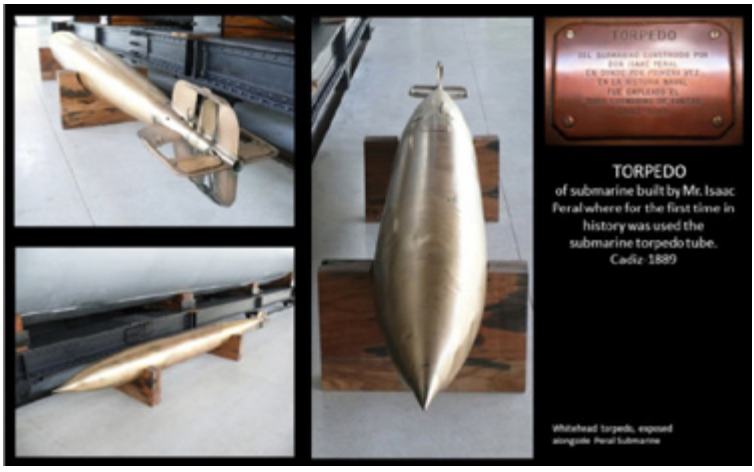
* Technical Commission for the restoration and enhancement of Submarine Peral, Spain, e-mail: fannycha@msn.com, cintasdelepanto@gmail.com, chaconarq@telefonica.net

This weapon was conceived by Captain Luppis from the Austrian Navy, and it was improved by Mr. Whitehead, a British engineer from the Fiume Factory; the latter gave his name to this system of torpedoes or locomotive torpedoes.



■ **Figure 1.** *Official books Torpedo School of Cartagena late 19th century*

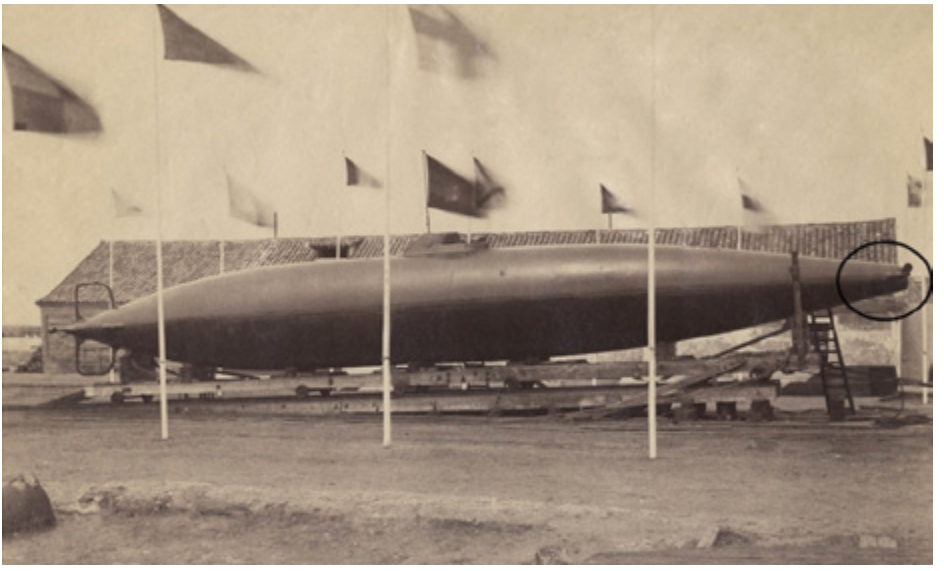
In 1871, after buying this torpedo´s patent, Germany improved it by making it with phosphor bronze, saving on maintenance and avoiding corrosion, thus extending its operating life.



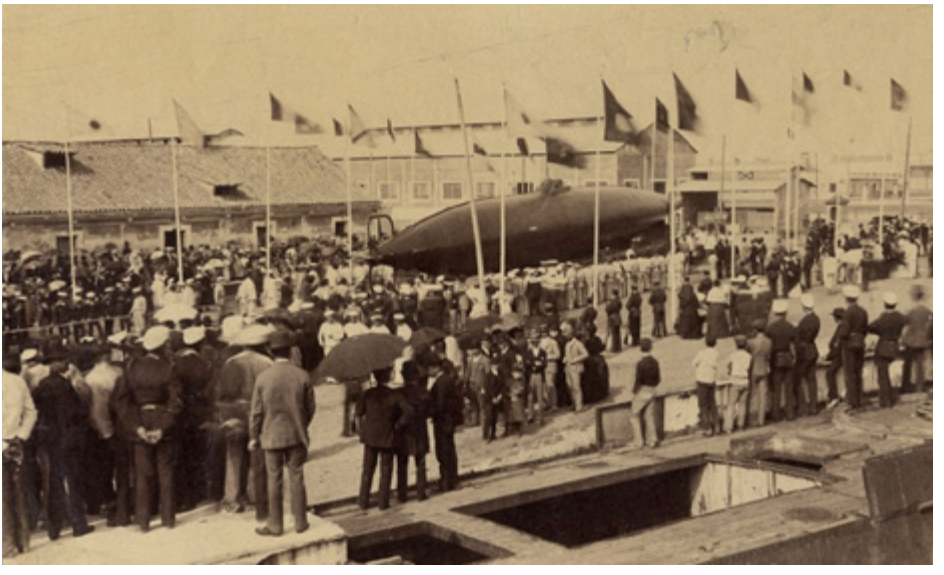
■ **Figure 2.** *Torpedo Whitehead Schwartzkopff*

In 1880, the Spanish Navy sent a commission to examine both torpedoes, and they chose the Whitehead torpedo type, buying 100 units from Schwartzkopff arms manufacturer.

In 1888, Navy Lieutenant Isaac Peral launched his submarine, which was equipped with a Schwartzkopff torpedo tube and had the ability to shoot three Whitehead type torpedoes. The previous existence of the locomotive torpedo allowed the inventor of the submarine to have the perfect weapon for these ships.



■ **Figure 3.** *Day of the launch, september 8, 1888*



■ **Figure 4.** *The launch ceremony, september 8, 1888*

The Peral Submarine was the first one in history to shoot torpedoes. On March 21st, 1889, it launched one on sea surface, and another one in immersion on January 16th, 1890. That same year, on June 7th, the Peral Submarine made the first immersion navigation in history: it sailed for an hour, 10 metres deep and emerged in preset coordinates.



■ **Figure 5.** Peral *submarine recharging batteries, 1889*

Despite the success of the tests, the Navy, not believing in the future of this new weapon, rejected the project. In fact, this was due to a lack of vision and political pressures from other countries, especially England.



Figure 6. Peral *submarine tests*

The submarine was dismantled in 1892: every valuable device and equipment is stripped, and the hull is left inside the Arsenal of Cádiz.



Figure 7. *Deserted submarine 37 years inside Carraca Arsenal, Cadiz*



In 1915, Spain bought his first submarine from the U.S.A., which was named after Isaac Peral, and the first submarine base was set in Cartagena. For this reason, in 1929 the Peral Submarine, still abandoned in Cádiz, was towed by sea to the Cartagena Submarine Base, where it was exhibited for 36 years.

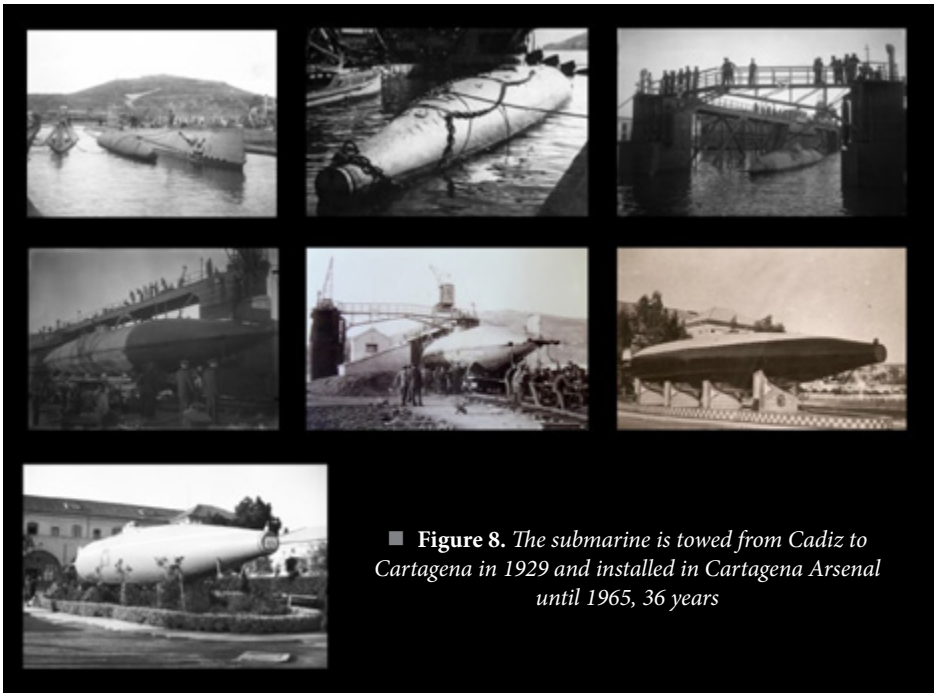


Figure 8. *The submarine is towed from Cadiz to Cartagena in 1929 and installed in Cartagena Arsenal until 1965, 36 years*

In 1965, the Peral Submarine is taken out of the Arsenal, to enjoyment of Cartagena inhabitants and tourists alike. In the absence of a crane large enough in the city, the submarine is cut into three pieces.

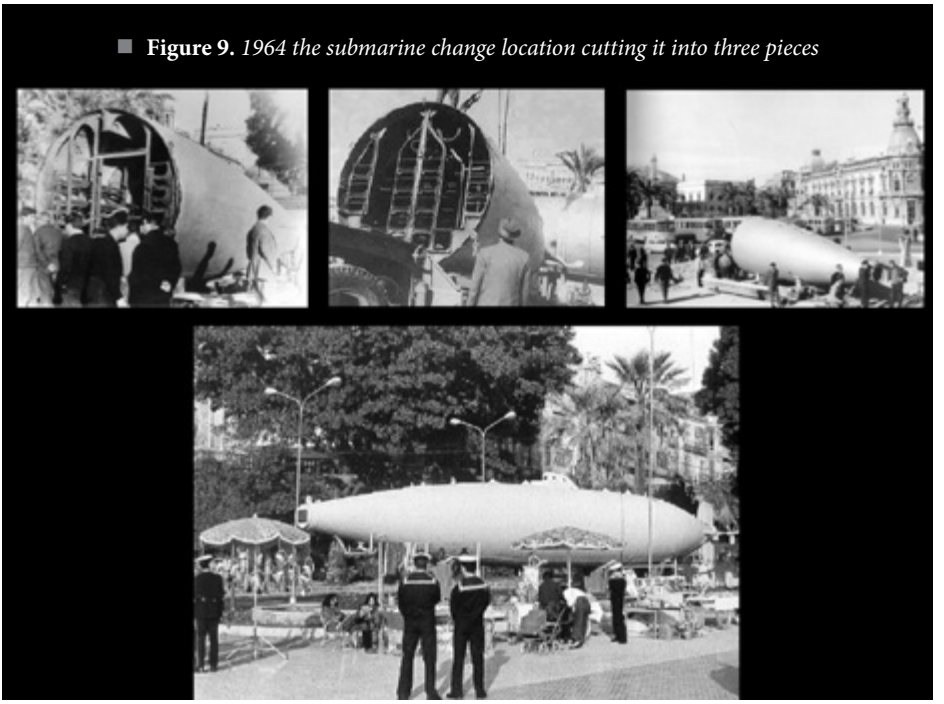


Figure 9. *1964 the submarine change location cutting it into three pieces*

The hull of the submarine became an ornament for a fountain, and thus a tourist attraction. The water jets eventually perforated the ship steel, and water ran inside it.

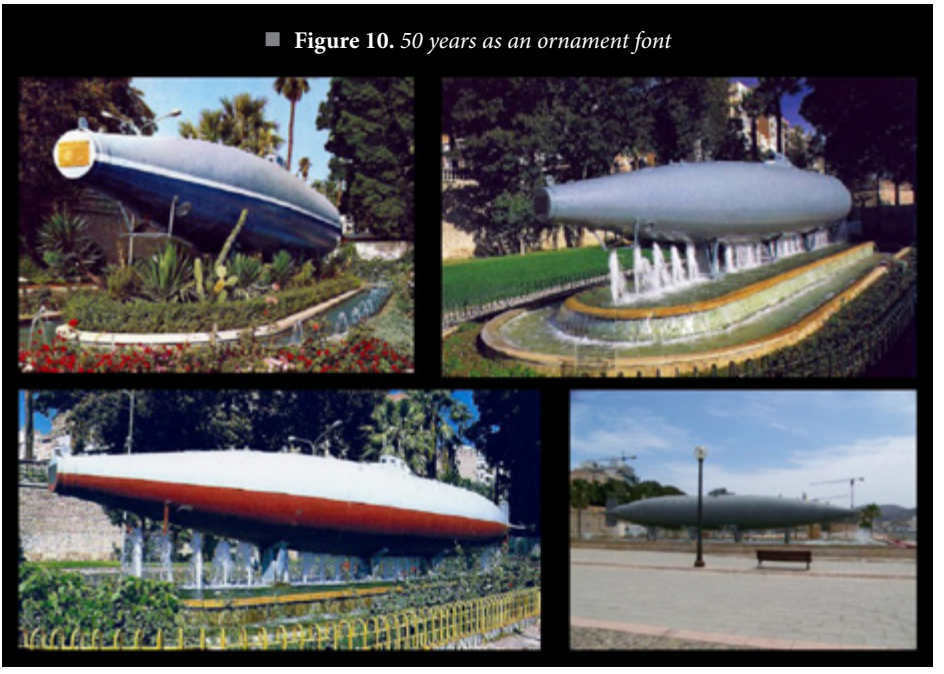


Figure 10. *50 years as an ornament font*

In April 2011 we entered the submarine to assess its condition, and we managed that the city of Cartagena, the Navy and the Institute of Cultural Heritage of Spain realized that this achievement of naval engineering from the nineteenth century should not be outdoors any longer, and that it should receive the necessary care for its conservation.



Figure 11. *April 29, 2011, entrance to the submarine*

The Juanelo Turriano Foundation, which is engaged in promoting, promulgating and preserving the industrial heritage, as well as in the historical study of Technics and Sciences, took charge of the submarine movement and part of its restoration, and the ship was moved in December 2012 to the Naval Museum of Cartagena.



Figure 12. *December 15, 2012, is translated into Naval Museum of Cartagena*

The Institute of Cultural Heritage of Spain (IPCE) is responsible for the first phase of restoration of the submarine exterior, including the assessment of the hull conditions.

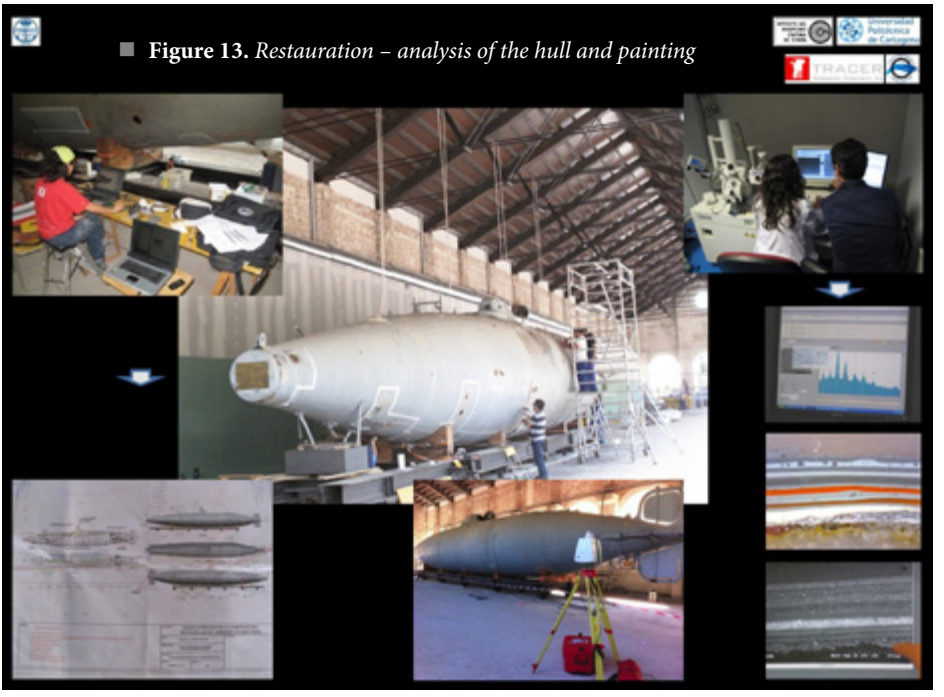


Figure 13. *Restauration – analysis of the hull and painting*

An attack plan is performed to remove the rust and stop the submarine corrosion.



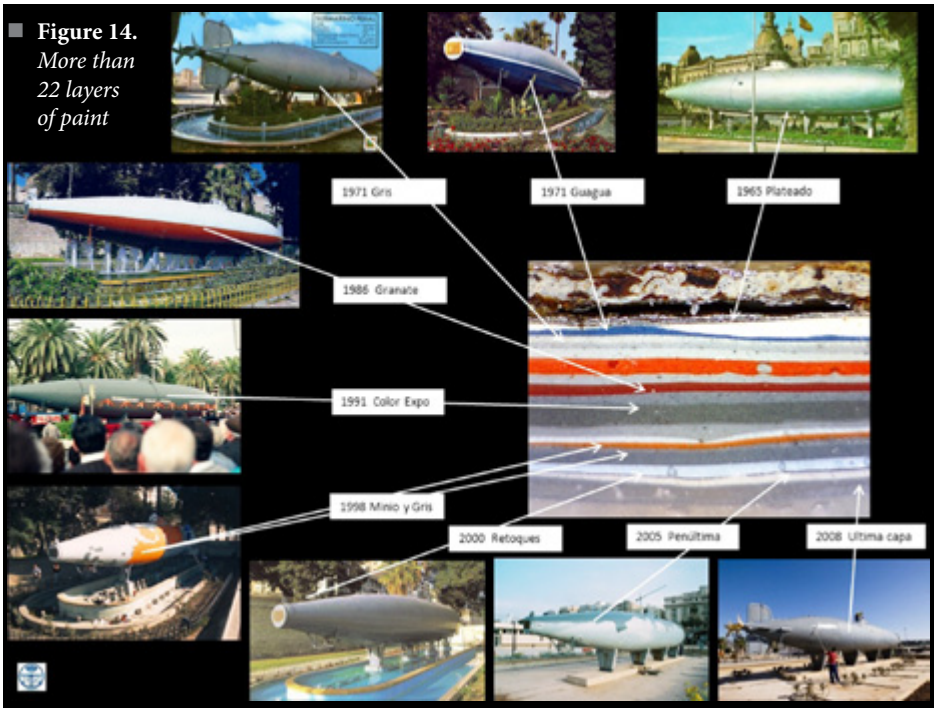


Figure 14. *More than 22 layers of paint*

The original coat of paint of the submarine was sought, but it was impossible to find it. The first paint layer found is from 1964. The 22 layers of paint, or more, that the ship has had over the years are subject to study.

At the same time, the Polytechnic and Salesians schools of Professional Training made the pieces that once were plucked off the submarine. Students and teachers made the pieces using the original plans drawn by Isaac Peral, which were in the National Historical Archive.

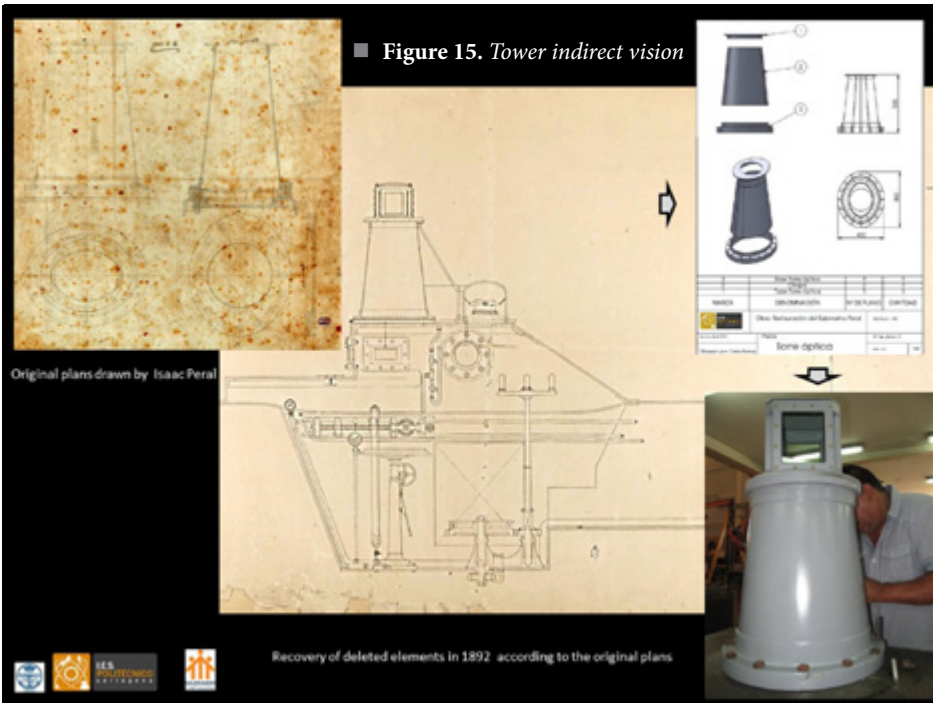


Figure 15. *Tower indirect vision*

Now that the pieces plucked off the ship 125 years ago have been replaced, you can explain, in the Musealization, the functioning of the first submarine in history.

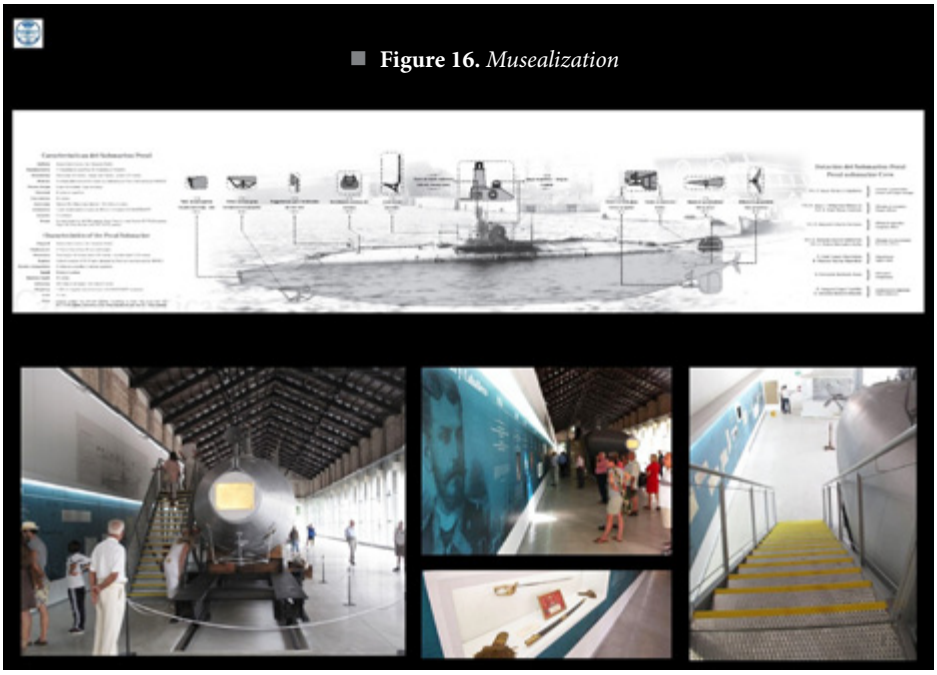


Figure 16. *Musealization*

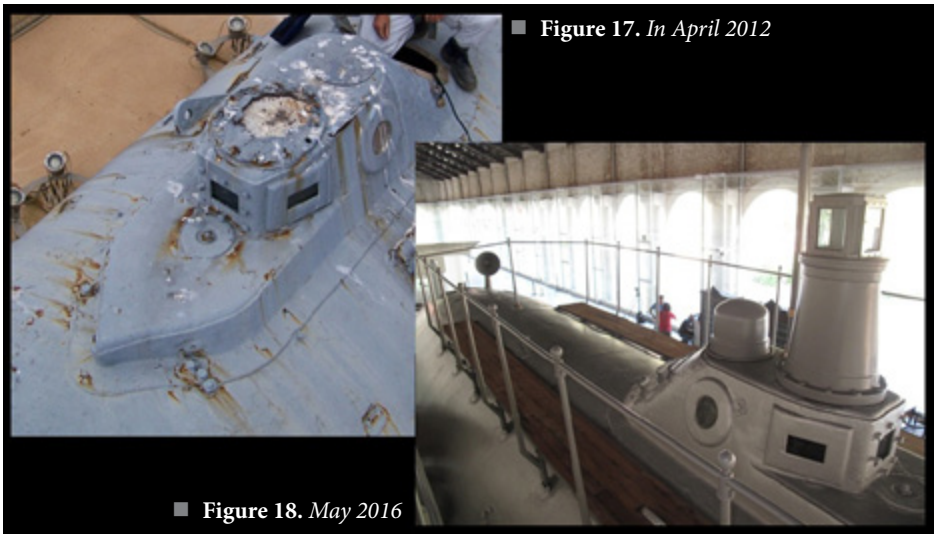


Figure 17. *In April 2012*

Figure 18. *May 2016*

I encourage you to come to Cartagena and see this ship invented by the Carthaginian Isaac Peral, the first submarine that used a torpedo tube and performed the first successful underwater navigation in history.

Next to the ship, you can see one of the Whitehead torpedoes used in his tests, and you will realize that Peral used the Whitehead torpedo shape to build his submarine.



Figure 19. *Naval Museum of Cartagena*

SAŽETAK

Ovo je oružje osmislio kapetan Austrijske mornarice Luppis, a usavršio Whitehead, britanski inženjer iz tvornice u Rijeci, davši istodobno ime ovom sustavu pokretnih torpeda. Godine 1871. Njemačka je kupila patent ovog torpeda i unaprijedila ga izradivši ga iz fosforne bronce, uštedjevši tako na održavanju i produživši mu vijek trajanja izbjegavanjem erozije. Španjolska je ratna mornarica, Armada, *1880. poslala svoju delegaciju da ispita oba torpeda. Odabrali su torpedo tipa* Whitehead, *kupivši stotinu jedinica od proizvođača oružja* Schwartzkopff.

Godine 1888. Isaac Peral, poručnik Armade, *lansirao je svoju podmornicu koja je bila opremljena* Schwartzkopffovom *torpednom cijevi, kapaciteta tri torpeda tipa* Whitehead. *Već postojeći pokretni torpedo omogućio je izumitelju podmornice da napravi savršeno oružje za ove brodove.*

Podmornica Peral *bila je prva podmornice u povijesti koje je gađala torpedima. Dana 21. ožujka 1889. lansirala je jedan torpedo na površini, a 16. je siječnja 1890. uronjena. Iste je godine, 7. lipnja, prvi put u povijesti, zaplovila uronjena 10 metara ispod morske površine. Isaac Peral bio je prvi koji je na podmornicu stavljao torpeda, a njegov sustav zadržao se i danas u modernim borbenim podmornicama. Stvorio je sustav kojim se mogu lansirati do tri torpeda ispod morske površine a da podmornica ne izgubi stabilnost.*

Unatoč uspjehu tih testiranja Ratna mornarica odbila je taj projekt, a podmornica je bila rastavljena, napuštena i zaboravljena više od četrdeset godina u istom brodogradilištu, Arsenal de La Carraca *(Cadiz), u kojem je bila porinuta 1888. Nakon četrdeset godina, morskim je putom odvučena do Cartagene gdje je najprije izložena u arsenalu toga grada, a poslije i u samome gradu. Godine 2013. obnovljena je i postavljena kao najznačajniji izložak u Mornaričkome muzeju Cartagene, zadobivši tako svoje pravo mjesto u povijesti mornarice.*

Ključne riječi: Armada, *podmornica* Peral, *Isaac Peral, Whitehead, Cartagena*

TORPEDO BOAT CARRIERS

Nosači torpednih čamaca

Roger B. Cook*

SUMMARY

The steam launches carried on larger warships in the middle of the Nineteenth Century proved their value, as 'picket' boats circling around their parent vessel to guard her at anchor, or supporting armed landings or cutting-out expeditions, armed with small quick-firing cannon. With the introduction of spar torpedoes, the picket boats took on a new role, as auxiliary warships carrying out torpedo attacks on enemy ships.

When the locomotive torpedo came into use, the picket boats were fitted with carrying cradles to launch the new weapons. These early small calibre torpedoes continued to be carried on board warships such as HMS Dreadnought *to arm their picket boats for inshore work. The rapid growth in torpedo size and range, however, led to the introduction of the first specifically-designed torpedo boats.*

Realistic manoeuvres by the French led to the unpleasant discovery that their planned swarms of torpedo boats were not seaworthy enough to carry out by themselves the interdiction role the French had hoped. They still needed to be carried to the scene of the action. At first they themselves were still small enough to be carried aboard the larger men-of-war, but soon torpedo boats grew too big to be easily carried, and moreover, safely hoisted overboard when at sea.

Towards the end of the 19th Century two major navies experimented with specially-designed and equipped warships, motherships intended to carry, maintain and launch on the open sea their flotilla of torpedo boats, for attacks on enemy harbours. If necessary, the motherships could intervene in an action to protect their flock.

I will be examining these designs in detail, and will describe their ultimate fates. I will also detail the lesser-known torpedo-boat carriers of the First and Second World Wars, many of which ultimately saw action.

Finally I will ponder the wasted potential of these first motherships, born a half century before their time.

Keywords: *picket boat, torpedo boat, mothership*

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SAŽETAK

Čamci na paru koje su sredinom 19. stoljeća nosili veći ratni brodovi, dokazali su se kao „stražarski čamci" kružeći oko svoga roditeljskog broda i tako ga čuvajući na sidrištu, kao podrška pri oružanom iskrcavanju na kopno ili pak u osvajanju većeg broda, naoružani malim brzometnim topom. Uvođenjem mine na štapu ispred pramca, „stražarski čamci" zadobili su ulogu pomoćnih bojnih brodica koje su torpedirale neprijateljske brodove.

Kada se počeo upotrebljavati pokretan torpedo, stražarski čamci opremljeni su kolijevkama za lansiranje novog oružja. Ta rana torpeda malog kalibra i dalje su prevožena ratnim brodovima poput HMS Dreadnoughta *kako bi se naoružavali stražarski čamci za djelovanje uz obalu. Brz porast veličine i dosega torpeda, međutim, doveo je do uvođenja prvih, posebno projektiranih torpednih čamaca.*

Konkretni manevri koje su provodili Francuzi doveli su do neugodne spoznaje da njihova planirana jata torpednih čamaca nisu dovoljno plovna da bi sama provela presretanje onako kako su Francuzi očekivali. I dalje ih je trebalo prenositi do mjesta djelovanja. U samom početku bili su još dovoljno mali da bi ih jači mornari mogli prenijeti na brod, no uskoro su postali preveliki za to. Štoviše, nisu se više mogli sigurno podignuti i spustiti preko palube u more kada je brod bio na pučini.

Krajem 19. stoljeća dvije velike ratne mornarice eksperimentirale su s posebno projektiranim i opremljenim ratnim brodovima, matičnim brodovima čija je namjena bila prevoziti, održavati i lansirati na otvoreno more njihove flotile torpednih čamaca za napade u neprijateljskim lukama. Ako je to bilo potrebno, matični brodovi mogli su i intervenirati u bitci kako bi zaštitili svoje jato.

Te ću projekte detaljno ispitati i opisati njihovu konačnu sudbinu. Bavit ću se i pojedinostima manje poznatih nosača torpednih čamaca u Prvome i Drugome svjetskom ratu, od kojih su mnogi sudjelovali u bitkama.

Na kraju ću razmatrati neiskorišten potencijal ovih prvih matičnih brodova, rođenih pola stoljeća prije svoga vremena.

Ključne riječi: *stražarski čamci, torpedni čamac, matični brod*

REVITALISATION OF HARBOUR STRUCTURES THROUGH THEIR CULTURAL VALUES – THE EXAMPLE OF THE WINTER HARBOUR IN BRATISLAVA

Revitalizacija lučkih struktura putem njihovih kulturnih vrijednosti na primjeru Zimske luke u Bratislavi

Martin Dubiny, Katarína Mackovičová, Eva Kráľová

SUMMARY

The Winter Harbour in Bratislava makes part of the landing port that was among the biggest inland river harbours in Central Europe in the first half of the twentieth century. The area of the Winter Harbour was first used in 1897 with the purpose of being ships' wintering place, while later it was also used for the transloading of goods. As the harbour complex had extraordinarily intensive transport, technical and economic activities evolved when the two artificial basins were built in the immediate proximity of the navigable stream of the Danube. In the second half of the twentieth century, some new activities began evolving. A new technical and with repair services equipped complex has developed around the new buildings located by the river. Landing stages and surfaces of the Winter Harbour have begun to be taken over for the new residential and commercial construction; historical harbour buildings being demolished.

Not long ago, the Slovak National Board for Monument Preservation took the decision that some of the buildings of the Winter Harbour had to be listed as national monuments. The owners of these buildings protested defying that decision and raised the objection that the abandoned buildings do not have any cultural values while their preservation restricts the business development.

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Subsequently elaborated expert opinion confirmed the inherence of the noteworthy values. At the same time, a study of usability of historic buildings of the Winter Harbour in keeping with their cultural values was elaborated, in the way of supporting the tourism activities in the context of the whole town of Bratislava.
The paper presents the results of the study when the restored historic buildings (the Old Shipmen House, the Ship Repair Hall, a ship elevator and the towboat Šturec) became included into revitalization of whole complex of the Winter Harbour as an active part in the development of the river navigation tourism and for educational and recreational activities in line with development programme of the town.

Keywords: *Winter Harbour, Danube, Bratislava, monuments, preservation, revitalization*

1. INTRODUCTION

The historic industrial sites have stopped or stopped authentic function from different reasons. Finishing the production can be for different reasons but they have one common: they have lost their status as an important factor in the life of a city or region. The buildings and whole areas are abandoned or only partially used. Disreputability has resulted in their physical degradation and social dishonor of unused industrial areas. Many of these areas sites disappear, despite the fact that they contain values and potentials that could be further exploited. The abandoned buildings and areas are generally in good physical condition after their finishing production. They contain extensive areas and volumes, which can be developed different functions than was the original function. Also, labour power (employees related to the original production), the good name of the original industry, products and persistent positive social relationships are at disposal and they are waiting for activation. These are factors that can be expressed oral but also economical and they presenting disposable territorial capital. The problem of its activation is a disability of real and potential stakeholders and to imagine the possible transformation. The result is ignorance identify exploitable potential and quantify it in the economic capital terms.

Such example is the Winter Harbour in Bratislava, which is the industrial heritage of the city and it creates the important part of its identity. Several objects are abandoned with own destiny. Other spaces have served an original or similar purpose.

The group of the National Cultural Monuments (NCM) can be the inspiration for the future of industrial heritage. Paper present significant values and necessary to protect them and to the possibility re-activation of buildings as cultural and economic values of the city.

2. THE INDUSTRIAL HERITAGE AND ITS VALUES

The monument values are according to the Law of Protection of Monuments § 2 clauses 2 defined as "Cultural heritage value is a summary of significant historical, social, landscape, urban, architectural, scientific, technical, artistic or art and craft values for which things can be covered by an individual or territorial protection [10]. The definition of industrial heritage is "The industrial heritage is the evidence of activities which had and continue to have profound historical consequences." Industrial heritage consists of the remains of industrial culture which are of historical, technological, social, architectural, scientific or urbanistic values [8].

The historic values are linked not only by time of build-out of buildings but also of the different stages of conversions as the document of its development. People are including here too, who worked in that industry, visited or otherwise visibility of operations. The important event is also the carrier of value not only in the context of the operation itself but a wider range too.

Architectural values are formed by the organisation and composition of the buildings, including the residential area and the facilities of serving staff. It can also be the document of an eminent architect. Architectural values contain decorative solutions of buildings in exterior and interior as well as their surrounding and location of industrial architecture in the country.

Technological values do not express quantity, material, energy and economic indicators as an active industrial company. These values express the contribution of contemporary technology – its development. Preserved machines and other technological equipment belong in this category. They are not only as tangible but also intangible value in the form of know-how [6], [9].

Scientific values are linked to all the values mentioned above. The material documents may serve for further scientific research, the learning and recorded.

Technological and scientific values may have considerable aesthetic value for the quality of its architecture, design or planning.

Social values are the important element of the industrial heritage. It forms impact to culture – its refinement and improvement of lifestyle and interpersonal relationships. The industrial heritage influence and form work habits, ethics and morals of people in a broader territorial contact [6].

Urbanistic values can be defined as a location or the picture of the country.

The important question is: How are perceived culture values in the present?

Many buildings contain these values, but they are often taken as the limit for further economic development. They are considered as an obstacle, which limits the arbitrary handling of any sites. The conditions of handling are established by the Monuments Board. Buildings/areas are demolished and new

project is built in this places with markedly higher capacity and volumes. The aim is to get the highest possible profit.

The historic harbours are industrial heritage too, which includes the important cultural values. They document shipping activities and boatmen life. We will devote case study, where is shown the possibility of re-use of industrial heritage with its significant cultural values. We will be paying attention to a case study the Winter Harbour in Slovakia.

3. THE WINTER HARBOUR

The river Danube is important to transport artery. It flows through 10 European countries. The length of rivers is 172 cm in the Slovak section and is located midway between the connections North and the Black Sea. The section of river has three harbours in Slovakia – in Bratislava, Komárno and Štúrovo [12].

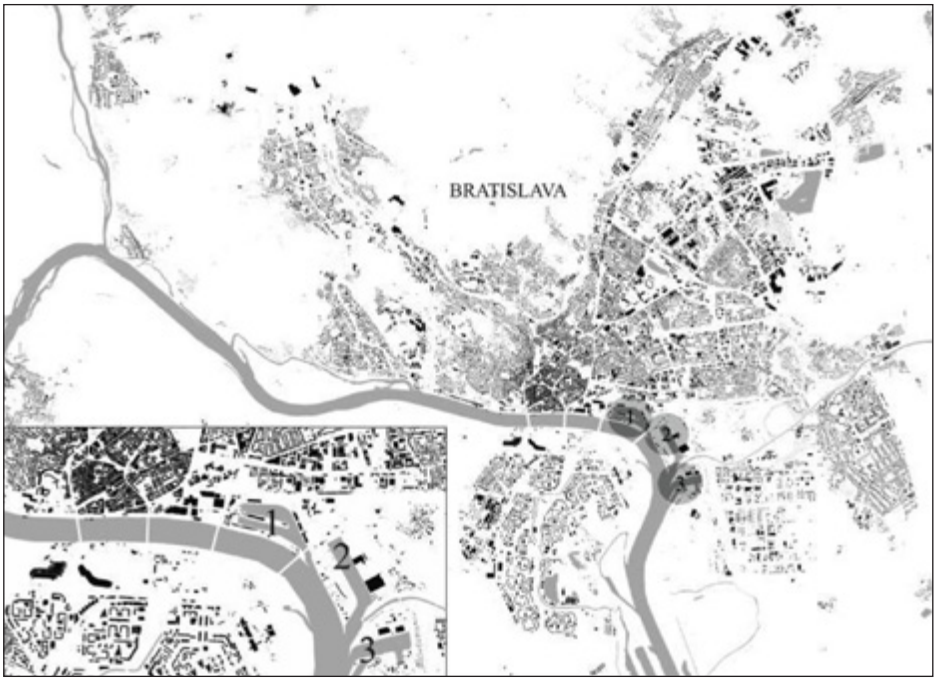


Figure 1. *Harbour in Bratislava; 1 – Winter Harbour, 2 – Pálenisko, 3 – Lodenica (source: authors)*

Bratislava's harbour – the cargo harbour was built by Royal Hungarian Ministry of Agriculture in 90 years of the 19th century. There was a possibility of mooring 250 boats on the 6 km long river edge [4]. It was a complex having extraordinary intensive transport, technical and economic activities in the 1st

half of 20th century. The cargo river harbour belonged among the biggest inland river harbours in Middle Europe and it was important shipping crossroads. At that time, The International Danube Fair took place in Bratislava and its pavilions were stationed right in the Bratislava City and the Winter Harbour. The fairs belonged to the world's major events and offered many commodities and innovative technology of the time. The period of greatest fame was interrupted during the World War II.

In the present, the Winter Harbour is preserved the oldest part of cargo harbour. It is located on the left bank of river Danube and it is between two bridges – Apollo and Prístavný bridge. Area of the Winter Harbour was built in 1897 and it has been used for a purpose of ships wintering place, later there was affiliated also goods transloading. It consists of two basins – North and South basin. The exceptionality is documenting by buildings that are listed as the National Cultural Monuments (NCM) – a Boatmen house (2008), a Pumping Station (2011), a tugboat Šturec (2011), a Shipping Workshop and a Boat Lift (2015). These objects create the complex of National Cultural Monument.

Pálenisko is a new part of cargo harbour, which has built from 1975. This harbour is contained by one basin. Industrial activities are gradually moving from the Winter Harbour to this part. Original historic harbour facilities are thus abandoned [3].



■ **Figure 2.** *Harbour in Bratislava, past and present (source: SPaP, a.s.; Martin Dubiny)*

The actual trend is gradual occupy of this abandoned or partially abandoned areas for new construction, whether residential or commercial architecture. Many of areas/buildings could use for other function, but many of them are demolished with their significant cultural values. Investors residential and office interventions are aimed at quick profit, the historical and cultural values are not taken into account.

3.1. The Winter Harbour and its values

Many buildings are important documents of life and harbour organisation. They were used for different original purposes – as a warehouse, accommodation, administration, workshops, ship lift, technological equipment (pontoons, harbour cranes, overhead crane, anchor or rail siding). In the present some of them are still used for industry activities of the harbour, but part of this buildings are unused or they serve only for secondary substitute function.

Their existence is linked with historical events (The International Danube Fair) and contexts relating to not only the harbour area and its activities, but also the history of the city, or to the operation of important personalities in the harbour (visit of the then President Milan Rastislav Štefánik). The **historical values** of buildings do not depend on the current technical condition of the affected objects or their actual use. They depend on the existence of historical facts.

Buildings and all areas include other values, which create the complex of cultural values.

The urbanistic values are location on the bank of important European river, also its impact on the composition and configuration of the construction near the historical, cultural-social centre. The harbour has an identification position in the picture of the city.

The documentary values of the monuments is an uncontroverted document not only the operation of the harbour but construction method (dispositional, material and design structures in given period) and life in the harbour too. Each building or technological equipment has documentary values. The Boatmen House or preserved building of wardrobe document the life of boatmen in the area. Warehouses, workshops, cranes, rail siding and other technological features document industrial activities an industrial character environment too.

The unique **technical values** are preserved as harbour cranes, located along the edges of the harbour as well as an overhead crane in the Ship Workshop. Preserved rail siding and other technologies for ships anchoring are including to these values. Especially high technical value has the harbour. This value is not visible at first sight as a technical product. The flow of the Danube was reconstructed several times. The last change is build-out of the harbour edge in the bend of the river. This construction is situated under the water and it has to withstand the impact pressure on a bend of the river. The edge has resisted to more floods and war events [9], [11].

The question arises: How to use these values in order to increase the economic benefits?

4. EXAMPLES REVITALIZATION AND ADAPTATION OF HARBOURS

Many positive examples of adaptation and revitalization harbour edges, harbours or other industrial areas are in abroad. These examples have used culture values whereby have increased the potential of abandoned spaces.

The most famous examples of harbour revitalization are docks in London, "Hafen City" in Hamburg and old harbour in Strasbourg. Each transformed harbour was an industrial zone of the city in the past. Today they become the new cultural and social centre.

London docks which known "Docklands" have modified by different changes from 1980. World's major companies operating in the field of finance, business and law have moved to this city part from the early 90s of the 20th century.

The build-out of "Hafen City" have started in 2001 and is still in progress. It will provide a total area of 157 hectares space of living for 12 thousand people and almost 45 thousand new jobs after its completing. It is an exceptional project with the concept of urban development and public dialogue.

The old Strasbourg harbour is located on the arm of the Rhine. The new polyfunctional centre has built in this harbour. It contains many functions as a shopping centre, parking house, cinema, apartment house, conservatory and a library. University is before completing. The harbour area and its surroundings on the main flow of Rhine is a subject of transformation in the present [3].



Figure 3. *1 – Docklands, 2 – Hafen City, 3 – Strasbourg (source: author)*

The revitalization of these harbours consists in their transformation to cultural-social centre with preservation of the harbour character. The architecture as warehouse or harbour technologies (cranes, anchors) or architectural country (shape and form of harbour basins and edges) have preserved the cultural values. It creates interesting space and potentiates the feeling of past industrial activity. The areas integrate buildings of old warehouses as a Monuments with modern urban structure in one place.

5. THE CASE STUDIES – BRATISLAVA'S WINTER HARBOUR

After the declaration of the said objects for the NCM was shown necessary to create a vision – how can work with these value of historic harbour.

In 2015, four studies of new use were created in the Faculty of Architecture – Slovak University of Technology. In the context of this paper, it is interesting to see what they provide and allowing objects that are listed as NCM and why they are protected. These objects are included as part of the revitalization of the whole area in the Winter Harbour – focusing on the development of tourism, river cruises and sightseeing and recreational activities in accordance with the city development programmes.

5.1. Urbanism

The role of two further studies mentioned above was a solution of urban surroundings objects and its wider context too. Near the Winter Harbour is a promenade, which is ending in front of cultural-social centre (shopping center Eurovea and Slovak National Theater), which is located in the immediate proximity. Continuation of the existing promenade within the harbour it could be extended by 1.2 kilometres in direct contact with the river. The promenade around the perimeter of the basins has the potential to reshape the 4 km area.

City considers about the extension of the existing ship stops. The study has included the proposed ship stops of the city and has added the next stops within the Winter Harbour. The territory between South basin and the river Danube was designed for using – sport-recreation function. It was created the spaces for the creation of a small architecture for services connected with shipping themes but also other spaces as café with overlooking the Danube.

South basin is used for winter storage of boats and transloading of goods in the present. The study shows the possibility of a gradual transformation of this space to private mooring small boats. The first phase considers the transfer of six anchor fields and the subsequent construction of six floating moles with the possibility of mooring for 72 small boats. Phase II considers in addition to the first stage of transformation 5 tank vessels for multipurpose boats with different functions. Phase III is considering further to the transfer of five other anchors fields, thus creating ten floating moles with the possibility of mooring for almost 120 small boats. The study did not consider with the transformation anchorage areas in the North pool. This would be the next phase of design, bringing the total capacity of small boats has expanded by about double. A study creates spaces with preserved the technical values (harbour cranes, rail siding, anchors) and reflected in the draft revitalization as an element reminiscent harbour character of the territory.

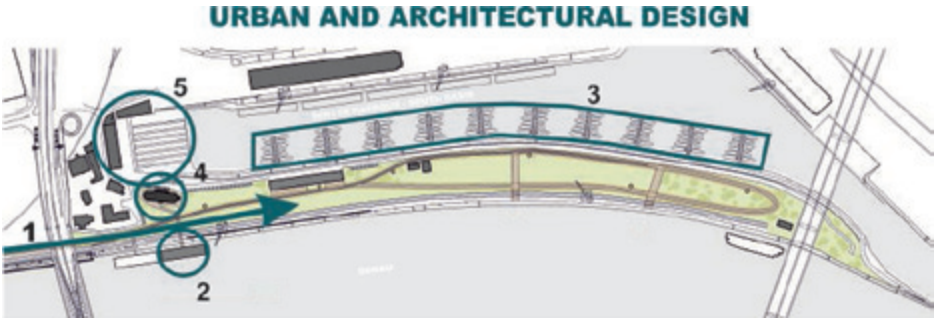


Figure 4. *Architectural study – urbanism: 1 – extention of the promenade, 2 – ship transportation, 3 – marina (small boats), 4 – Boatmen House (accommodation), 5 – Ship Workshop, Ship Lift, tugboat Šturec – museum (source: authors)*

The fundamental problem of revitalization is closeness area. However, the study resolves this problem with the gradual transformation closeness of the harbour. It should bring the bigger connection city with the harbour and open the area for public [2], [7].

5.2. The Boatmen House

The Boatmen House was built in 1942. It was designed by architect Július Lehocký and built by company Bohumír and Martin Zaťko. This building was created in the functionalist style with elements reminiscent of the architecture of the ship. It was built for the purpose of accommodation and board ship crews. The Boatmen House was a place of administration and station of radiolocation after the original function.

The building is the holder of many important values not only from an architectural point of view but also urban. It is located on the left bank of the Danube river and it defines the end of the coastal line of buildings. The house is welcoming element of the industrial harbour space and has an important place in the panorama of the city from the surface of the river. It becomes the identity of the place but also a part of a veduta. Therefore, it is an object of a preservation.

The veduta is a public value, which affects the whole city and, therefore, it has a higher social status. It is the holder of the important, visual information and characteristic features of the landscape [7]. It does not create the only panorama in the country with a dominant, the structure of buildings and their characteristic features of the region (windows, gates, roofs, small architectures…). The characteristic view of the country should be protected according to the Law of Protection of Landscape and Country 543/2002. Destruction of the image of the country is the whole society injury [5].

The architecture is unique with its character in Slovakia and its profile and elements create the architecture of ship – roundness facades, observation tower

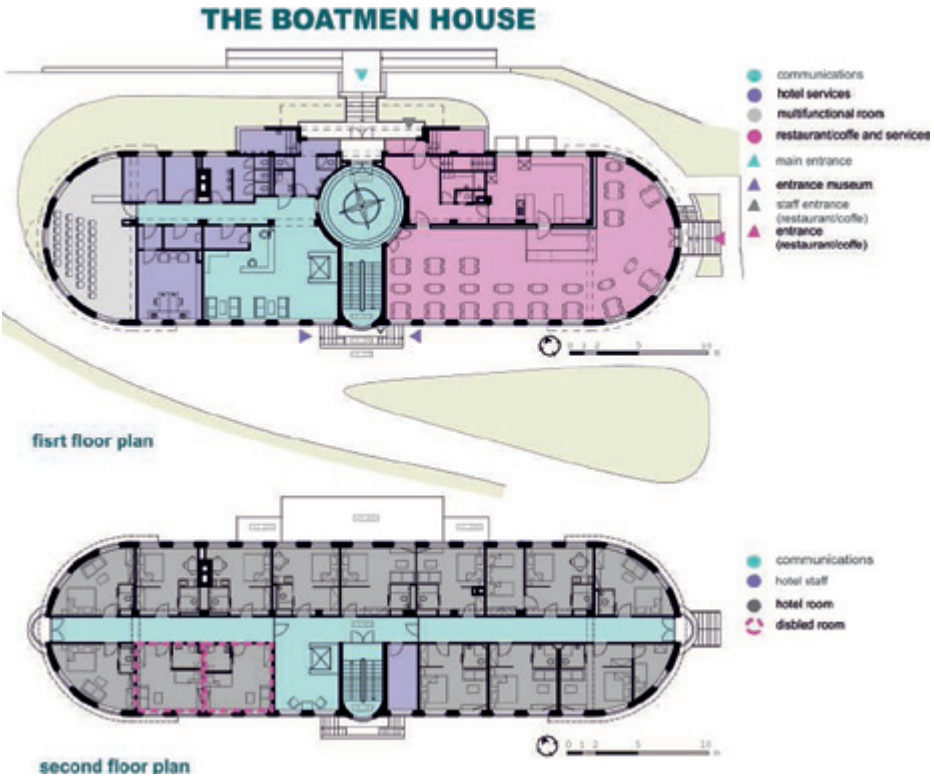


■ **Figure 5.** *The Boatmen House – present (source: Martin Dubiny)*

and an entrance hall that create and support the harbour architecture. Also, the values are a construction system or symmetry on the facade and in the floorplan. Other important elements are double glazed windows with adjustable ventilation, on the south side of the wooden shutters, original floors (terrazzo, parquet, tiles), railings (exterior, interior), ceiling and floor with starfish in the entrance space and glass walls. These authentic features increase its documentary value of the time and they speak about social values, which are the expression of a social culture. These are values that are still there and can still be used.

Function changes of the building left traces in the floorplans. Many rooms have been adapted for the then function. According to original plans, was observed the changes in the floorplan. Subsequently, in architectural studies, these changes have been returned to its original state with smaller changes by adapting to today's conditions. The aim of the study was to insert function which is near to the original purpose with preserved of valuable elements. It was also the preservation of the division of functions in the vertical direction.

The study showed the possibility of inserting hotel facility with a standard of 3 stars with own restaurant and café. Also, it would offer additional services such as bike rental, multi-function hall, observation tower and the basement as wellness spaces or space for a museum (life of boatmen). Today's demands are placed mainly on Friendly design, which was accomplished by sensitive inserting a lift. A sanitary facilities were located on the corridors in the original plan. The study was submitted reversible sanitary cells in each accommodation room.



■ **Figure 6.** *Architectural study – The Boatmen House (source: Katarína Mackovičová)*

This accommodation could provide 36 hotel's room (including 2 disabled rooms) for 76 people, 48 places in restaurant and 26 places in café. Multifunctional room could provide space for around 35 persons.

This study accepted its values and authentic elements with strict compliance the requirements of preservationists [7].

5.3. The Ship Workshop, Ship Lift and tugboat Šturec

The Ship Workshop was built on the site of a former colony, which was demolished in 1943. The first phase of construction workshop was from 1943-44. During the World War II in 1944, the construction and development of the harbour stopped the bombing. The floor plan of Ship Workshop was extended for another six fields after repairing the harbour in 1947. It is unique preserved hall construction this type in Slovakia.

The Ship Workshop belongs to the industrial buildings. Basic of construction is composed by 12 reinforced concrete frames filled with brick masonry and wooden roof structure. In the past, it served for repair ship parts. Stiffening element across the hall is crane track, where is overhead crane with a lifting capacity 2500 kg [2].



■ **Figure 7.** *The Ship Workshop, Ship lift and tugboat Šturec (source: Martin Dubiny)*

Rebuilding hall was around the 70s of the 20th century. The exact dating is not known but it has brought layout changes. The hall was divided by a wall, which created space for a smaller frame of three fields.

Room for chief, small workshop and wooden warehouse (on the second floor) are situated in the southwestern part of the hall. Whether its original condition or delayed reconstruction is not entirely clear.

Window panels are large-sized rectangular windows in a metal grid. Several of them are preserved in original state – architectural, documentary values. It is preserved building of warehouse and it was built in the time that belonged to the most significant period of development of harbours in Slovakia, respectively in Czechoslovakia. This is historical values and documentary values too.

The Ship lift was built in the 30s of the 20th century by german company – Hitzler Regensburg. Elevator operates seven tracks to a cable winch. A crane track and an engine room is including in this lift. The crane has unfortunately not survived. It was removed in a later second half of the 20th century. This lift is used for repair and maintenance of ships as in the past. Today, it is home to the tugboat Šturec, which is in the list of NCM since 2011. It is the unique technological mechanism from a historical and technical point of view, which have resisted the bombing during the World War II and is fully functional to this day.

The tugboat Šturec, originally named Štúr, was built as tanker by Komárno shipyard in 1937. It was injured during the bombing of June 16, 1944. In this time, there were damaged many ships. In 1962, the tugboat was rebuilt. His torso was shortened and the ship has got a new name "Šturec". Tugboat Šturec served for harbour several years [1].

The architectural study designed a new function – The museum of water transport. This museum consists of exhibition space, conference rooms, public spaces and facilities of the museum. **The Ship Workshop** – Exhibition spaces is designed in the central volume of the main hall. The conference hall is with a capacity of about 100 people. Space can be converted into two smaller ones. Souvenirs shop and café are incorporate among the public spaces in addition to the museum. The café is designed on the second floor with possibility of view on tugboat Šturec and surrounding South basin. The created architecture elements have not markedly changed in comparison with original. Mass shipping halls remain in the traditional breakdown. Markedly change is reflected only in the interior of the hall. The construction height of the hall is fully used. The hall was divided into two floors on the southwest and northeast part. This dividing increase floor space.

Lightweight steel reversible construction of ramps and stairs is a new element in **the Ship Lift**. It is construction for better access to tugboat Šturec. The life of boatmen is a possibility for presenting in the **Šturec** as authentic space. In the present, it is under the reconstruction. The study has the ambition

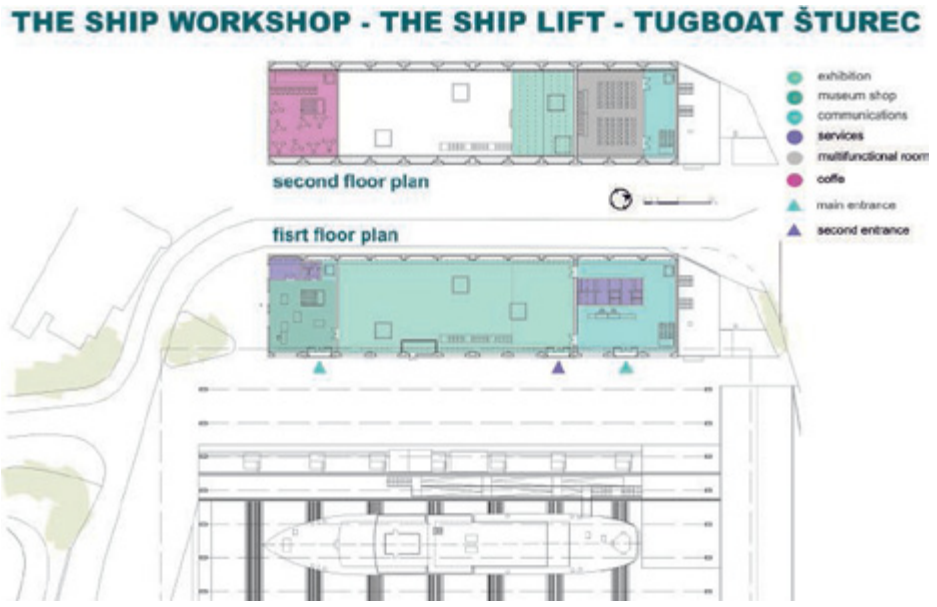


Figure 8. *Architectural study – The Ship Workshop, Ship lift and tugboat Šturec – floorplan (source: Martin Dubiny)*

to contribute to defining an appropriate disposition for cultural function within the space tugs.

A significant element of the design is covering, which provides protection for the Ship Lift and tugboat Šturec from the weather. It is a simple steel structure, which is slim and light in the overall impression. Height does not exceed the surrounding building that will not become competition for the other buildings and monuments. [2]

The architectural study sensitively work with monument values and highlight this values of each object at the same time. Each object has unique values, which share their common functional identity, historical and documentary value. They document a development harbour infrastructure in Slovakia, respectively former Czechoslovakia.

6. CONCLUSION

The preservation of industrial heritage is important not only for us but for future generations as evidence of industrial activity ever since. It often happens that their cultural values are put into contrast with the economic development of the area. However, it can be refuted on the positive examples not only the existing revitalization but also other perspective adaptation by architectural studies. Prepared studies have shown that adapting and revitalizing areas is possible connect with the use of cultural values and include them in active life of the city. They will not only create atmosphere but will also generate profit.

Acknowledgement

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SAŽETAK

Zimska luka u Bratislavi dijelom je luke koja je u prvoj polovici 20. stoljeća spadala među najveće kopnene riječne luke u središnjoj Europi. Područje Zimske luke počelo se razvijati od 1897. kao mjesto na kojemu će brodovi prezimiti, a poslije je bilo povezano i s prekrcajem roba. Budući da je kompleks luke imao intenzivan transport, tehničke i gospodarske aktivnosti razvile su se izgradnjom dvaju umjetnih bazena u blizini plovidbenog toka rijeke Dunav. U drugoj polovici 20. stoljeća počele su se razvijati nove djelatnosti. Novi, tehnički i uslugom popravaka opremljen kompleks razvio se oko novoizgrađenih zgrada uz rijeku. Površine koje su pripadale pristaništu brodova Zimske luke sada preuzimaju nove rezidencijalne i komercijalne građevine, a povijesne lučke zgrade se ruše.

Nedavno je Slovački državni odbor za očuvanje spomenika odlučio neke zgrade Zimske luke staviti na popis nacionalnih zaštićenih spomenika. Vlasnici tih zgrada uložili su žalbu na tu odluku obrazlažući je time da napuštene zgrade nemaju kulturološku vrijednost i da njihovo očuvanje ograničava poslovni razvoj. Izrađena je stručna studija koja je potvrdila postojanje tih vrijednosti. Istodobno je napravljena studija o iskoristivosti tih povijesnih zgrada Zimske luke kako bi se sačuvale njihove kulturološke vrijednosti i to tako da se unaprijede i podrže turističke aktivnosti u kontekstu cijeloga grada Bratislave.

Ovaj rad prikazuje rezultate te studije nakon uključivanja obnovljenih povijesnih zgrada (Stara kuća pomoraca, Dvorana za popravak brodova, brodsko dizalo i teglenica Šturec) u revitalizaciju cijelog kompleksa Zimske luke kao aktivnog dijela razvoja turizma riječne plovidbe i obrazovno-rekreacijskih aktivnosti u skladu s razvojnim programom grada.

Ključne riječi: *Zimska luka, Dunav, Bratislava, spomenici, očuvanje, revitalizacija*

THE GLOBAL ARMS MARKET AND THE CHALLENGES OF TORPEDO PRODUCTION

Globalno tržište oružja i izazovi u proizvodnji torpeda

Katherine C. Epstein*

SUMMARY

I propose to write a 10,000-word paper exploring three themes: first, the nature of torpedo production, focusing on Whitehead's works in Fiume; second, the ways in which torpedo production created intellectual property rights problems; and third, the reasons why torpedo production, with its associated intellectual property rights problems, may be considered the start of the military-industrial complex. My paper will cover some of the same ground that I covered in my book Torpedo: Inventing the Military-Industrial Complex in the United States and Great Britain *(Harvard University Press, 2014), and it will contain some unpublished material on Whitehead's works.*

In the decades before World War I, naval strategy and tactics were transformed by a wave of new technologies. One of the most important was the torpedo, and navies around the world competed to develop ever faster, more accurate, and longer-range versions. However, the complexity and expense of the torpedo rendered traditional methods of weapons procurement impossible. Whitehead's works in Fiume were the center of international torpedo work, but there were a number of other private-sector suppliers, and several national governments established their own public-sector torpedo research, development, and production capabilities as well. Instead of simply building torpedoes for themselves or purchasing them as finished products from the private sector, as had been the norm, governments found themselves having to invest in private-sector torpedo research and development (R&D). This collaboration between the public and private sectors during the R&D phase made it difficult to establish which party owned the resulting intellectual property rights. Efforts by governments and defense contractors to navigate these challenges may reasonably be said to have created the military-industrial complex.

Keywords: *mass production, flexible specialization, Fiume, arms market, torpedo*

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SAŽETAK

Namjeravam napisati rad od 10.000 riječi, u kojem će se razmatrati tri teme – najprije o prirodi proizvodnje torpeda s težištem na Whiteheadov rad u Rijeci, nakon toga o proizvodnji torpeda koja je izazvala probleme s pravima za zaštitu intelektualnog vlasništva te o razlozima zbog kojih se proizvodnja torpeda, zajedno s vezanim problemima o pravima intelektualnog vlasništva, može smatrati početkom vojnoindustrijskog kompleksa. Moj će rad obuhvatiti neke od istih tema o kojima sam pisala u svojoj knjizi Torpedo: Inventing the Military-Industrial Complex in the United States and Great Britain *(Torpedo: Stvaranje vojnoindustrijskog kompleksa u SAD-u i u Velikoj Britaniji),* Harvard University Press*, 2014., a sadržavat će i neke neobjavljene materijale o Whiteheadovim radovima.*

U desetljećima prije Prvoga svjetskog rata val novih tehnologija preobrazio je strategiju i taktiku ratne mornarice. Torpedo je bio je među najznačajnijima tako da su se mornarice diljem svijeta natjecale kako razviti brže i preciznije verzije dužeg dometa. Zbog njegove složenosti i troškova, međutim, tradicionalni načini nabave oružja postali su nemogući. Whiteheadov rad u Rijeci bio je središte međunarodnog rada na torpedu, međutim niz dobavljača iz privatnog sektora te nekoliko državnih vlada započeli su vlastito istraživanje, potaknuli razvoj i otvorili mogućnost proizvodnje unutar javnog sektora. Umjesto da sami izgrade torpeda za sebe ili da ih kupe kao gotov proizvod od privatnog sektora, što je dotad bilo pravilo, vlade su počele investirati u istraživanje i razvoj torpeda u privatnom sektoru. Zbog te suradnje između javnog i privatnog sektora u fazi istraživanja i razvoja otežano je utvrđivanje činjenice koja strana posjeduje posljedična prava intelektualnog vlasništva. Smatra se da je trud koji su uložile vlade i dobavljači za obranu kako bi upravljali ovim izazovima doveo do stvaranja vojnoindustrijskog kompleksa.

Ključne riječi: *masovna proizvodnja, fleksibilna specijalizacija, Fiume, tržište oružjem, torpedo*

THERMODYNAMICS OF TORPEDO PROPULSION ENGINES

Termodinamika pogonskih strojeva torpeda

Bernard Franković*, Paolo Blecich**

SUMMARY

The torpedo has fascinated engineers, historians and military experts since the time of its invention. The first torpedoes were powered by engines that converted compressed air into useful work for running the propellers. The energy density of compressed air is rather poor and could not meet the demands for increased speed and range. This demand led to the development of new engines and innovative technologies to fire the torpedo faster and further. At first, the air tank size and the air pressure were increased but with modest results and more problems to solve. Air engines could handle medium pressure while air tanks were pressurized at much higher pressures. The solution was to install a pressure reduction valve between the air tank and the air engine. However, the problem was air cooling caused by free expansion in the pressure reducer. Excessive air cooling could have led to ice formation and engine malfunction. The new solution was to use fuel to preheat air before the pressure reducer. Yet again, a new problem emerged. Air overheating adversely affected the equipment and the air engine durability. Water was the new solution. Spraying water into the combustion chamber, the temperature is maintained within safe limits but the work potential of compressed air is increased. This alternation between problems and solutions made the torpedo a revolutionary weapon that transformed naval warfare forever.

This paper studies the physics and follows the innovation process behind the torpedo engine. Different countries had different lines of development. The Whitehead company was for long a successful family enterprise, relying on the loyalty of its members and on the ingenuity of their workers. Great Britain, United States, Germany and Japan followed closely the development of the Whitehead while hoping to build better designs. Other countries chose to purchase the Whitehead torpedo or to rely on less-performing copies.

Keywords: *torpedo engine, compressed air, cold running torpedo, dry heated torpedo, wet heated torpedo, Gesztesy wet heater, turbine torpedo, Whitehead torpedo, multi-cylinder radial engine, double-acting two-cylinder engine*

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1. INTRODUCTION

In the first half of the 19th century, navies and inventors wanted to develop self- propelled underwater mines that could target and sink enemy ships, as a weapon of defense and attack. This new device needed a compound system of technologies, such as the exploder and warhead, the fuel and air storage, the propulsion engine, the steering and targeting mechanisms. The development of a reliable and strong propulsion system was among the main concerns. In 1866, Giovanni Luppis and Robert Whitehead built the first torpedo, which would become a revolutionary weapon in the years to come [1]. For sure, the initial years were marked by technical problems. The innovative solutions and new technologies brought to solve these problems testify on the ingenuity of the engineers working on the torpedo. Robert Whitehead adopted a steam engine working on compressed air. The performance of the first torpedo was modest: a firing range of 200 meters at a speed of 6.5 knots. Three decades later and the Whitehead torpedo had a mass of 530 kg, a warhead of 90 kg, and achieved a firing range of 1000 m at a speed of 25 knots. The first, two-cylinder engine was replaced by three and four-cylinder radial engines working with air at 100 bar of pressure. From 1895, torpedoes were equipped with gyroscopes that improved the range and accuracy. The next step was to build stronger and bigger air tanks and warhead. Higher speed and longer range were imperatives. The intensive research and painstaking experiments at the turn of the century transformed the torpedo into a feared weapon capable of sinking the strongest ships and taking hundreds of lives. Dry air heaters used fuel to increase the air temperature before the engine, thus giving more power, more speed and increased range. However, excessive temperatures adversely affected the engine performance and the durability of the equipment. In a matter of few years, dry air heaters were replaced by wet air heaters and air-steam engines. In just one decade (1895-1905) the torpedo became a weapon of attack: the firing range increased tenfold (from 1,000 m to 10,000 m) and its speed twofold (from 25 kn to 50 kn). The new torpedo was bigger, stronger, faster and so dangerous that navies started to reconsider the basements of marine warfare.

The hope of the authors is to offer readers new insight into the physics of torpedo engines and to explain the motives behind their evolution. The paper is organized into two principal parts. The first part brings the thermodynamic analysis of torpedo engines (sections 2 and 3) and the second part unfolds the technology development of torpedo engines (section 4).

2. PROPERTIES OF COMPRESSED AIR

2.1. Equation of state of real gases

At atmospheric temperature and pressure air is approximated by the equation of state of ideal gases. However, at higher pressures, the kind of encountered in torpedoes air engines, air departures from the ideal gas behaviour [2]. The equation of state of real gases uses the compressibility factor to account for this behaviour

$$pv = ZRT$$

In the above equation p is the pressure, v is the specific volume, T is the absolute temperature, R is the gas constant and Z is the compressibility factor. Figure 1 shows the variation in the compressibility factor of air with temperature and pressure.

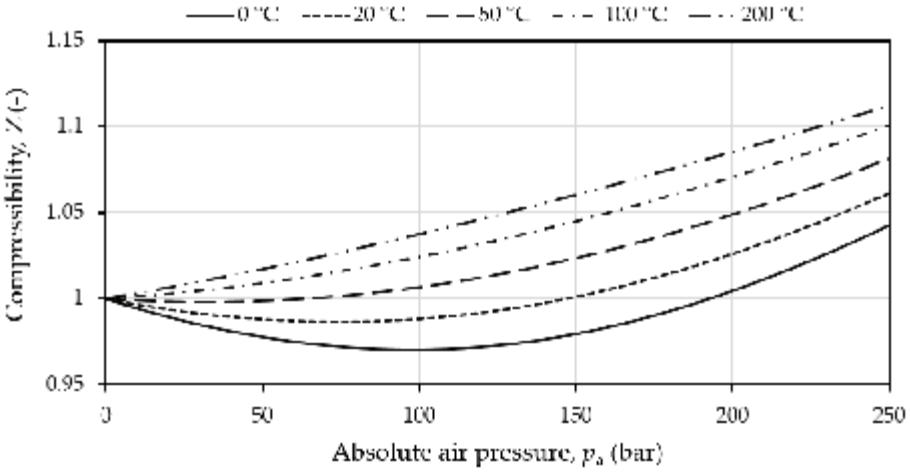


Figure 1. *The compressibility factor Z of air*

The specific heat capacity of air is the amount of heating energy necessary to achieve a unit temperature change per unit of mass. For air and other gases, the specific heat capacity at constant pressure (c_p) is larger than the specific heat capacity at constant volume (c_v) because during an isobaric process the gas volume changes and work is performed. The heat capacity ratio is defined as the ratio between heat capacity at constant pressure and heat capacity at constant volume

$$\kappa = \frac{c_p}{c_v}$$

The heat capacity ratio of air is 1.4 at atmospheric temperature and pressure. the heat capacity ratio. At higher pressures, however, a variation is seen in both specific heat capacities change as it is in the heat capacity ratio. The specific heat capacity at constant pressure and the heat capacity ratio of are are given in Figure 2 and 3.

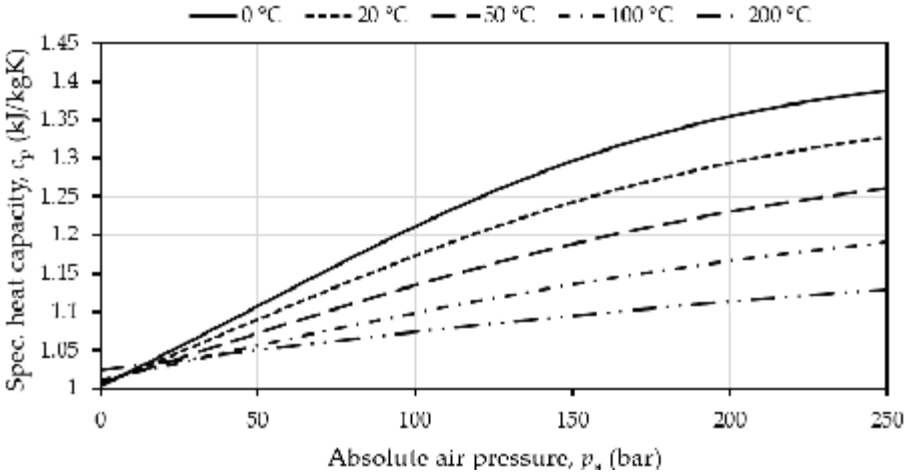


Figure 2. *Specific heat capacity of air at constant pressure*

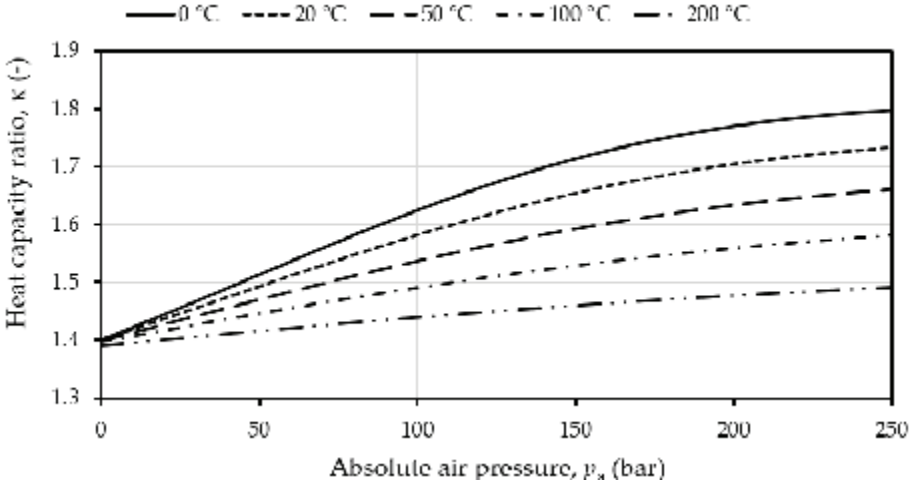


Figure 3. *Heat capacity ratio of air*

2.2. Joule-Kelvin cooling effect

Piston engines can handle pressures in the range of 30 to 50 bar. The first Whitehead torpedoes carried compressed air at 25 bar and a pressure reduction valve was not necessary since the cylinders could handle the air tank pressure. However, demand for increased torpedo power led to the development of air tanks which could store air at higher pressure. In that case, a pressure reducer is installed between the air tank and the engine. Air throttling in the pressure reduces is an adiabatic and non-isentropic free expansion process which is accompanied by cooling (Joule-Kelvin effect, 1852). During free expansion no work is performed and enthalpy remains constant $h = cvT + pv = const$. If air was an ideal gas the temperature would not change because air would behave as an ideal gas with $pv = RT$. However, air is a real gas and its temperature changes by the rate of change in the compressibility factor. During free expansion from a high pressure at atmospheric temperature, the compressibility factor Z increases, so that $Z \rightarrow 1$ (Figure 1). For the enthalpy to remain constant, the temperature has to decrease $h = cvT\downarrow + ZRT\uparrow = const$, with $pv = ZRT$. The Joule-Kelvin coefficient of air has a value of around 0.2 K/bar, which means that the temperature drop is 0.2 K for a pressure drop of 1 bar. The drop in air temperature increases with the air tank pressure. In the event that the air tank pressure is 135 bar and that the reduced pressure is 35 bar, the pressure drop is 100 bar while the air temperature drop is 20 °C. This can result with temperature below 0 °C, causing freezing of air moisture, ice formation and engine malfunction.

3. ANALYSIS OF TORPEDO ENGINES

3.1. Cold running torpedo

The principle of operation of the air engine is similar to that of the reciprocating steam engine [3]. In the air engine, the working medium is compressed cold air (*cold running torpedo*), compressed heated air (*hot running torpedo*) or wet-heated compressed air (*steam torpedo* or *wet heated torpedo*). Figure 4 shows the schematic of the air cylinder.

Inside the cylinder, air expands and pushes the piston downwards. The volume displaced by the piston from the start of the stroke (top dead center: TDC) to the end of the stroke (bottom dead center: BDC) is called swept or displacement volume. When the piston is at the top dead center (TDC), the volume left inside the cylinder is called clearance volume. The rapid expansion of air in the cylinder can be idealized as an adiabatic process process ($pV^k = C$) since heat transfer with the surrounding is negligible.

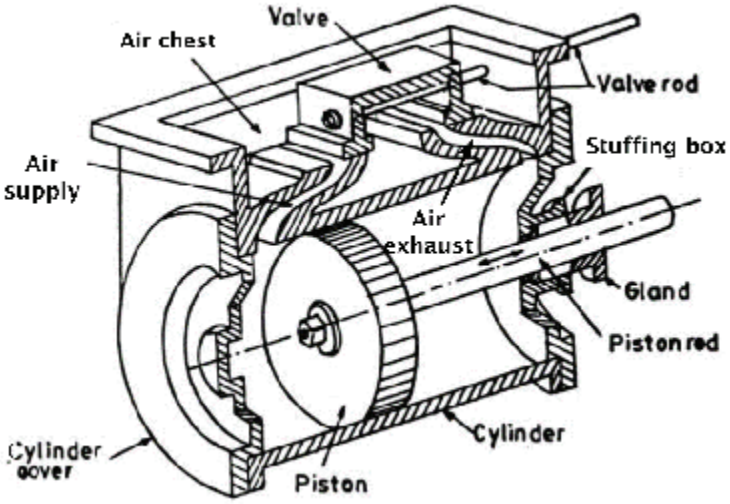


Figure 4. *The cylinder of the air (steam) engine*

The theoretical process (1-2-3-4-5-1) and the actual process (A-B-C-D-E-F-A) in the cylinder of the air engine are given by the indicator diagram in Figure 5.

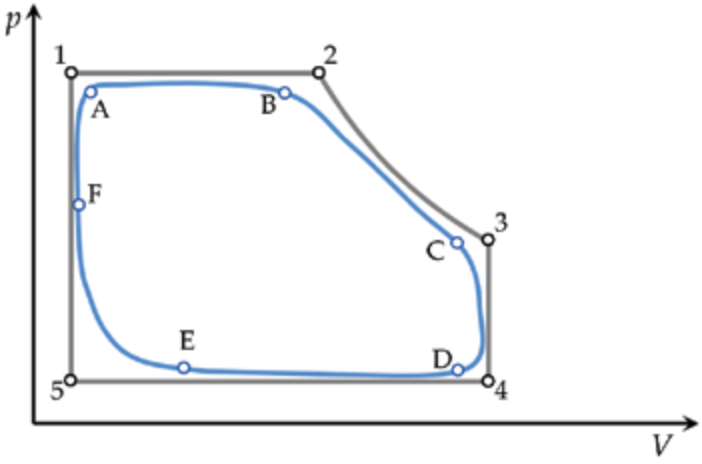


Figure 5. *The pV indicator diagram of the air engine: theoretical process (1-2-3-4-5-1) and actual process (A-B-C-D-E-F-A)*

In point 1, compressed air enters the cylinder at constant pressure $p1$ and the piston moves downwards. In the cut-off point 2, the supply port closes and expansion of air is performed up until point 3. The expansion of air is an adiabatic process, with the relation $pV^k = C$. The downwards movement of the piston is transformed into shaft rotation and positive work is obtained. Before

the end of the forward stroke, in the release point 3, the exhaust port opens and air begins to exit from the cylinder. As result, the pressure drops rapidly without change in volume (3-4 and C-D). Then, the piston moves in the opposite direction and air is exhausted into the atmosphere at constant pressure (4-5 and D-E). From point 5 to point 1, the cylinder is filled by compressed air at constant volume. In the actual process, compression starts before the end of the return stroke and continues up until the point of admission (E-F), after which air is supplied at constant volume (F-A).

The area enclosed by the processes 1-2-3-4-5-1 is the useful work obtained by the theoretical process in the air engine. The actual process A-B-C-D-E-F-A, on the other hand, achieves a smaller useful work due to heat losses, friction losses, pressure drop in the supply and exhaust valves. The theoretical area can be calculated as the sum of the work of the adiabatic expansion (2-3), isochoric expansion (3-4) and the negative work of the isochoric compression (4-1)

$$W_{\text{theory}} = W_{23} + W_{34} + W_{41} = \frac{\kappa}{\kappa - 1} p_2 V_2 \left[1 - \left(\frac{p_3}{p_2} \right)^{\frac{\kappa-1}{\kappa}} \right] + V_3 (p_3 - p_4) - V_1 (p_1 - p_4)$$

The ratio of the actual process work to the theoretical process work is called diagram factor (F) and is between 0.70 and 0.90, depending on the engine efficiency.

$$W_{\text{actual}} = F \cdot W_{\text{theory}}$$

For an estimate of the air engine power, the following assumptions are made: the compound two-cylinder air engine performs the combined expansion of the two cylinders without condensation of air moisture; the cut-off volume is three times the clearance volume ($V_2 \approx 5V_1$) and the exhaust absolute pressure is 5 Atm ($p_3 = 5\, p_0$). In that case, the swept volume is

$$p_2 V_2^{\kappa} = p_3 V_3^{\kappa} \quad \rightarrow \quad V_3 = V_2 \left(\frac{p_2}{p_3} \right)^{1/\kappa}$$

The Whitehead prototype torpedo from 1866 was 3.4 m in length, 0.36 m in diameter, with an air tank pressure of 25 Atm, a firing range of 200 m at a speed of 6.5 knots. The air tank volume was $V = 0.15$ m^3 and the air tank temperature $T_1 = 293$ K (atmosphere temperature). It follows that the total air mass is 4.5 kg. At the end of the torpedo run, it is assumed that the air tank pressure is 5 Atm, which means that 0.9 kg of air is left in the tank. The amount of air available for the torpedo run is then 3.6 kg or 0.12 m^3. The torpedo completes the 200 m range in 60 seconds. The specific air consumption is then $\dot{V}_1 = 0.002$ m^3/s or 0.06 kg/s. Assuming that the actual power of the air engine is 0.7 (diagram

factor) of the theoretical, the average power of the torpedo air engine over its effective range is then

$$P = 0.7 p_2 \dot{V}_2 \left\{ \frac{\kappa}{\kappa - 1} \left[1 - \left(\frac{5 p_0}{p_2} \right)^{\frac{\kappa-1}{\kappa}} \right] + \frac{4}{5^{1/\kappa}} \left(\frac{p_0}{p_2} \right)^{\frac{\kappa-1}{\kappa}} + \frac{1}{5} \left(\frac{p_0}{p_2} - 1 \right) \right\} = 5.7 \text{ kW}$$

It should be noted that this is the power of the air engine, and that the power of the propulsion system is certainly reduced by all the losses (friction, heat, gears, bearings) occurring in between the engine and the propeller. The specific air consumption per unit of generated energy in the air engine is calculated

$$m_{spec} = \frac{m_{air}}{P \cdot \tau}$$

Since the mass of air available for work is 3.6 kg and the generated energy is 95 Wh (product of engine power and time in hours), the specific air consumption is 38 kg/kWh. The exergy (maximum useful work) of the compressed air that expands from point 2 to the ambient state 0 is

$$B = H_2 - H_0 - T_0 (S_2 - S_0) = \dot{m} c_p (T_2 - T_0) - \dot{m} T_0 \left(c_p \ln \frac{T_2}{T_0} - R \ln \frac{p_2}{p_0} \right)$$

The air temperature at the cut-off point is the air tank temperature, which is about equal the atmosphere temperature ($T_2 = T_0$). The exergy of the compressed unheated air is equal to the useful work of the isotherm expansion between tank pressure and atmosphere pressure

$$B = \dot{m} R T_0 \ln \frac{p_2}{p_0} = 16.2 \text{ kW}$$

The exergy efficiency of the torpedo air engine is determined as the ratio of the actual engine power to the maximum useful work of compressed air

$$\eta_B = P / B = 35\%$$

The specific exergy (or energy density, B/V) of compressed air is low compared to other energy sources. The energy density of air at a pressure of 25 Atm is only 2.3 kWh/m^3 while it would be 30 kWh/m^3 at 200 Atm. The Howell's flywheel spun at 10,000 rpm would also achieve about 30 kWh/m^3. For comparison, the energy density of modern energy storage is: 600 kWh/m^3 for lithium-ion batteries, 2700 kWh/m^3 for CNG (at 250 Atm), 6400 kWh/m^3 for LNG and 9000 kWh/m^3 for gasoline and diesel.

The cold running Mk1 and Mk2 Whitehead torpedoes (0.45 m × 3.55 m) manufactured for the US Navy in the 1890s had an air tank volume of 0.2 m^3 at a pressure of 92 Atm [4]. The total mass of air in the tank is 22.5 kg (at 20 °C, compressibility factor Z = 0.987). A valve was used to reduce the air pressure to 35 Atm before the engine. The firing range and speed of the torpedo was 730 meters at a speed of 26.5 knots (13.6 m/s), which return a running time 54 seconds. Assuming that at the end of the run the air tank pressure is 5 Atm, the mass of air in the tank is 1.2 kg. Therefore, the mass of air available for work is 21.3 kg, which returns a specific air consumption of 0.4 kg/s. Free expansion of air (Joule-Kelvin effect) in the pressure reducing valve causes air cooling from 20 °C to 8.6 °C. The air flow rate through the engine is then 0.0091 m^3/s at a pressure of 35 Atm. The power of the three-cylinder reciprocating engine is 42.5 kW.

This power increase with respect to earlier Whitehead models can be attributed to a higher inlet pressure and increased air flow rate in the three-cylinder engine.

In the early 1900s, the most advanced cold running torpedoes (0.45 × 5.1 m) had a four- cylinder radial engine. Air was stored at pressure of 150 Atm inside a tank of 0.3 m^3. The total mass of air in the tank is 54 kg (at 20 °C, compressibility factor Z = 1.001). A pressure reducer was used to reduce air pressure to 40 Atm before the engine. These torpedoes had the following range (d) and speed (w) adjustment capability:

a) d = 1500 m, w = 30 knots
b) d = 2500 m, w = 24 knots
c) d = 3500 m, w = 20 knots

Free expansion of air in the pressure reducer may cause freezing as the cooling effect is bigger, from 20 °C to -2 °C (150 → 40 Atm). Taking that the pressure in the air tank is 5 Atm at the end, the amount of air available for work is 52.2 kg. Based on range- speed settings, the torpedo running time (t) and the air specific consumption ($\dot{G}$) are

a) t = 97 s, $\dot{G}$ = 0.538 kg/s
b) t = 202 s, $\dot{G}$ = 0.258 kg/s
c) t = 340 s, $\dot{G}$ = 0.153 kg/s

The power of the four-cylinder reciprocating engine is higher for a shorter run and lower for a longer run

a) P = 57 kW
b) P = 27.4 kW
c) P = 16.3 kW

In the above case, the energy generated over the torpedo run is 1.54 kWh, the specific air consumption is 34 kg/kWh and the exergy efficiency is 37%. [4, p. 49]

3.2. Hot running torpedo

Kerosene is a low viscosity fuel with a density of around 0.8 kg/m^3 and is composed of hydrocarbons containing between 8 and 16 carbon atoms. In a simplified combustion process, kerosene can be expressed as decane with chemical formula $C_{10}H_{22}$, its reaction with oxygen is

$$1\ \text{mol}\ C_{10}H_{22} + 15.5\ \text{mol}\ O_2 \rightarrow 10\ \text{mol}\ CO_2 + 11\ \text{mol}\ H_2O$$

$$1\ \text{kg}\ C_{10}H_{22} + 3.5\ \text{kg}\ O_2 \rightarrow 3.1\ CO_2 + 1.4\ H_2O$$

The specific oxygen demand for the complete combustion of decane is 15.5 kmol/kmol. Taking that the volume ratio of oxygen in air is 21%, the specific air demand is then 73.8 kmol/kmol. In other words, the air to fuel mass ratio is 15 kg/kg

$$1\ \text{kg}\ C_{10}H_{22} + 3.5\ \text{kg}\ O_2 + 11.5\ \text{kg}\ N_2 \rightarrow 3.1\ \text{kg}\ CO_2 + 1.4\ \text{kg}\ H_2O + 11.5\ \text{kg}\ N_2$$

The above reaction represents the reaction of decane with the minimum amount of air for complete combustion. The lower heating value of decane is 44 MJ/kg, which is near to the heating value of kerosene 43 MJ/kg. The flash point temperature (combustion of vapors with presence of ignition source) of kerosene is between 40 and 60 °C. The idea behind adding fuel to compressed air is clear. The performance of the torpedo engine can be substantially enhanced by increasing the energy content of the working medium. The energy density of kerosene is 35 MJ/L or 9700 kWh/m^3. On the other side, the energy density of compressed air at 150 Atm is only 21 kWh/m^3. The energy balance for the wet heater

$$H_{\text{air}} + H_{\text{water}} + \eta H_{\text{fuel}} = H_{\text{gases}} + H_{\text{steam}}$$

The enthalpies of air, water, fuel gases and steam are expressed as

$$m_a c_p t_0 + m_w c_w t_0 + \eta m_f H_d = m_{a+f} c_p t_1 + \left[m_w c_w t_{sat} + m_w \cdot r + m_w c_{vap} (t_1 - t_{sat}) \right]$$

The temperature of the gas-steam mixture

$$t_1 = \frac{m_a c_p t_0 + m_w c_w t_0 + \eta m_f H_d - m_w c_w t_{sat} - m_w \cdot r + m_w c_{vap} t_{sat}}{m_{a+f} c_p + m_w c_{vap}}$$

Taking that the specific heat capacities are: 1.1 kJ/kgK for air, 1.2 kJ/kgK for gases, 4.2 kJ/kgK for water, 2.2 kJ/kgK for superheated steam. The volume fraction of steam in the gas-steam mixture is about 40%, the saturation

temperature is t_{sat} = 200 °C) and the latent heat of vaporization r = 1935 kJ/kg. The temperature of the gas-steam mixture depends on the mass ratio between fuel (F), water (W) and air (A). Assuming that heat losses and incomplete combustion reduce the heating value by 40%, the fuel efficiency is η = 0.6. Now, the following temperature are

t_1 = 1065 °C, for F:W:A = 1:0:15} *dry heated torpedo*

t_1 = 774 °C, for F:W:A = 1:3:15
t_1 = 633 °C, for F:W:A = 1:4:15
t_1 = 512 °C, for F:W:A = 1:5:15 } *wet heated torpedoes*
t_1 = 408 °C, for F:W:A = 1:6:15
t_1 = 317 °C, for F:W:A = 1:7:15

Generally, wet heated torpedoes operated with temperatures in the range of 400 to 600 °C. By adjusting the F:W:A ratio, the temperature of the gas-steam mixture can be fine-tuned. As in the previous example, the cold-running torpedo with 52.2 kg of cold air and an inlet temperature of -2 °C would now become a wet heated torpedo with 52.5 kg of gas-steam-mixture (F:W:A = 2.5 : 12.5 : 37.5) and inlet temperature of 512 °C. This wet heated torpedo would have the following range-speed settings [5]

a) d = 1500 m, w = 41 knots
b) d = 3000 m, w = 35 knots
c) d = 5000 m, w = 30 knots

Based on these range-speed settings, the torpedo running time (t) and the air specific consumption ($\dot{G}$) are

d) t = 71 s, $\dot{G}$ = 0.739 kg/s
e) t = 167 s, $\dot{G}$ = 0.314 kg/s
f) t = 324 s, $\dot{G}$ = 0.162 kg/s

The power of the four-cylinder reciprocating engine is higher for a shorter run and lower for a longer run

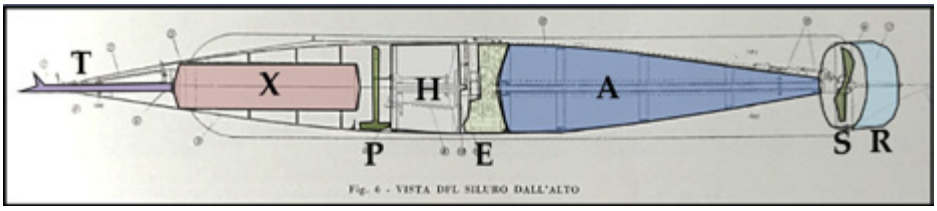
d) P = 226.7 kW
e) P = 96.3 kW
f) P = 49.7 kW

Now, the wet heated engine generates 4.5 kWh of energy with a specific consumption of 11.7 kWh/kg and the exergy efficiency is 46%.

4. HISTORICAL DEVELOPMENT OF TORPEDO ENGINES

4.1. Cold-running torpedoes (1866-1900)

In the beginning of the torpedo development, the air engine employed by Whitehead is an adapted cross-compound steam engine [6], patented by Arthur Woolf in 1805. The Whitehead torpedo from 1866, shown in Figure 6, used compressed air at 25 Atm. This engine uses a high-pressure cylinder and one subsequent low-pressure cylinder (Figure 7), a design that avoids excessive expansion inside a single cylinder, which could cause condensation and re-evaporation of air moisture and loss of efficiency.

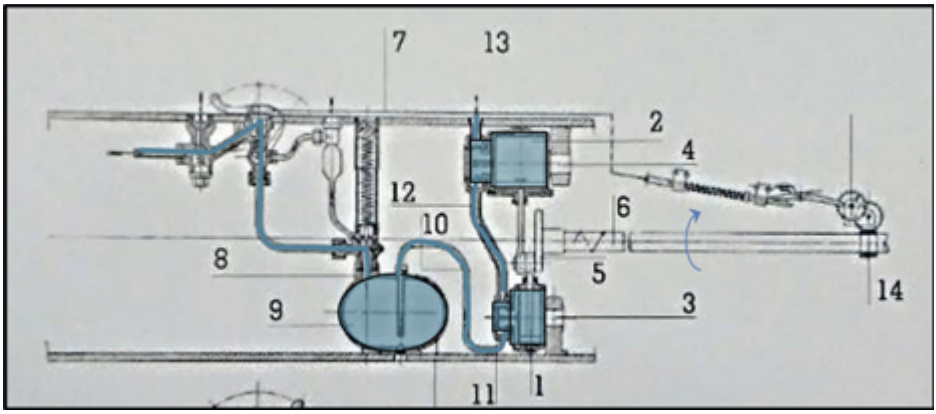


Warhead:		Propulsion system:		Guidance/steering:	
T	trigger (war nose)	A	compressed air tank	H	hydrostatic chamber
X	explosive charge	E	air engine	P	pendulum and hydrostatic valve
		S	single propeller	R	rudders and armour ring

Figure 6. *The main parts of the Whitehead torpedo (1866)*

The cylinders convert compressed air into mechanical work. The pressure of air pushes the piston in back-and-forth motion. The back-and-forth motion of the piston is converted into rotation motion of the crankshaft through a connecting rod. The crankshaft rotation is geared down and transferred to the drive shaft of the propeller.

Early Whitehead torpedoes used a two-cylinder reciprocating engine running on compressed cold air and connected to a single propeller. The torpedo steering control was adversely affected by the lateral placement of the air exhaust and the asymmetrical torque caused by the single propeller.



1	high-pressure cylinder	6	drive shaft	11	high-pressure air pipe
2	low-pressure cylinder	7	housing	12	low-pressure air pipe
3	bearing pocket (HPC)	8	air supply pipe	13	air exhaust
4	bearing pocket (LPC)	9	lubricating oil tank	14	cogged gears for firing range adjustment
5	shaft gear	10	lubricated air pipe		

Figure 7. *The two-cylinder cross-compound engine of the Whitehead torpedo (1866)*

Peter Brotherhood, a British engineer, developed a three-cylinder radial-pattern reciprocating engine, in which air flowed through the propeller hollow drive shaft down to the exhaust at the torpedo tail. The torpedo propulsion system was also improved replacing the single propeller with balanced contra-rotating propellers.

In 1877, Whitehead adapted the Brotherhood three-cylinder engine and the contra- rotating propeller. The three cylinders (A) are placed in the transverse vertical plane with their axes 120° apart, Figure 8. Compressed air from the air tank passes through a reducing-valve that ensures constant air flow rate regardless of the air tank pressure. The pistons have a longintudinal motion over the piston stroke, alternatively opening air supply ports, closing them and opening air exhaust ports. The single propeller screw was replaced by contra rotating propellers. In the last decade of the 19th century, the Whitehead torpedo was substantially improved in terms of engine power, speed, range and accuracy. The following innovations were introduced:

- 1889: Whitehead started the production of 18-inch torpedoes, beside the standard 14-inch model, to further meet the requirements for increased range and speed (US Navy: Whitehead Mk 1 and Mk 2).
- 1895: the Obry gyroscope was added to torpedoes for increased horizontal accuracy (US Navy: Whitehead Mk 3). The horizontal firing deviation

improved from ±22 m down to ±7 m, at a firing range of 730 m, meaning that the effective firing range increased to 2000 m.

- 1898: nickel-steel air tanks replaced the standard steel tanks and allowed for higher air pressures. The maximum air tank pressure was increased from 100 bar to 150 bar, meaning higher energy density in the stored compressed air.
- 1900: the three-cylinder radial engine was replaced by a four-cylinder Brotherhood radial engine. The 18-inch Whitehead model with the four-cylinder Brotherhood radial engine was the Whitehead Fiume III torpedo in the Royal Navy.

In this period, Whitehead tested various engine designs including the eight-cylinder radial engine and the gyroscopic engine. Air pressure and flow rate, the cylinder compression ratio, the size and number of cylinders, the piston geometry, the placement of admission and exhaust ports were considered all affecting the performance of the air engine. The goal was to find the optimal design and operating conditions that would lead to increased engine power, torpedo speed and firing range. Some of these research efforts and designs never found practical application, but they testify on the Whitehead's deep understanding of the development process necessary for technology improvement.

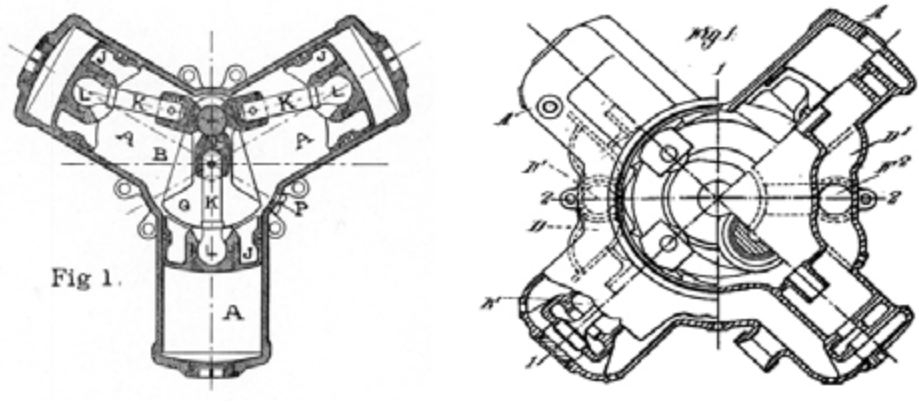


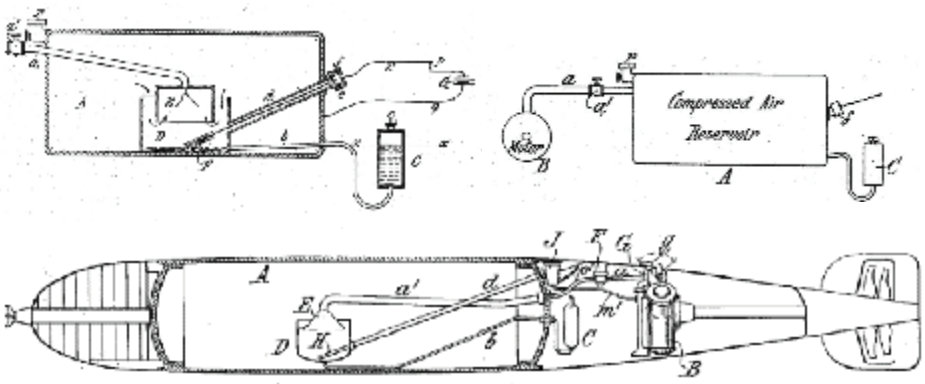
Figure 8. *The three-cylinder and the four-cylinder radial engine (Brotherhood design) of the Whitehead Mk 1 torpedo, produced for the US Navy in 1892.*

In the late 19th century, Whitehead torpedoes were propelled by compressed air and were deemed "cold running" torpedoes. The speed and the firing range as well as the overall performance of these torpedoes could be increased by either larger air tanks or higher air pressures. At first, bigger torpedoes with larger air tanks were produced (18-inch torpedo). This solution proved to be partially successful since the maximum torpedo dimensions were

limited by the firing tube size and the available space on warships and submarines. The other solution was to increase the air tank pressure, which was a real possibility following the improvement of materials and manufacturing techniques for pressurized tanks (nickel-steel tanks). Higher air tank pressure leads to increased engine power due to a larger total expansion of air. However, larger air expansion causes more air cooling, which leads to moisture freezing, air pipe clogging and engine malfunction, eventually.

4.2. Hot running torpedoes (1900-1905)

Several solutions to the freezing problem had been proposed. The first was to preheat the air before entering the engine in long coils using the surrounding seawater. The second was to add an air heating device (air heater or superheater) between the air tank and the air engine, in which air would be heated by combustion of a fuel. The Royal Navy tested both solutions and concluded that the seawater heated coil slightly increased the torpedo speed while fuel combustion increased the engine power by 10 percent. The first air heater designs included burning a spray of liquid fuel (alcohol or kerosene) in the air tank itself (inside air heater). Figure 9 depicts the Leavitt's torpedo with an air heater placed in the air tank. Alcohol from the fuel tank (C) is supplied through a small pipe (b) to the air heater (D) placed inside the air tank (A). The fuel is ignited by means of a percussion fuse or electric fuse (H, F). Heated air enters is ducted into an inverted hood (D) and through the air supply pipe (a') is brought to the engine (B). In his patent application, Leavitt mentions that the air heater increases the work obtained by the air engine by about 50 percent.



■ **Figure 9**. *The Leavitt's torpedo with inside air heater. US patents 693871, 693872 (1902)*

The inside air heater developed by Leavitt, the lead engineer of the Bliss Company, proved to be a limited design. Inside the air tank the fuel burned erratically causing uneven thermal stress and soot formation. In the extreme event, this would cause tank rupture or soot buildup in the air supply pipe. So,

in 1905, the Bliss Company purchased the license for the application of Armstrong outside air heaters, developed by W. H. Sodeau, for Whitehead and Bliss-Leavitt torpedoes produced in America. Naturally, the Bliss Company also wanted to find the best design for maximum engine power. They carried trials to compare the torpedo engine performance using Leavitt inside air heaters and Armstrong outside air heaters. They found the outside air heater to be in clear advantage: the engine generated 50 percent more power than the engine with an inside air heater [7]. Leavitt estimated his inside air heater adding 50% to the engine performance. Thus, a rough estimate is that the outside air heater doubles the performance of the cold running engine (100% increase).

The reason for this is in the placement of the air heater with regard to the reduction valve. The inside air heater is placed upstream of the reduction valve. This means that the temperature increase of the inside air heater is partially cancelled by the temperature drop in the reduction valve. In the case of the outside air heater, air is first throttled and cooled in the reduction valve and then after heated, which positively affects the performance of the air engine. This experiment clearly revealed that air heaters should be placed in between the air tank and the reduction valve on the one side and the air engine on the other side. Further tests showed that the outside air heater added 10 knots while the inside air heater added 6 knots of speed to cold- running torpedoes. Alternatively, the range could be increased between 2 and 5 times for the same torpedo speed. The Armstrong-Whitworth outside air heater, developed by W. H. Sodeau is showed in Figure 10.

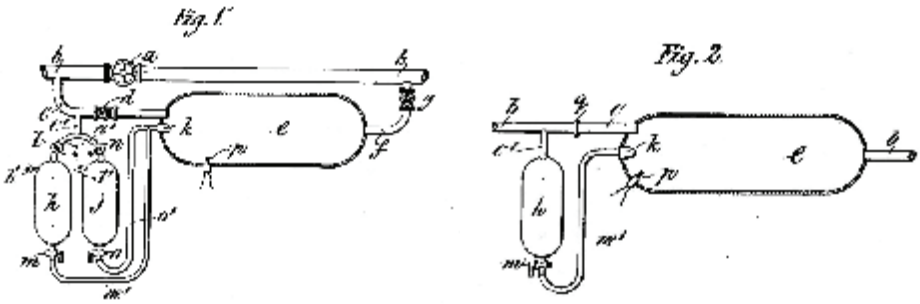


Figure 10. *The outside air heater designed by W.H. Sodeau of Armstrong-Whitworth in 1905, US patent: 835262-1906.*

The left scheme is meant for pneumatic hand-drills and the right scheme the right for torpedo propulsion. The air tank and reduction valve would be on the left side and the engine on the right side of the air heater. The main parts are: combustion pot (e), fuel tank (h, j), fuel spray nozzle (k), electric igniter (p), air supply pipe (b). Sodeau developed a total of seven designs for the outside air heater, published in US patent 964574-1910 (Means for increasing the energy of stored compressed air).

Whitehead purchased the rights for the Armstrong outside air heater, which guaranteed the torpedo superior performance compared to earlier cold running versions. The first Whitehead hot running torpedoes entered production in 1901. This torpedo was named Whitehead Mk 5 in the US and Whitehead Fiume Mk 3 in Britain. It was equipped with an air heater burning kerosene and a four-cylinder Brotherhood radial engine. It achieved a factor five increase in the firing range over older versions and was the first torpedo with range and speed adjustment capability. The speed and range adjustment had to be made through an access hole provided in the torpedo hull before loading in the firing tube. This adjustment consisted by acting on the reduction valve, which controlled the pressure and flow of air and fuel to the air heater. Three settings were available: a high speed of 40 knots over a range of 900 m, a medium speed of 36 knots over 1800 m and a low speed of 27 knots over 3600 m. Soon, air heaters were installed in all new torpedoes while older versions received air heater upgrades.

4.3. Wet heated (steam) torpedoes (from 1905)

Dry air heaters inevitably caused excessive air temperatures that negatively affected the air piping, the valves and the engine. Yet, there was increasing demand for larger, faster and further reaching torpedoes. In a matter of a few years, the focus of the torpedo development switched from dry air heaters onto wet air heaters and air-steam engines. This idea came naturally. Adding water to the hot combustion gases had twofold advantage: while the air temperature is reduced the volume and the energy content of the working medium is increased. In just one decade (1895-1905), the maximum range increased tenfold (from 1,000 m to 10,000 m) and the maximum speed increased twofold (from 25 kn to 50 kn). Suddenly, from a weapon of defense the torpedo developed into a weapon of attack, threatening to outrange the naval big guns and to change the strategy and tactics of marine warfare. By 1905, a lieutenant of the Austrian Navy stationed in Pula, Johann Gesztesy, developed the first design for the wet air heater. Together with Julius von Petravic, a skilled engineer based in Vienna, Gesztesy submitted his wet heater designs to patent offices in Austria, France and Great Britain. The details of the collaboration between Gesztesy and the Whitehead Company are not clear. Most likely, Gesztesy developed his wet air heaters for Austrian Navy torpedoes independently and was later approached by the Whitehead Company when they felt his design was good enough for industrial application. The gradual improvement of the Gesztesy wet air heater in the period from 1905 to 1909 is showed in Figures 11-13. In his early design, Gesztesy claims that the efficiency of air engines is increased by heating the air and mixing it with steam on its way the engine. Water is stored in the compressed air tank (a), which is an unusual solution, and is sprayed into the combustion chamber (f) after flowing through supply pipe (d)

and the valve (e). Air is supplied by the pipe (c) and mixes with fuel which is stored in the fuel tank (g), beneath the combustion chamber (f). Combustion is started by means of an igniter (j). The engine is on the right of the diagram, after the starting valve (i) and the reduction valve (k). The second, improved design is showed in Fig. 14. Now, water is stored in a separate tank (v), outside the air tank (a). The pressure in the water tank (v) is balanced to the reduced air pressure via pipe (w). The reduction valve (k) is moved upstream of the combustion chamber (f) and acts only on compressed air from the air tank (a).

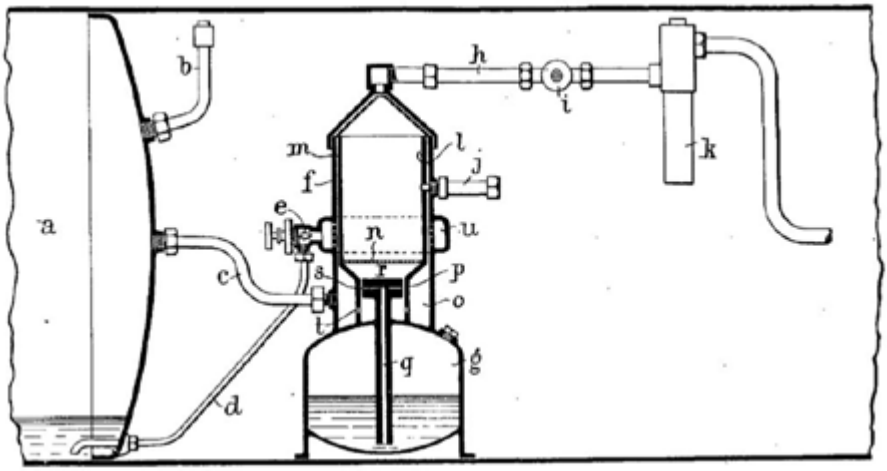


Figure 11. *The early Gesztesy wet air heater (1905). The drawing is from FR patent 373, 757, 1906*

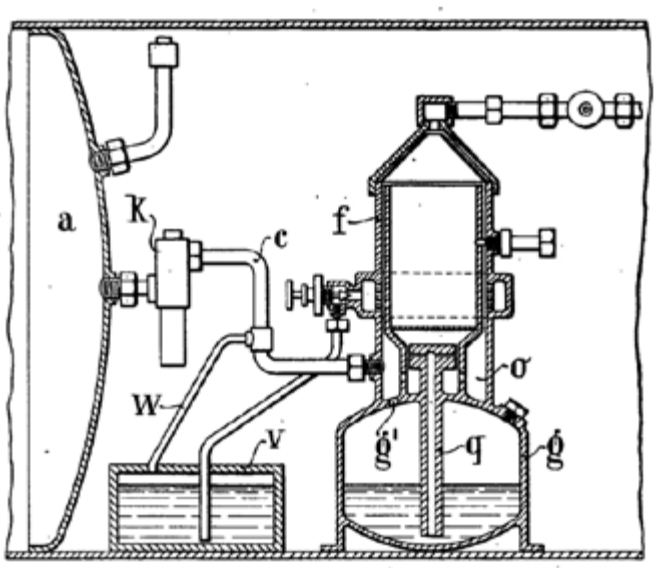
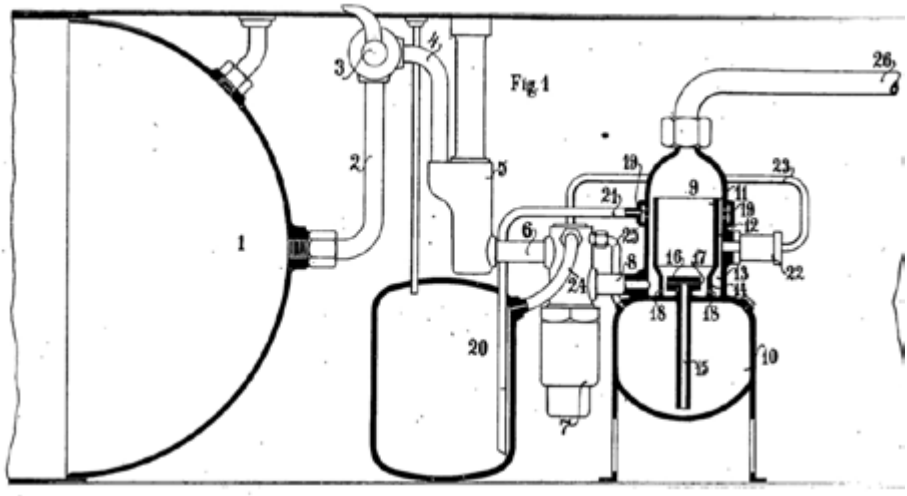


Figure 12. *The improved Gesztesy wet air heater (1906). Drawing from FR patent 373, 757, 1907 – 1st addition*

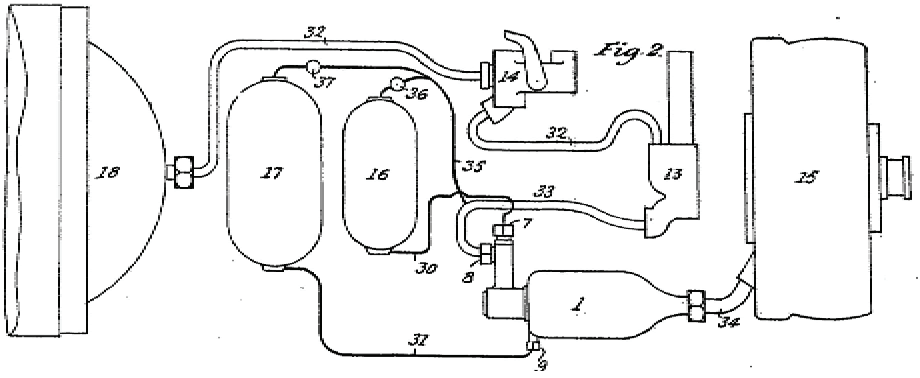
The final design of the Gesztesy wet air heater is showed in Figure 15. The propulsion system is switched on by acting on the starting valve (3). Compressed air flows towards the reduction valve (5) through the piping (2, 4). The novelty of this design is the pressure retarder (7), which postpones the start of the wet heater. When released, the pressure retarder activates the heating system by acting on the water tank (20) via the pipe (24), on the fuel tank (10) via the pipe (25) and on the igniter (22) via the pipe (23). The heating system is started only after a predefined pressure drop in the system or a number of engine revolutions. Thus, in the first part of the run the torpedo is cold running and air passes through the inactive heating system (6-7-8-9-26). In the second part of the run, the torpedo becomes hot running, and the engine performance is boosted by the wet heater. Water is drawn via pipe (21) and sprayed into the combustion chamber (9). This design suggests that adding too much power too soon negatively affects the engine performance. This design is clearly the most advanced propulsion system at the time and the result of extensive torpedo trials carried in Rijeka. In the patent application, Gesztesy explains the purpose of the pressure retarder as to prevent water and fuel spills during torpedo handling and, very vaguely, to control the supply of air, water and fuel in a convenient way.



■ **Figure 13.** *The final Gesztesy wet heater. Drawing from FR patent 393, 324, 1908*

It is worth noting that Hardcastle designed a wet air heater shortly after Gesztesy. The Hardcastle design is similar to Gesztesy's but with two main differences. The Hardcastle wet heater has no pressure retarder and the fuel tank is detached from the combustion chamber, as shown in figure 14. Oxygen is mentioned as a possible replacement for air, which is indicative of that time. After WWI, Great Britain started with the development of oxygen enriched

torpedoes, a design that was later dropped in favour of the Brotherhood burner cycle engine (GB patent 6789-1905). The Royal Navy perfected the Brotherhood burner cycle by 1925. The burner-cycle is adopted in four-cylinder radial engines and works similarly to the diesel internal combustion engine. Compressed air is heated by a small amount of kerosene before entering the engine. This is needed to avoid freezing due to expansion in the pressure reduction valve. The hot gases are supplied to the cylinders just before the TDC. Kerosene is injected in the cylinders and self-ignited in contact with the hot gases. The burner cycle engine propelled 18 and 21-inch torpedoes at a speed and range of 45 knots/5000 m or 40 knots/7000 m. On the other side, the Imperial Japanese Navy thought of oxygen torpedoes as a promising program and, in the 1930s, developed the secret oxygen-enriched torpedo program.



■ **Figure 14.** *The Hardcastle wet air heater (1908), drawing from the FR patent 538,133, 1921. Main parts: air/oxygen tank (18), water tank (17), fuel tank (16), combustion chamber (1), starting valve (14), reduction valve (13), engine (15), supply nozzles: fuel (7), air (8), water (9). The original patent (GB patent 27,347-1908) was secret as highlighted by Epstein* [7, 8].

After Robert Whitehead died 1905, the armaments and engineering concern of Vickers and Armstrong-Whitworth, in agreement with the Great Britain government, purchased the control share packet in the Whitehead Company, including the Fiume and Weymouth factories. Although with no valid reasons, Armstrong-Whitworth decided to sue both Hardcastle [7, 8] and Gesztesy [9] and over patents infringements. Armstrong-Whitworth was dissatisfied by the decision of the Royal Navy to adopt the Hardcastle wet heater, even though it clearly outperformed the Sodeau dry heater. During torpedo runs at 4000 meters, the cold running variant of the RGF Mk VI torpedo achieved 20 knots, the Sodeau variant did 25 knots while the Hardcastle did 34 knots [7]. Later in 1911, Sodeau developed his wet heater variant. The wet heater success urged countries to equip their navies with the newest wet heated torpedoes or to retrofit existing cold running torpedoes as a temporary solution. Much depended also on the patent battle. The Gesztesy wet

heater was used in France (Schneider-Toulon and Whitehead-Saint Tropez) and Germany (Schwartzkopff) while the Armstrong wet heater was used by the Bliss Company and Newport Naval Station. In Rijeka (Austro-Hungarian Empire), torpedoes carried the Gesztesy wet heater but later switched to the Armstrong version before being replaced definitely by the new Whitehead-Jones double-acting two cylinder inclined engine.

4.4. The flywheel torpedo

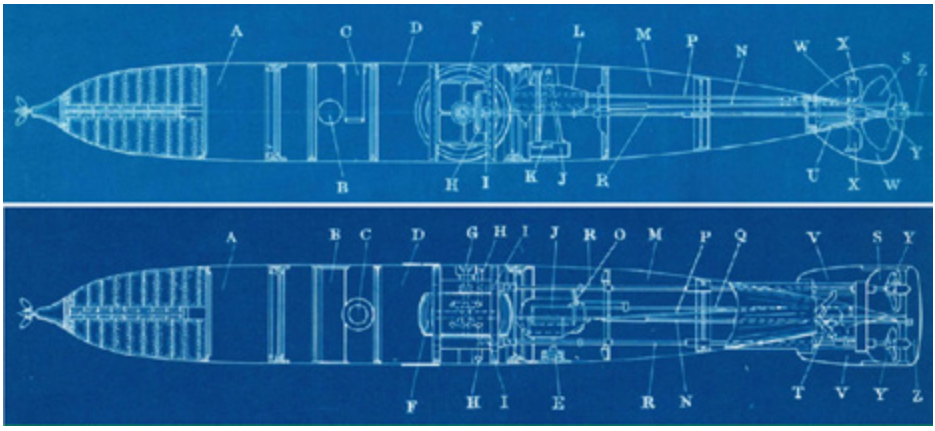
In the 1870s and 80s, the US Navy wanted to develop its own torpedo instead of buying them from the Whitehead Factory. Different propulsion systems for torpedoes were experimented at the Naval Station at Newport: chemical, electrical and rocket propulsion [10]. Perhaps the most promising attempt was the flywheel torpedo designed by John A. Howell, a Lieutenant of the US Navy, in 1870. Production of 50 units was ordered in 1889 and remained in service throughout the 1890s.

The Howell's torpedo driven by a 60 kg flywheel rotating at 10-12,000 RPM. The flywheel is spun up to 10,000 RPM prior to launching, by a steam engine mounted on the torpedo launching tube, on the ship deck. The longitudinal section of the Howell's torpedo is shown in Figure 4. The flywheel (F) is at the core of the Howell's torpedo propulsion system. The kinetic energy stored in the flywheel is utilized by the propeller shafts (R), the vertical (X) and horizontal (Z) rudders, the speed-regulator (T) and the unlocking-mechanism (O). The gyroscopic effect of the flywheel stiffens the torpedo laterally, causing it to roll. The rolling motion of the torpedo is corrected by the vertical-rudder (X) in response to the swing of the vertical-rudder pendulum (K). The flywheel speed is geared down by eight to ten times to the propeller speed (Y) by shaft-gears (H) and fly-wheel gears (I). As the flywheel speed reduced, the variable pitch blades of the propellers were adjusted to maintain constant torpedo speed. The Howell's torpedo lacked vertical stability (depth control) but the flywheel acted as a gyroscope, thus improving the horizontal stability. The stored energy and the power of the Howell's flywheel propulsion system can be estimated from the stored kinetic energy over the firing time.

$$P = \eta \frac{E_{\text{kin}}}{t} = \eta \frac{\frac{1}{2} I \omega^2}{t} = \eta \frac{\frac{1}{4} m (r_{\text{out}}{}^2 + r_{\text{in}}{}^2) \omega^2}{t}$$

The Howell's flywheel was spun at around 11,000 rpm (ω = 1152 rad/s) and the mass was m = 60 kg. The diameter of the Howell's torpedo was 14.2 inch (360 mm) and the length was 132 inch (3.35 m). The Howell's flywheel was a thick-walled semi-empty cylinder with external radius of r_{out} = 0.17 m and internal radius of r_{in} = 0.11 m. The stored kinetic energy in the flywheel is then 816 kJ, returning a specific kinetic energy storage of 13.6 kJ/kg (30 kWh/m^3 for

steel density of 7850 kg/m^3). The efficiency of the Howell's flywheel propulsion system is estimated at η = 0.70. For comparison, modern flywheels spin at speeds of 20-50,000 rpm, achieve specific energy storage of 40 kJ/kg, and have energy conversion efficiency of 0.90. The time to the target is estimated at t = 28.4 seconds, which follows from the firing range of 400 yards (366 m) at a speed of 25 knots (12.9 m/s). From the previous analysis, it follows that the Howell's propulsion system achieves an average power of 20 kW (27 HP), over the firing range.



A	head	J	horizontal-rudder pendulum	R	propeller-shafts
B	depth-register pocket	K	vertical-rudder pendulum	S	tail
C	calcium-phosphide pocket	L	impulse-mechanism	T	speed-regulator
D	middle-body	M	after-body	U	tail-cone
F	flywheel	N	horizontal-rudder tiller-rod	V	side-blades
G	clutches	O	unlocking-mechanism	W	top & bottom blades
H	shaft-gears	P	vertical-rudder tiller-rod	X	vertical rudder
I	flywheel gears	Q	unlocking-rod	Y	propellers
				Z	horizontal rudder

■ **Figure 15.** *Longitudinal sections of the Howell's flywheel torpedo* [11]. *Video of at https://www.youtube.com/watch?v=epvEyiVby9A*

4.5. The Bliss-Leavitt turbine torpedo

The Howell's torpedo proved to be inferior to the Whitehead torpedo and, in 1892, the US Navy decided to purchase torpedo manufacturing rights from the Whitehead Company. The E.W. Bliss Company was accredited for the manufacture of Whitehead Mk 1, Mk 2, Mk 3 and Mk 5 torpedoes. Aside from

manufacturing licensed Whitehead torpedoes, the Americans and the British continued to develop their independent designs. At the beginning of the 20th century, Frank McDowell Leavitt, a founding member and engineer of the E. W. Bliss Company, started developing a new torpedo. This decision was driven in part by the high costs of manufacturing rights and patent royalties and in part by the desire to develop a torpedo with superior performance. The production of the Bliss-Leavitt Mk 1 torpedo started in 1904. This torpedo was 5 m in length and 0.53 m in diameter and used a single-stage vertical turbine which run on compressed heated air. Alcohol was the fuel used to heat air before entering the turbine. The air tank pressure of the test torpedoes was 100 bar. The range and speed of the cold running variant torpedo were 1100 m at a speed of 30 knots. The hot running variant of the same torpedo achieved 1100 m at a speed of 35 knots, 1800 m at 29.5 knots and 2700 m at 24.5 knots. The final variant of this torpedo had air tank pressure of 155 bar and achieved firing range of 3600 m at a speed of 27 knots. [10]

The drawbacks of the single-stage vertical turbine were unwanted gyroscopic effects and unbalanced torque, which caused the torpedo to roll. However, the placement of the air exhaust may also had played a role in the torpedo rolling. The Bliss-Leavitt Mk 2 torpedo, Figure 16, implemented a two-stage vertical turbine and contra-rotating propellers, which eliminated the rolling problem at a slight cost in range and speed.

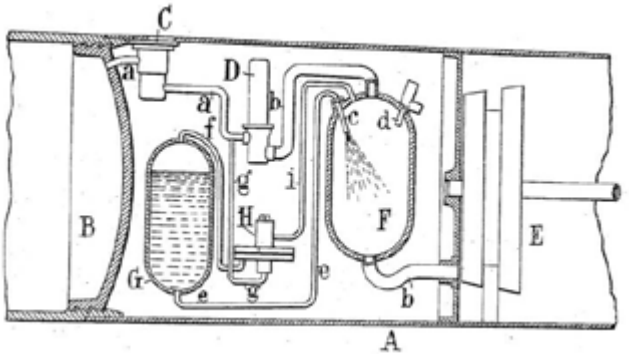
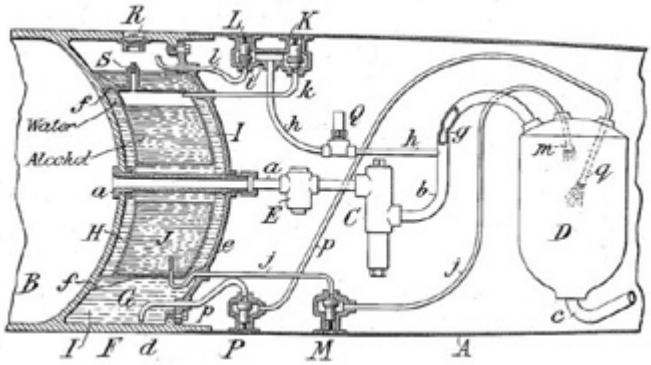


Figure 16. *The engine of the Bliss-Leavitt Mk 2 torpedo designed by Leavitt in 1905 (US patent 943833-1909). Main parts: torpedo shell (A), air tank (B), starting valve (C), air reduction valve (D), two-stage vertical turbine (E), outside air heater (F), fuel tank (G), fuel valve (H).*

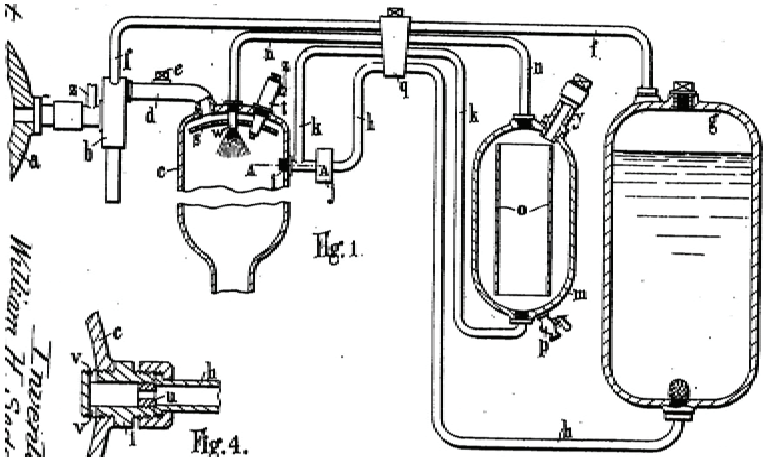
The Bliss-Leavitt Mk 2, Mk 3 and Mk 4 torpedoes were similar, with slight differences in performance, in mechanical characteristics and dimensions. They all used two-stage vertical turbine with contra-rotating propellers. The Bliss-Leavitt Mk 6 was the first to use two-stage horizontal turbines but achieved firing range of 1800 m at a speed of 35 knots. The Bliss-Leavitt Mk 7 torpedo used an improved air heater (combustion pot) with water spray along

with fuel spray. Air, fuel and water are supplied simultaneously into the wet air heater, shown in Figure 17. In the original Leavitt's design, the air tank has a double wall cavity inside which fuel and water are stored.



■ **Figure 17.** *The Leavitt wet air heater (US patent 1,022,486-1912). Main parts: torpedo shell (A), air tank (B), reduction valve (C), combustion chamber (D), starting valve (E), water tank (G), fuel tank (J).*

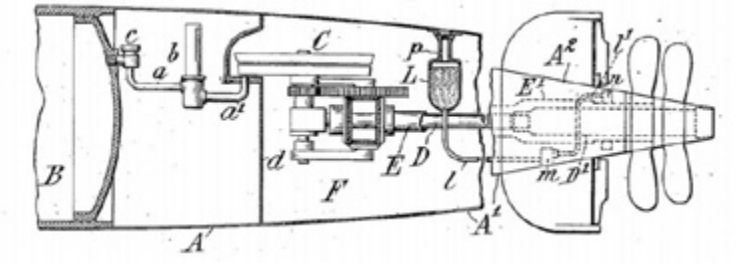
It should be noted that US torpedoes produced by the Bliss Company were equipped with Sodeau (Armstrong-Whitworth) air heaters rather than with Leavitt's, following the license agreement of 1905. The Sodeau wet air heater, shown in Figure 18, is by no means different from the Gesztesy or Hardcastle designs.



■ **Figure 18.** *The Sodeau wet air heater (US patent 1,008,871-1911). Main parts: air tank (a), reduction valve (b), combustion chamber (c), starting valve (q), water tank (g), fuel tank (m), igniter (j).*

The heat generated by fuel combustion heats up air while water reduces the flue gases temperature and prevents overheating. The two-stage turbine converts the sensible heat of flue gases and the latent heat of the steam into useful work. This torpedo is also known as "steam torpedo", although the working fluid is a mixture of hot flue gases and water steam (or wet-heated air). The wet-heated air is compressed at 172 bar. The performance was significantly improved: the firing range increased at 5500 m at a speed of 35 knots.

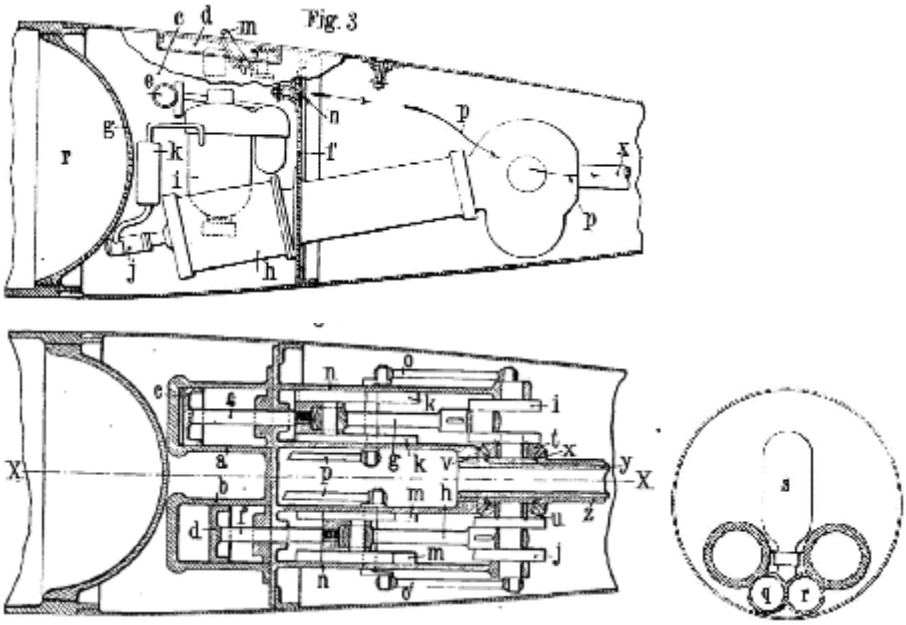
Production of the Bliss-Leavitt Mk 7 torpedo started in 1912 and remained in service up until the end of World War 2. Variants of the Mk 7 torpedo were produced for aircrafts and submarines. In the patent description, Leavitt omitted several parts: the wet air heating system, the combustion pot and the gearing system between the contra-rotating turbine rotors and the propellers, Figure 19. This was no mistake. In 1913, the US Navy won the lawsuit against the Bliss Company to prevent disclosing to foreign countries the details and the full design of the Leavitt steam torpedo. The US Navy regarded the Bliss-Leavitt steam torpedo a remarkable achievement and hoped it could give the necessary edge over other countries. The aggressive patent lawsuits filed by the US and Great Britain governments are thoroughly addressed in the exceptional book by K. C. Epstein [7]. A diametrically opposite attitude towards its inventors had the Austro-Hungarian Empire. It tolerated, for over half a century, an Englishman supplying enemy countries with a revolutionary naval weapon produced in the major-city port of the Empire. This attitude, among other missteps, sunk forever the century-old Empire that held together more than ten nations.



■ **Figure 19.** *The engine of the Bliss-Leavitt Mk 6 – Mk 7 torpedo (US patent 1108196- 1914). Main parts: torpedo shell (A), air tank (B), two-stage horizontal turbine (C), inner propeller shaft (D), outer propeller shaft (E), exhaust chamber (F), lubricating oil tank (L).*

4.6. The double-acting two-cylinder inclined engine

In 1905, the Whitehead company in Rijeka started designing a new torpedo engine: the double-acting two-cylinder inclined engine, Figure 20. The Brotherhood engine was considered outdated for longer ranges. The new engine of the Whitehead torpedo was first tested in November 1910 with impressive re-

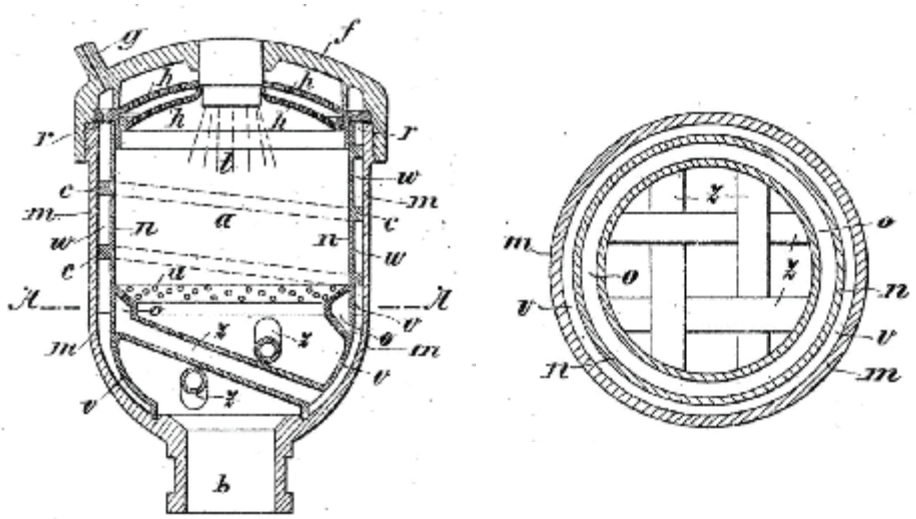


■ **Figure 20.** *The double-acting two cylinder inclined engine designed by A.E. Jones. Drawings from AT patents 49,530, 1910 and 53,500-1911. Main parts (up): air tank (r), inclined cylinders (h), water injection pump (j), air heater (i), water valve (k). Main part (down): double-acting inclined cylinders (a, b), pistons (c, d), piston rods (e, f), inclined connecting rods (g, h), cranks disposed at an angle of 90° (i, j), slide guides (k, m), eccentrics (o), connecting rods (p), framework (n), crankshaft gears (t, u), propeller shaft gears (v, x), contra-rotating propeller hollow shafts (y, z), distribution chests (q, r), combustion chamber (s).*

sults. Compared to the Brotherhood radial engine, the inclined engine improved the running stability and the range of the torpedo. The moving parts are brought in the direction of the torpedo running thus avoiding radial instabilities. The center of gravity of the torpedo is lowered by placing the two cylinders beneath the longitudinal axis of the torpedo. The torpedo speed and range are increased by employing two large double-acting cylinders with longer strokes. The lubricating oil tank is placed below the cylinders, integrated in the torpedo hull. During the torpedo run, seawater floods the engine compartment for cooling. This engine was designed by a group of engineers led by Albert Edward Jones, the technical director of the Whitehead factory in Rijeka. A. E. "Tal" Jones (1864-1934) was an electrical engineer, prolific inventor, engineer and technical manager at the Whitehead factories in Rijeka (1887-1914) and Weymouth (1922-1934) [12]. Patents of the new engine were filed to offices in Austria, France and Great Britain. This engine proved very successful and became the standard engine of Whitehead torpedoes in the interwar period. The two-cylinder double-acting engine was considered the best at that time. At torpedo trials, 18-inch and 21-inch torpedoes achieved 47 knots at 1500 m, 44 kn

at 2000 m, 40 kn at 3000 m and 31 kn at 6000 m, 27 kn at 8000 m. The maximum speed was 49 knots. In the 1930s, the Imperial Japanese Navy developed the kerosene-oxygen wet heated torpedo (Type 93) that gave the edge in the Pacific during the years of WWII. The engine was a modified two-cylinder double-acting Whitehead [13]. The engine developed an average power of 520 HP for a speed of 50 knots at 15000 m.

The wet heater of the double-acting two-cylinder engine is a double-walled heating chamber (a) which surrounds the flame, Figure 21. First, water flows downwards in a spiral path (w) between the walls (m, n), round the heating chamber, and evaporates. Second, water vapor enters the heating chamber through a perforated ring (o, u) where is blown out upwards against the hot flue gases, in the flame zone (t). The fuel spray nozzle is placed at the top of the chamber where air is also admitted. The heating chamber is heat exchanger, and specifically, a water evaporator and steam superheater. The counterflow arrangement between water vapor and flue gases in the chamber promotes uniform mixing.

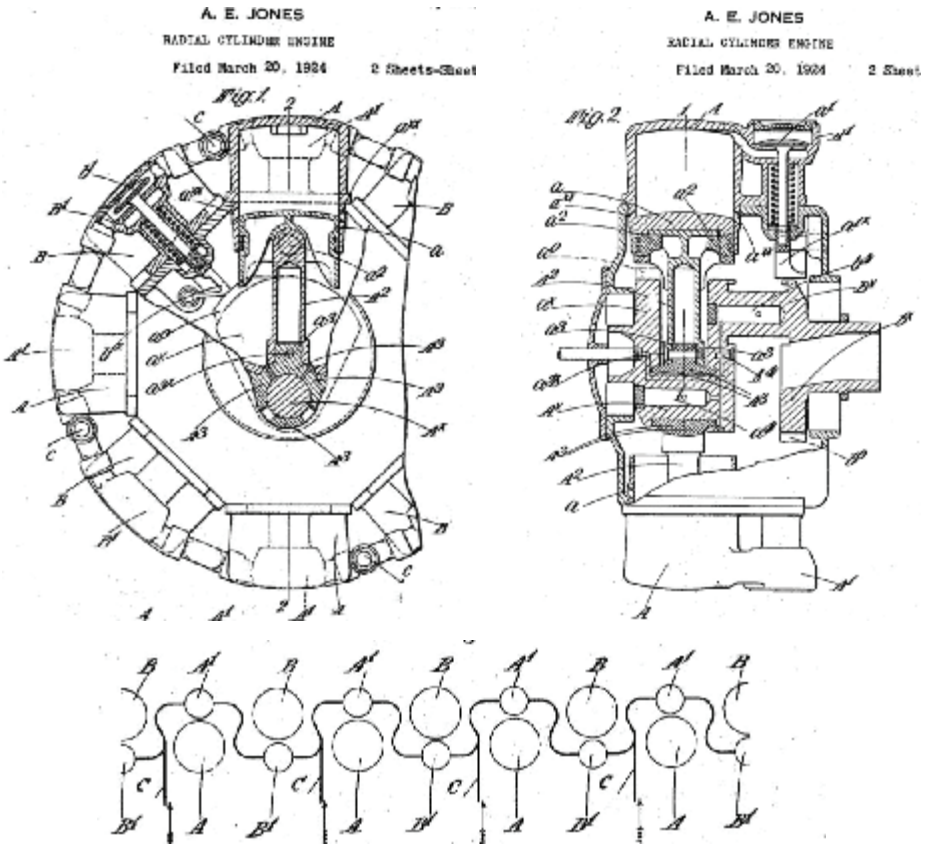


■ **Figure 21.** *The wet heater for the double-acting two-cylinder engine (AT patent 81,706- 1915 and GB patent 147,518-1920). Parts: double-walled heating chamber (a), outlet (b), helical ribs (c), chamber cover (f), water supply manifold (g), outer wall (m), inner wall (n), perforated ring (r), helical channel (w), air admission diaphragm (h), flame zone (t), cavity (v), evaporation pipes (z), ring cavity (o) with perforations (u).*

4.7. Experimental Whitehead engines

4.7.1. The eight-cylinder radial engine

The eight-cylinder radial engine originated from the Whitehead factory in Rijeka, somewhere in the early 1900s. The idea behind it was better torpedo performance, increased engine power and thus speed and range. The first prototype was an inline eight-cylinder engine which was most likely designed by the technical director A. E. Jones. This design was later shelved in favor of the inclined double-acting two-cylinder engine. For the eight-cylinder engine it was considered having too many moving parts that made its manufacture overly expensive. However, in the 1920s, and now working at the Whitehead factory in Weymouth, A. E. Jones regained interest in the eight-cylinder engine.



■ **Figure 22.** *The dual-row eight-cylinder radial engine designed by A.E. Jones (GB patent (GB patent 228,313-1923). Parts: first row cylinders (A) and appertaining chests (A'), second row cylinders (B) and appertaining chests (B'), air supply pipes (C).*

In Weymouth, A.E. Jones designed a slightly different model with staggered (or dual-row) cylinder arrangement. In Weymouth the dual-row eight-cylinder engine never made beyond experimental prototypes. However, the Torpedo factory in Naples (Silurificio Italiano di Baia) was interested in this design and produced 18 and 21-inch torpedoes with this type of engine [14]. On the other hand, the Whitehead factory in Rijeka (Silurificio Whitehead di Fiume, now part of Italy) continued developing the double-acting two-cylinder engine. Both factories produced 18-inch torpedoes running 42 knots at 3000 meters and 21-inch torpedoes running 50 knots at 4000 meters. The inclined two-cylinder engine was, however, considered superior to the eight-cylinder radial engine. Among the buyers of the Torpedo factory in Naples was he Imperial Navy of Japan. In the 1930s, Japan developed a prototype kerosene-oxygen torpedo for aircrafts (Type 94) powered by the dual-row eight-cylinder radial engine, from the Italian 18-inch variant [15, 16]. It likely never went into service.

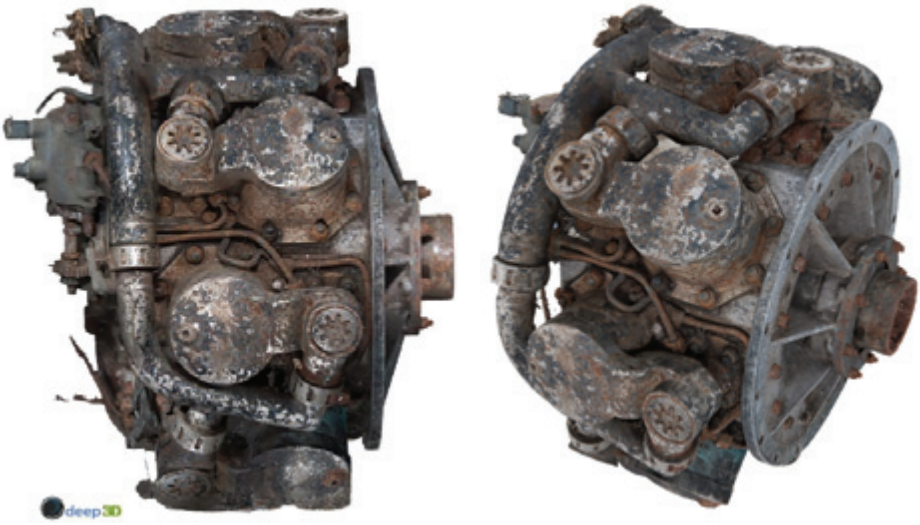


Figure 23. *The two-row eight-cylinder radial engine designed by A.E. Jones, recovered in the Weymouth Bay. Photo courtesy of Simon Brown. Orthophoto 3D engine model at URL: http://deep3d.co.uk/2018/12/30/more-than-one-orthophoto/*

4.7.2. The Whitehead turbine

The Whitehead Company submitted patents for turbine torpedoes in Austria, France and Great Britain. There are no records if these prototypes were ever built and tested. It could had been a backup alternative to the inclined two-cylinder engine. Or, it could had been a move against the competition. In 1913, the Schneider torpedo factory in Toulon started experimenting with turbine torpedoes, a design that the French Navy accepted before WWII. In the Whitehead turbine propulsion, the propellers are mounted on coaxial or double

contra-rotating shafts driven by a single vertical turbine or twin horizontal turbine with simplified gearing down mechanisms, see Figures 24 and 25.

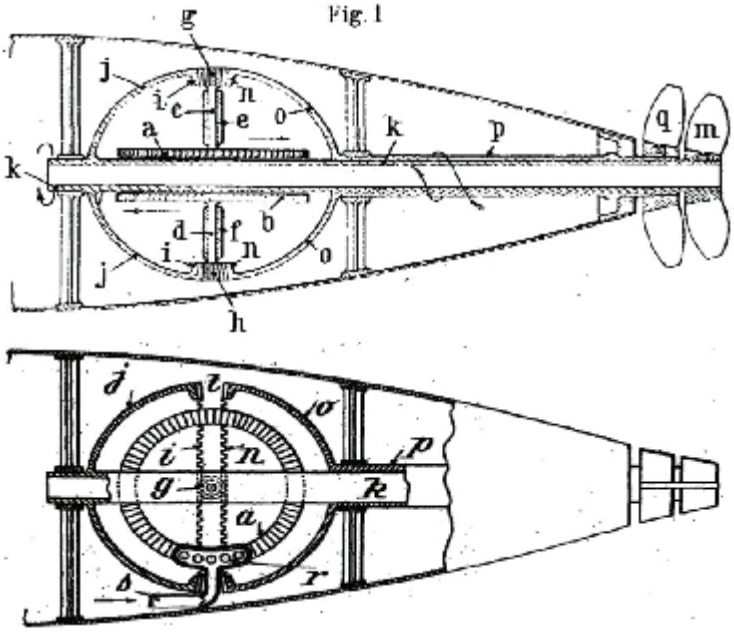


Figure 24. *The Whitehead contra-rotating horizontal turbine (GB patent 5522-1914). Parts: contra-rotating turbine wheels (a, b), turbine shafts (c, d), bearings (e, f), bevel pinions (g, h), toothed rings (i, n) hemispherical gear wheels (j, o), double hollow shaft (k, p), contra-rotating propellers (m, q), injection nozzles (r), steam supply pipe (s).*

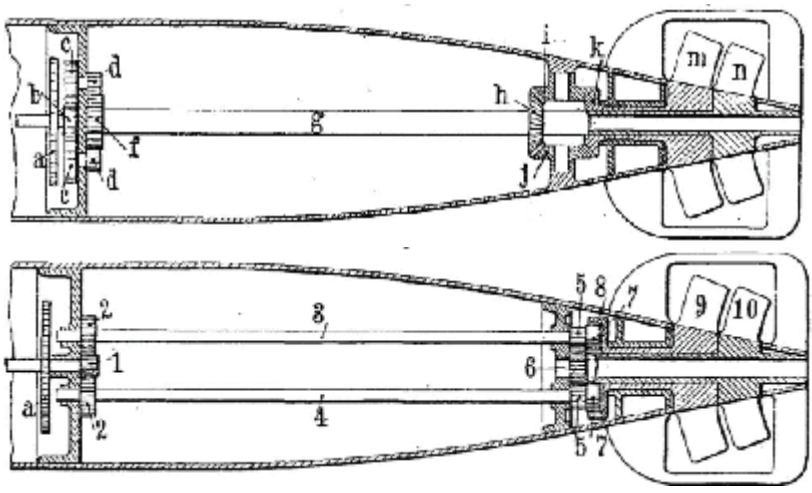


Figure 25. *The Whitehead single vertical turbine (FR patent 433,998-1910). Usual solution (up): turbine wheel (a), double gearing down mechanism (b, c, d, e, f), shaft (g), bevel gears (h, i, j, k), contra-rotating propellers (m, n). Patented solution (down): turbine wheel (a), first-stage gearing down (1, 2), shafts (3, 4), second-stage (5, 6, 7, 8), contra-rotating propellers (9, 10).*

5. CONCLUSION

The torpedo was a weapon that brought new perspective into naval warfare. Since the time of its inception, engineers and naval officers understood its great potential. It was a war device, one of the most feared at that period, that claimed hundreds of ships and thousands of lives. On the other side, the human efforts and means invested in the research and development process had led to perfection of existing technologies and to the even invention of new designs. The hydrodynamics of underwater objects, the technology of pressurized tanks and compressors, the mechanisms of steering and targeting, the techniques of precise manufacturing were all improved. New multi- cylinder engines were designed. Improved metal alloys allowed for increased air tank pressures. In 1895, the Obry gyroscope ensured better horizontal accuracy. In 1900, dry air heaters increased the work potential of compressed air. In 1905-1910, the development of wet air heaters transformed the torpedo from a weapon of defense into a weapon of attack. Given the same range, cold running torpedoes made 20-25 knots, dry heated air torpedoes did 25-30 knots while wet heated torpedoes did 35-40 knots. Given the same speed, wet heated torpedoes outranged by far cold running and dry hot running torpedoes.

At the turn of the century, the torpedo development was so fast that naval officers and tacticians contemplated changing the strategy of marine warfare. In those few years, the torpedo firing range increased from 1,000 to 10,000 meters and its speed increased from 25 to 50 knots. The torpedo threatened to outrange the big guns on warships. The Whitehead torpedo, from its inception in 1866 up until the outbreak of WWI, was the model design to be imitated and to be compared to. The Whitehead torpedo factory in Rijeka was unchallenged in innovation, quality of manufacturing and product performance.

The attention of this paper was focused on the analysis and historical development of torpedo cylinder engines working on cold and hot compressed air, or on superheated gas-steam mixtures, which was the preferred design up until WWI. After WWI, things changed and different lines of development were pursued by different countries. Great Britain became the leader of torpedo technology with the application of internal combustion engines (burner cycle). In the same period, Germany worked on electric torpedoes and the United States on turbine torpedoes. In the 1930s, Japan modified Whitehead engines to work with kerosene and enriched-oxygen, the most advanced torpedoes at that time.

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SAŽETAK

U prvoj polovici 19. stoljeća bilo je više pokušaja izuma podvodne mine ili bombe koja se autonomno kreće prema cilju. Najvažnije tehničke karakteristike takva oružja bile su domet i eksplozivno punjenje, zajedno s pogonskim strojem koji je morao biti u stanju održavati željeni kurs i konstantnu dubinu kretanja.

Prvi koji su uspjeli konstruirati takvu napravu bili su Giovanni Luppis i Robert Whitehead 1866. Robert Whitehead ugradio je u torpedo pneumatski stroj čije je „gorivo" bio komprimirani zrak na 70 bara. Prvi torpedo imao je ukupnu masu od 264 kg, od čega je eksplozivno punjenje težilo 19,5 kg, a domet mu je bio između 200 i 300 m pri brzini od 19 čvorova. Krajem 19. stoljeća Whiteheadova torpeda imaju masu od 530 kg, tlak zraka u spremniku od 100 bara, domet između 800 i 1200 m i eksplozivno punjenje od 90 kg.

Nedostatak je ovog stroja bio nagla ekspanzija zraka koja je izazivala hlađenje i suženje presjeka zbog pojave leda u cijevi dovoda zraka, tako da se ta bojna naprava često nazivala i hladnim torpedom.

Energija komprimiranog zraka povećala se dodavanjem goriva koje zauzima manji prostor. Sada u pogonski stroj ulaze dimni plinovi izgaranja visoke temperature i tlaka. Nastali plinovi izgaranja služe za pogon torpeda koji se sada naziva torpedo s grijanjem. *Povećanjem radne snage torpeda Whiteheadova se konstrukcija pogonskog stroja s tri cilindra trebala zamijeniti konstrukcijom s četiri cilindara. To je rezultiralo konstrukcijom naprave za izgaranje u* modernom torpedu s grijanjem i unutarnjim hlađenjem.

Ključne riječi: *Whiteheadov torpedo, torpedo s grijanjem, naprava za izgaranje, torpeda s grijanjem i unutarnjem hlađenjem*

CARL PAUL GOTTFRIED VON LINDE – PIONIR TEHNIKE HLAĐENJA (1842. – 1934.)

Carl Paul Gottfried von Linde: Pioneer of cooling technology (1842 – 1934)

Bernard Franković*, Marko Perčić**

SAŽETAK

Ljevokretni kružni proces termodinamička je osnova rashladne tehnike: rashladnih uređaja za hlađenje i tehnike grijanja dizalicom topline, rashladnih uređaja niskih temperatura i tehnike ukapljivanja plinova. Prve početke tehnike hlađenja vezujemo za sredinu 18. stoljeća i Williama Cullena, Benjamina Franklina i Johna Hadleya te prvu polovicu 19. stoljeća i Olivera Evansa, Michaela Faradaya, Jacoba Perkinsa... Krajem toga stoljeća jedan od pionira tehnike hlađenja Carl von Linde (1842. – 1934.) upotrijebio je u ljevokretnome kružnom procesu kompresor kojim se koristio Robert Whitehead za komprimiranje zraka za pogon pneumatskog stroja torpeda. Lindeov kružni proces ukapljivanja zraka bio je proveden 1895. u pogonima riječke tvornice Torpedo. *Carl von Linde se kao dvadesetčetverogodišnjak zapošljava na* Polytechnischen Schule München, *s dvadeset šest godina postaje izvanredni profesor, a 1872. redoviti profesor konstrukcije motora. Na toj prestižnoj visokoj školi ustrojio je prvi laboratorij za toplinske strojeve. U to su vrijeme konstruirani prvi motori s unutarnjim izgaranjem pa je vrijedno spomenuti da je Carl von Linde bio profesor Rudolfu Dieselu, izumitelju diezelskih motora.*

U radu se uz povijesni trenutak primjene riječkog kompresora za ljevokretni kružni proces Carla von Lindea, daje pregled razvoja rashladne tehnike, tehnike ukapljivanja plinova i tehnike grijanja i hlađenja do danas.

Ključne riječi: *Carl Paul Gottfried von Linde,* Torpedo *Rijeka, ljevokretni kružni proces, ukapljivanje plinova, rashladni sustavi*

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SUMMARY

The heat pump cycle, sometimes referred as refrigeration cycle, is the basis of refrigeration thermodynamics, cooling devices and heat pump technology, low temperature refrigeration systems and techniques of gas liquefaction. The origination of cooling techniques can be traced to the middle of the eighteenth century: William Cullen, Benjamin Franklin, John Hadley; and in the first half of the nineteenth century: Oliver Evans, Michael Faraday, Jacob Perkins... At the end of the century, one of the pioneers of cooling technology, Carl von Linde (1842 –1934), developed a novel application of the heat pump cycle by using the compressor previously used by Robert Whitehead for compressing air to drive pneumatic machine torpedoes. Linde's application developed with Whitehead's compressor resulted in a novel cascade cycle for liquefaction of air which was implemented in 1895 in the manufacturing facilities of the Torpedo factory in Rijeka. Carl von Linde at the age of 24 years began working at Polytechnischen Schule Munich*, and with 26 years became associate professor, only in 1872 to become a full professor of mechanical engineering. At this prestigious Academy he established the first Laboratory for Heat Engines. It was at that time that the first internal combustion engines were designed; therefore it is worthwhile mentioning that Rudolf Diesel, the inventor of the diesel engine, was Carl von Linde's student.*

This work provides an overview of this historically important moment of the application of Carl von Linde's liquefaction cycle, and also the development of heating and cooling systems to date.

Keywords: *Carl Paul Gottfried von Linde, Torpedo Rijeka, heat pump cycle, gas liquefaction, cooling systems*

DEMISTIFYING AND "DEMYTHIFYING" THE EARLY TORPEDO HISTORY

Demistificirajući i „demitologizirajući" ranu povijest torpeda

Terje Fossnes*

When you have excluded the impossible, whatever remains, however improbable, must be the truth.

SIR Arthur Conan Doyle

The Adventure of the Beryl Coronet, 1892

SUMMARY

This paper reports on an in-depth study of the literature covering the history of the naval torpedo. The sources for the books and manuscripts examined encompass international authors, printed in a variety of languages, and published over the 150 years of torpedo history. The contributions are summarized and analysed to provide a longitudinal perspective of this technology and the references provide a bibliography of rare and useful readings.

This study revealed that the early history of the torpedo contains quite a few discrepancies or anomalous descriptions, and even some mythical events that are still perceived as the truth today.

The author analysed over 100 artefacts to identify pertinent sources, resolve some incongruities, and put straight the events riddled with myths related to the early history of the torpedo. The paper also uncovers for the first time a five-step progressive evolution of the hydrostatic control mechanisms that were unique to the Whitehead torpedoes. This result is based on a careful scrutiny of the very limited literature in the public domain concerning The Secret *– the depth keeping devices of Whitehead's torpedoes in the early days.*

At the end, this paper sheds some light on a hereto rather unknown 19th century torpedo – The Halpine Torpedo. This contribution and the pertinent references may be considered an addendum to page 200 in Edwyn Gray's book 19th Century Torpedoes and Their Inventors.

Keywords: *early history of torpedo, torpedo bibliography, hydrostatic control of depth, "the secret" device, Whitehead's torpedo*

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1. TORPEDOES – A DANGEROUS, UNFAIR AND COWARDLY FORM OF WEAPON

A thorough study of the historical literature encompassing the naval *torpedo* as a subject reveals to this author that the history of the torpedo contains quite a few discrepancies or anomalous descriptions that have not yet been addressed or invalidated across the board, and even some mythical events that are still perceived as the truth. The reasons for this are surely manifold. However, it is not for this manuscript to analyse those causes, but rather to identify the relevant sources, resolve some incongruities and put straight some myths and events related to the early history of the torpedo.

1.1. "Damn the Torpedoes"

The torpedo and the way we do warfare has changed considerably since Admiral David Glasgow Farragut gave his famous battle order during the American Civil War Battle of Mobil Bay on August 5th in 1864.

When a ship had fallen out of position in the attack column, Farragut asked: "*What's the trouble?*" The reply: "*Torpedoes!*" made Farragut shout back: "*Damn the torpedoes! Four bells, Captain Drayton. Go ahead!*" (Harris 1997; xiii).

If we accept these words actually to have been proclaimed by Admiral Farragut, the commonly repeated quote: "*Damn the torpedoes! Full speed ahead!*" is modernised, enabling us today to understand the intent of the original message. Otherwise, who would, without adequate knowledge of the past line of communication between the commanding officer on a ship's bridge and the machine control room operator, understand that 'four bells' is equivalent to full speed? Not all of us.

1.2. Robert Fulton – "Demythifying" the use of the 'plunging boat' *Nautilus*

The torpedoes in action in 1864 are not even torpedoes in the same way we think of naval torpedoes in present time; primarily thanks to Robert Whitehead.

Looking in the historical archives, the first time the word 'torpedo' is documented in a written source must be accredited to Robert Fulton in *Torpedo War and Submarine Explosions*, 1810.

On October 15th 1805 at 5 pm Robert Fulton demonstrated by using 2 canisters, each filled with 180 pounds (80 kg) of gunpowder, the effect on a ship from of an underwater explosion under its keel. The target was the 200 tons brig *Dorothea*, anchored for the demonstration.

The manifestation was, indeed, carried through by means of two rowing boats and the tide, and **not** his successfully developed 'plunging boat' Nautilus, as claimed by some sources.[1]

Both canisters were thrown into the water according to a well-rehearsed plan, and …

"… when properly placed on the tide, the Torpedoes would invariably go under the bottom of the vessel. … the explosion appeared to raise her bodily about six feet; she separated in the middle, and the two ends went down; in twenty seconds, nothing was to be seen of her except floating fragments; the pumps and foremast were blown out of her; the fore- topsail-yard was thrown up to the cross-trees; the fore-chain-plates, with their bolts, were torn from her sides; the mizen-chain-plates and shrouds, being stronger than those of the foremast, or the shock being more forward than aft, the mizenmast was broke off in two places; these discoveries were made by means of the pieces which were found afloat" (Fulton 1810; 5-6).

Fulton truly believed that his inventions would prevent wars due to the weapons' inherent cruelty – as did Robert Whitehead half a century later. Fulton wrote in 1810, in the chapter heading: 'ON the imaginary inhumanity of Torpedo war':

"But men, without reflecting, or from attachment to established and familiar tyranny, exclaim that it is barbarous to blow up a ship with all her crew. This I admit, and lament that it should be necessary; but all wars are barbarous, and particularly wars of offence. … It would be barbarous for ships of war to enter the harbour of New-York, fire on the city, destroy property, and murder many of the peaceful inhabitants; yet we have great reason to expect such a scene of barbarism and distress, unless means are taken to prevent it; therefore, if Torpedoes should prevent such acts of violence, the invention must be humane." (Fulton 1810; 44)

1.3. David Bushnell – "Demythifying" the first to use the term '*torpedo*'

The term '*torpedo*' applies allegedly to the payload of Bushnell's barrel submarine *The Turtle* – conceived in 1771 and completed in 1775. Bushnell, however, did not express his explosive device as a torpedo.

Wrongfully, sources since the late 19th century accredit David Bushnell to be the first to use the term torpedo for an underwater weapon.[2]

In October 1787 Bushnell wrote a long letter to Thomas Jefferson, then Minister Plenipotentiary of the United States in Paris, France. Bushnell described in detail his invention in this letter. After an elaborate description of his submarine in the letter's first pages, Bushnell directed the subject to the explosives carried by *The Turtle*, under the headline: "*Description of a magazine and its appendages designed to be conveyed by the submarine vessel to the bottom of a ship*" (Barnes 1869; 21). In the second subparagraph Bushnell described:

> "Behind the vessel was a place, above the rudder, for carrying a large powder magazine. This was made of two pieces of oak timber, large enough, when hollowed out, to contain an hundred and fifty pounds of powder, with the apparatus used in firing it" (ibid).

Bushnell continued, using the expression '*magazine*' each time he mentioned the explosive device on board *The Turtle*. He also described towards the end of his letter, another experiment involving explosives, performed in 1777. In this part of the letter Bushnell used the term '*keg*':

> "After this, I fixed several kegs under water charged with powder, to explode upon touching anything as they floated along with the tide" (ibid; 24).

Hence, the pre-Fulton accounts of the term '*torpedo*' are modern-day attempts to "linguistically" make us understand that these early naval weapons contained explosives. However, even this is ambiguous, in that during the first half of the 19th century most apparatuses referred to as torpedoes were not propelled and could not move autonomously in any way. A more correct classification for those devices using contemporary terminology is to call them mines.

1.4. Anno 1258 - "*... an egg which moves itself and burns*"

For centuries inventors have been experimenting with explosives and devices similar to what Fulton called torpedoes. In 1270 the Syrian, Hassan Al-Rammah, published *The Book of Military Horsemanship and Ingenious War Devices*, including more than 100 recipes for gunpowder, whereof 22 could be used as rocket fuel. Al-Rammah also included in the book, his design for a rocket propelled naval weapon known as "the egg which moves itself and burns" invented in 1258 (Schiffner et al. 1990; 8).

Al-Rammah's rocket torpedo was constructed in full-scale based on the original drawings and information available about propulsion and explosive mixtures used in the Middle Ages, similar to A. Rahman Zaky's description (Zaky 1967). The constructed rocket proved feasible both in the approach towards the target as well as in impact and explosion, as shown in a Canadian TV documentary (The Re-Inventors 2007).

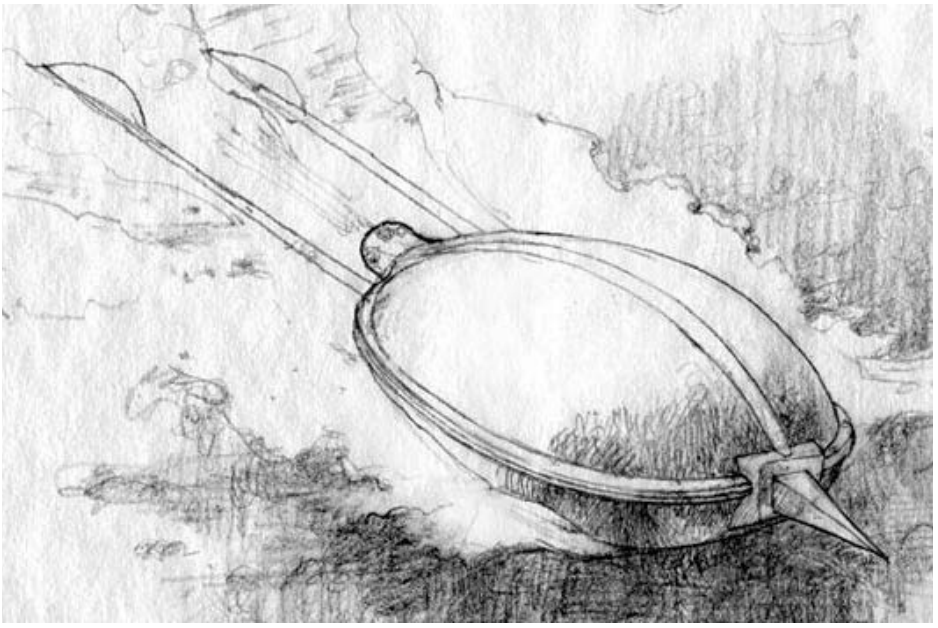


Figure 1. *This illustration from an Arabic military treatise in the 15th century shows that "the egg which moves itself and burns" was intended to move on the surface (Mansour, 2011).*

"The egg" was filled with explosives, could move on the surface of the water, aimed towards enemy ships. "The egg", 29 inches long [without rods] and 13 inches wide, was made of 2 sheet iron pans fastened together. It was filled with naphtha, metal fillings, and an explosive mixture probably containing saltpetre. The apparatus included two rods to provide course stability, and was propelled by a rocket (Mansour, 2011).

1.5. Etymology – '*Torpedo*' versus '*Siluro*'

Historical records are linguistically challenging and sometimes confusing, in that mines, surface rockets, spar torpedoes, and all kinds of drifting canisters filled with explosives, as well as self-propelled torpedoes, all have been described as, and fit under the basic etymological description of the naval '*torpedo*'.

Etymology is the theory and study of the origins and true sense of a word, and the related historical linguistic change. According to *Merriam-Webster Online Dictionary* 'Torpedo' is described to originate from the Latin word 'torpEre', which means "*to be sluggish or numb*".

Fulton's use of the term 'torpedo' was inspired by a fish, a genus of rays in the order *Torpediniformes*, which are best known for their highly specialized electro-genic organs. 'Torpere' is also translated as stun, paralyze, daze and stiffen, depending on the source of reference. Use of the word '*torpedo*' makes sense in the language of modern naval warfare; targets hit by a torpedo are

anaesthetized to the extent that they cannot carry out their intended mission – permanently (ship kill) or for a constrained period of time (mission kill).

Another interesting etymological note refers to the Italian Captain, G. Scafati, who in 1875 proposed to call the auto-mobile fish torpedo 'siluro' not to confuse this new weapon with the aforementioned weapons associated with the word 'torpedo' (Scafati 1875; 48-64).

The word 'siluro' stems from a different fish; namely, a big catfish found in the river Nile in Africa. Today the Italians **do** use the word 'siluro' – translated into English and many other languages as 'torpedo'. However, in Italy the use of this word is accredited to Admiral Simone Pacoret di Saint Bon (Silurificio Whitehead di Fiume 1936; 6-7).

1.6. The 19th Century Classification and Futuristic Thoughts of Torpedoes

The ambiguous linguistic use of the word '*torpedo*' did not become much clearer towards the end of the 19th century either; despite the efforts of C. W. Sleeman, a late Commander of the Imperial Ottoman Navy (Austria). He classified different types of mines and torpedoes in his book *Torpedoes and Torpedo Warfare*. The first edition is dated 1880; later updated in 1889.

1.6.1. C. W. Sleeman – Classification of Torpedoes

Sleeman classified and identified, by type, both mines and torpedoes, but did not really make a clear distinction between the two. Even the more elaborate classification in the 1889 edition as compared to the four classes he presented in 1880, did not clarify the subject. The main difference, according to Sleeman, laid in the defensive and offensive use of the underwater weapons, of which there were many of variations.

The mines were divided in two distinct classes, each one embracing a variety of mines; Self- acting Mines, and Controlled Mines (those will not be further dealt with in this manuscript). On the other hand, according to Sleeman:

> "Submarine [underwater] mines …" were weapons of "…various means extant for the defence of harbours, rivers, &c." (Sleeman 1889; 21);
>
> – The operative word here being **defence**.

> "… the **torpedo** in its many forms, that is to say, of any case of explosive which, by some means or other, is provided with the power of aggression either on or below the surface, and which is primarily intended for the purpose of offence." (ibid; 157);
>
> – The operative word here being **offence**.

Also the torpedoes were divided in two distinct partitions, "… *further subdivided into classes according to some typical feature of their manipulation*" (ibid; 158):

Controllable Torpedoes; the Auto-Mobile (not Fish) torpedo was classified under the controllable torpedoes; hereunder Sleeman named torpedoes that were tethered to, for example, a controlling vessel. The remaining four classes within the controllable torpedoes were: Spar, Towing, Dirigible, and Locomotive torpedoes. For the last, the propelling power (e.g. electricity or steam) was described to be fed to the torpedo, through a cable of one kind or another, from a remote generator.

The **Uncontrollable Torpedoes** were decomposed into: Projectile, Rocket, Drifting, and Auto-Mobile (Fish) torpedoes. Some types were exemplified; for example Robert Whitehead's torpedoes fell under the last class.

Some of these categories and classes could be suitable also today, though the capabilities of today's contemporary torpedoes – functionally and performance – probably exceeds Sleeman's wildest dreams. He listed three sources of weakness in the application of, among others, the Whitehead torpedo (ibid; 159).

1. The want of absolute certainty of hitting.
2. The uncertainty of subsequent action in the event of a miss.
3. The impossibility of distinguishing friend from foe.

Sleeman considered the first defect to be the most serious one, inherent in every uncontrollable torpedo. Of course, he was correct; it is still an objective that cannot be guaranteed, even today. His summarizing comment addressing the weaknesses observed was:

> "Both of the latter defects, common to all torpedoes of this group [*uncontrollable torpedoes*], will most unquestionably tend to limit their application as ship weapons in naval actions" (ibid; 161).

Sleeman's proclamation from 1889 definitely had validity at the time, and still holds merit today. Improvements made over the last century[3] enable naval authorities to accept the inherent risk in present-day warfare; a risk that is mitigated by taking the combat management and torpedo control systems at large into consideration.

1.6.2. John Townsend Bucknill – Addressing Scepticism towards the Torpedo

John Townsend Bucknill, a former Lieutenant-Colonel in the Royal Navy [UK] and a contemporary of Sleeman, published his book in 1889. Bucknill focused on all features related to mines, technically and tactically. He obviously did not believe in the future of the Whitehead torpedo:

> "The Whitehead torpedo has been adopted as a naval arm by so many nations, and has received so much attention for a long period of years, that it has probably been brought to the maximum state of efficiency obtainable from it." (Bucknill 1889; 226)

Bucknill concentrates in his description of the weapon, not on the detailed description (as he does for all the mine technologies), but rather on the "defects inherent to the invention" (ibid). He lists and provides rationale for 9 deficiencies, and claims that those are recognized by many critics of his day (ibid; 227-228):

1. Inefficiency due to small charge.
2. Uncertainty as to accuracy.
3. Expense.
4. Intricacy.
5. Difficulties in manipulation.
6. Difficulties in maintenance.
7. Loss of control after discharge.
8. Motive power dangerous.
9. Space occupied.

Bucknill clearly prefers mines to torpedoes: "… submarine mines should never be replaced by torpedo artillery or locomotive torpedoes …" (ibid; 250). However, as long as torpedoes have to be part of the naval armaments, he describes the Howell torpedo as a favourable alternative to the Whitehead because, he argues, nearly all of the defects of the latter have been overcome in the former.

Bucknill's classification of mines and his categorization of various torpedo types does not differ significantly from Sleeman's general approach. Bucknill's description of controllable torpedoes, though, identifies an imperfection in Sleeman's distinction of mines and torpedoes with respect to their defensive versus offensive use. Bucknill describes the controllable torpedo to be:

> "… that which is controlled after discharge and is directed to the object from the base whence it is launched. For many years it has been seen that a successful weapon of this nature would be useful in certain situations for harbour or river defence; … but at present the best known forms of controllable torpedo find no favour in our own or other navies." (Bucknill 1889; 233)

In summary, Bucknill contemplates that controllable torpedoes can have a defensive use, while Sleeman uses the defensive versus the offensive as distin-

guishing operational properties during his categorization. This incongruity is brought to the attention of the reader for the sole purpose of illustrating that categorizing torpedo types, and in some borderline cases to distinguish what is to be considered a mine versus a torpedo, has never been trivial.

1.6.3. "An Infernal Machine" – other authors express their opinions

Sleeman and Bucknill were not the only authors expressing scepticism towards the Fish torpedo.

1.6.3.1. Gerard Noel

An earlier sceptic, both towards its application as well as towards the mere existence of the weapon, was the Royal Navy [UK] Commander Gerard Noel. His prize winning essay *The Gun, Ram, and Torpedo* was published in 1874:

> "For the 'Fish' torpedo, I believe special vessels must also be fitted; but what place they will take in the line-of-battle it is very difficult to decide. So little is known of this infernal machine that it almost seems a pity it cannot be left out of civilized warfare altogether; we must, at least, trust that its evil effect will not, by mistake, be exhibited on a friendly ship instead of on a foe. I am sure that many generous hearts would gladly spare even the foe so dire an affliction. They would be **dangerous enemies to both sides** if let loose in a fleet action." (Noel 1874; 8)

1.6.3.2. Friedrich von Ehrenkrook

A more optimistic and futuristic opinion of the fish-torpedo is offered by von Ehrenkrook, who was a Lieutenant Commander in the [German] Kaiserlichen Marine. His book *Die Fisch- Torpedos* is written in German and published in 1878.

The introduction to the book starts with a statement of how peculiar von Ehrenkrook thinks it is that mines and torpedoes have not yet successfully gained sympathy from naval officers, despite the fact that the weapons have played a major role in former days (e.g., the Crimean War in 1853). He predicts torpedoes will play an even greater role in future naval warfare. The statement is justified later in the book, where von Ehrenkrook declares that steam engines and iron clad ships will need weapons beyond artillery; weapons with radical effects like rams, mines and torpedoes (von Ehrenkrook 1878; 4).

He advocates that with torpedoes one only needs to get the heading right, as opposed to artillery where the elevation and ballistics must be calculated as well, which is not an easy task at sea (ibid; 19). Another interesting anecdote from von Ehrenkrook is the revelation of the German plans to build facilities in

order to be self-sufficient with respect to maintenance and repair of torpedoes, in case of a war and a potential war materiel embargo from other countries towards Germany. Von Ehrenkrook states, however, that Germany [as of 1878] is reluctant to enter into national torpedo production (ibid; 21).

Yet, only 1 year later, the first sea trial of a German made Schwartzkopff torpedo took place.

1.6.3.3. George Elliot Armstrong

An even more optimistic and realistic (as we know today) futuristic opinion of the fish-torpedo is offered by Lieutenant Armstrong of the Royal Navy [UK] in his book *Torpedoes and Torpedo-Vessels*, published in 1896. Armstrong remarks the torpedo to be the most modern form of fighting, and thus the most powerful and destructive, before he declares:

He also suggests a very simple classification of a torpedo versus a mine:

> "It is not surprising that torpedoes used to be looked upon as unclean things, as something devilish and stealthy. Indeed by a certain school of seamen they are still considered an unfair and cowardly form of weapon; but that feeling is quickly dying out now, and torpedoes have, after many years of curious neglect, taken a front place in the art of naval warfare." (Armstrong 1896; 1)

> "The science of torpedoes may be divided into two branches – namely, the active torpedo proper, and the passive mine. The torpedo has to be guided or aimed by human agency in doing its work, whilst the mine does its work alone [*], after being carefully prepared and left to look after itself." (ibid; 1-2)
>
> [*] [Notwithstanding the 'observation mine' that has to be fired at a critical moment by an operator at a distance.]

Armstrong also issues a warning; a warning that some of the 20th century torpedo-related events – even post-World War II events into the 21st century – prove still valid (Fossnes 2016):

> "In the hands of ignorant or careless people, the Whitehead is nearly as dangerous to its friends as it is to its foes, but in the hands of skilful and resolute men, it is the most terrible engine of warfare which the world has ever seen." (Armstrong 1896; 8)

1.7. "Demythifying" and Demystifying "The first vessel in history to be sunk by a self- propelled torpedo"; 1861

Neither Sleeman nor any other 19th – early 20th century authors on the subject of torpedoes, have described the scenario described here.

The brig *Diana* allegedly merits the dubious honour[4] of being the first vessel to be sunk by an auto-motive torpedo. Because the EuroTorp CD-ROM was never generally accessible in the public domain, the full text is cited.

> "In 1861, an American inventor proposed a self-propelled torpedo. The inventor is poorly identified as the invention was claimed by several individuals and multiple lawsuits were unable to adjudicate.
>
> In short, the invention was essentially a small boat carrying a charge designed to explode on impact, propelled by a 'battery' of rockets from a 'mother-boat', the crew of which had to make last minute adjustments, block the torpedo's rudder and fire the rockets.
>
> The United States government, without waiting until the conclusion of the trial, decided to have a few torpedoes of this type built. Unfortunately, the boat had a bad tendency not to follow the intended trajectory: during the first and only live-fire test, the torpedo veered 45° off its initial direction and sunk the brig *Diana*, with members of the Trials Committee on board.
>
> The survivors compiled a totally unfavourable report.
>
> The *Diana* thus earned the formidable privilege of having been the first vessel in history to be sunk by a self-propelled torpedo." (EuroTorp 2004)

This author found the *Civil War Naval Chronology 1861-1865*, issued by the Naval History Division, Office of the Chief of Naval Operations, Navy Department, Washington D.C., referring to the book *Union and Confederate Submarine Warfare in the Civil War* by Mark Ragan. The inventor of the rocket-powered missile that EuroTorp's CD-ROM describes was Pascal Plant, and the schooner *Diana* was sunk in the Potomac River, just outside Washington D.C., in December 1862 (Ragan 1999; 85-86).

> "Two of Plant's torpedoes were sighted on a target anchored in the river and fired from a test platform. The first struck a distant mud bank, while the second veered off course and sank the small schooner *Diana*, anchored some distance from the proposed target.
>
> Although the botched test resulted in history's first recorded sinking of a vessel by a self- propelled torpedo, Union Naval personnel were unimpressed and wished nothing more than to wash their hands of the whole affair.
>
> Some weeks later […]. Shortly after firing the device at a floating target anchored in the Potomac, the torpedo soared into the air, and stayed air borne for over a hundred yards before splashing down into the muddy river." (ibid)

In fact, the claim of *Diana* being the first recorded sinking of a vessel by a self-propelled rocket / torpedo is foreshadowed by an earlier event recorded by Chr. Middelboe and Sleeman.

According to Middelboe 'a French' experimented in 1720 with fire-rockets on the Thames River. One of the rockets accidentally hit the hull of a ship beneath the surface. This purportedly gave 'the French' the idea of using the rocket as a self-mobile torpedo. After having failed numerous times, he finally succeeded in sinking a larger ship (Middelboe 1885; 26-27).

Sleeman, in his book's concluding table, named 'the French' to be Desaguliers, dated the occurrence 1730, and made this short remark: "This French scientist is said to have destroyed several boats by rockets fired under water." (Sleeman 1889; 330)

2. EARLY EVENTS PERTAINING TO THE USE OF TORPEDOES "FIRED IN ANGER"

Examining the synopsis of war-events involving auto-motive torpedoes in the 1870s, the list is rather short – and in the 1880s none are listed; so the opportunity for torpedo inventors and manufacturers to prove the sceptics wrong were limited. This chapter explores the earliest accounts of the use of torpedoes "fired in anger" with the intention of sinking a ship.

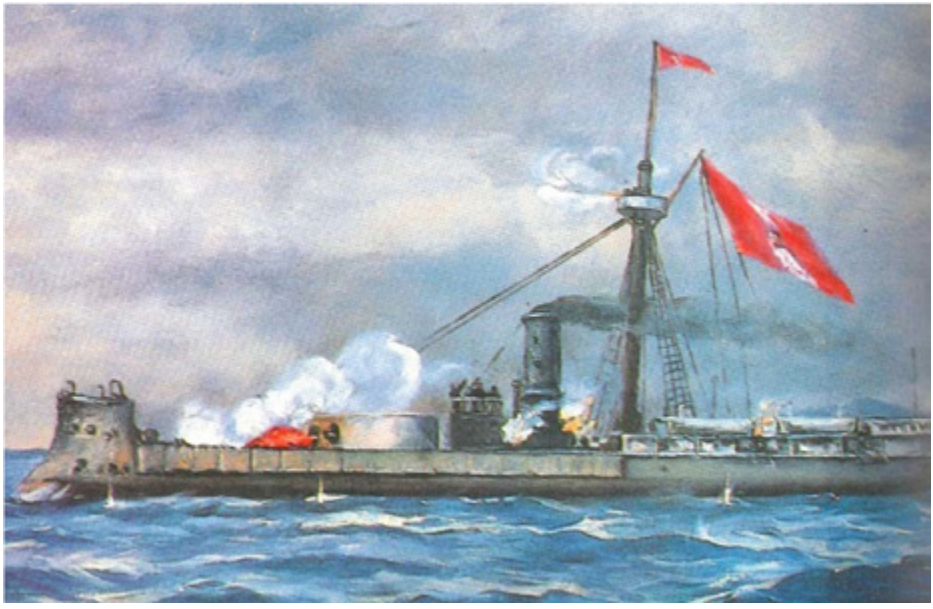


Figure 2. *Canvas of the Peruvian monitor* Huascar*; preserved at the "Asociaciòn de Oficiales Generales" in Lima, Peru (Petrucci 2008; 132).*

2.1. The first time in history a self-propelled torpedo was "fired in anger"

During the Peruvian civil war in 1877, the Peruvian ironclad *Huascar* had been captured by Peruvian rebels, and was regarded as a pirate vessel (Gray 2004; 53). On May 29th 1877 at about 3 p.m. the English ship *H.M.S. Shah* spotted *Huascar* and opened gun fire. About 2 hours later *Shah* fired one Whitehead torpedo against *Huascar* (Hellström 1991). The torpedo missed because the *Shah* fired from too long a distance for the torpedo to reach its moving target.

May 29th 1877 was the first time in recorded history that an auto-mobile torpedo was "fired in anger"; thus also the first time a Whitehead torpedo was launched in a war scenario (Sleeman 1889; 335), however it did not hit the target.

2.2. "Demythifying" *Huascar* was the target of its own torpedo "fired in anger"

The essence of the following story, described by among others by the Swede S. Dehlgren in 1905 (Dehlgren 1905; 29), and also mentioned by Fred Jane in 1904 (Jane 1904; 142), is frequently repeated also in contemporary torpedo literature (Gray 1991; 120-121); (Gray 2004; 53-54); (Branfill-Cook 2014; 170-171), and thus still seems to be generally accepted as factual.

"But on 27 August Miguel Grau, […] caught up with the corvette Abtao outside Antofagasta. Instead of turning to ram, the Huascar swung broadside on its opponent and launched one of the lay torpedoes from its deck. There was a mighty splash as the 2,500 pounds of steel struck the water and the electric cable paid out at lightning speed as it dashed towards the target.

Suddenly a wail of terror rose up from the Peruvian sailors who were lining the rails to witness the violent end of Abtao. The reason for their dismay was not hard to find. The lay torpedo had succeeded in reversing course through 180 degrees and was heading back, true as an arrow, towards the unfortunate Huascar. The operator sitting at the controls frantically turned every knob in sight, but nothing seemed to deter the traitorous torpedo and the crew waited passively for the inevitable explosion. One man, Teniente (Lieutenant) Diez Causeco (sic), fortunately kept his nerve, and diving into the sea, intercepted the uncontrollable weapon and managed to divert its course away from the ship." (Gray 1991; 120).

"The Huascar, however, was not equipped with torpedo tubes. At that latitudes August falls in full winter; the days are short and dawn comes late. Towards 4.30 am, while it was still pitch dark, the Huascar approached Abtao – unseen and unheard – up to a distance of about 400 metres. Admiral Grau, […] ordered one of the torpedoes to be lowered into the water with a winch. While the torpedo was thus being lowered into the sea, it accidentally struck against the hull of the ship (the operation was being carried out in total darkness, to prevent the Chilean vessel from detecting the Huascar's presence near by) and fell into the water.

During the fall one of the guide lights at the end of the rod on the torpedo's back, which were used by the operator to guide and steer the weapon against the target during the night, broke off, while the other turned upside down, with the risk of projecting light in the direction of the Abtao and revealing the entire operation to the enemy. Realizing the danger involved, Lieutenant Diez Canseco dived into the sea, followed by Carlos de los Heros and Midshipman Manuel Bonnemaison, to put out the other light as well, which they managed to achieve, albeit with some difficulty. The torpedo was then fastened to a rope and pulled aboard (which turned out to be a rather troublesome operation, due to the lack of visibility), while the fearless Lieutenant Canseco and his colleagues reached the main deck of the ship, tired and cold, but safe." (ibid).

Well over 2 years later [after the attack by the Shah], i.e. in 1879, the Huascar was nearly hit by another torpedo. This time by a torpedo classified as controllable; a dirigible Lay torpedo.

According to the literature, ironically, Huascar became both the firing vessel and the target in this case. The Lay torpedoes had recently been taken on-board due to the ongoing war between Peru and Chile (1879-1882). However, no trials or training for managing the torpedoes had been performed yet. Edwyn Gray describes the incident in *The Devil's Device*.

According to Gray "… *Huascar* became the first vessel to launch a Lay torpedo in anger- and perversely the second to become the target of one." (Gray 2004; 53-54)

However, the story turns out to be just that – a story.

Before revealing what really occurred, another correction should be pointed out: The name of the officer in the story is **Canseco** (as Dehlgren correctly identifies (Dehlgren 1905; 29)) – not Causeco as Edwyn Gray has written in both his books (Petrucci 2008; 143).

What really happened in the morning of August 27th 1879 has been described by Benito Petrucci in the first volume (of two) in *WASS 133 years of history*. These volumes are not made for commercial sale. Mr. Petrucci, former CEO of *Whitehead Spa*, found that several details made the account of the

incident very unlikely; especially that one man could push away in the water a two tons object travelling at high speed. Petrucci "…obtained a true account of the incident, from certain Peruvian Navy officers, who had learnt about it at the Naval Academy, where the incident is a part of the curriculum." (Petrucci 2008; 144)

Consequently, about 5 years later, Commander Noel was nearly deemed correct in his prediction (Noel 1874; 8) with respect to the Lay Torpedo: The danger to the torpedo-launching vessel was in the disclosing of its own position when the phosphorous light ignited unwittingly.

2.3. Russo-Turkish War – (De)mystifying the first time a torpedo "fired in anger" sunk a ship

Even **if** *Huascar* had been hit by its own torpedo and gone down, it would not have been the first ship to be sunk by an auto-motive torpedo "fired in anger".

2.3.1. The second time in history a self-propelled torpedo was "fired in anger"

During the war between Russia and Turkey (1877-78), the Russians fired several Whitehead torpedoes from the steamboat *Prince Constantine* on December 28th 1877. The attack was directed against a large Turkish naval squadron moored in the port of Batum.

> "The steamer Veliki Kniaz Constantine, having approached the Turkish port during the night, lowered two torpedo boats, the *Tchesma* and *Sinope*, which approached the Turkish ships undisturbed and fired several torpedoes in total darkness" (Petrucci 2008; 139-140).

This was the second firing in history of a self-propelled torpedo in anger (Sondhaus 2001; 124). The attack failed; not only did the torpedoes miss their targets, but according to Sleeman, the Turks even picked up two of the torpedoes (Sleeman 1889; 336). The latter is corroborated by an eyewitness account in a letter that the Italian Lieutenant G. B. Mirabello wrote. The letter is currently in the Historical Office of the Italian Navy: "Both the recovered torpedoes were found on the beach, one further up on the dry sand, the other on the shoreline." (Petrucci 2008; 140-141)

2.3.2. "Demythifying" The first time in history self-propelled torpedoes "fired in anger" sunk a target

A second attack on 25th January 1878 involving torpedoes during the Russo-Turkish war is very much disputed. It is described in several sources that the attack involved (the same) two Russian torpedo boats (launched from the (same) steamer commanded by the Russian Vice- Admiral Stepan Osipovich

Makarov) sinking the steamer *Intikbah* (Gray 2004; 124); (Sondhaus 2001; 124); (Sifferlinger 2003). Both torpedoes are reported to have hit their target, which sank (Sleeman 1889; 336).

However, one source tells a different story. Polmar and Noot (1991) claim to draw on sources inaccessible to the non-Russian language reader. In their sources the name of the Turkish ship is spelled *Intibakh*, (as opposed to *Intikbah*) and the attack is described to have happened on January 14th. The statements are rather brief (as are the details in the other sources in this matter):

> "The following January [i.e. 1878] Makarov acquired Whitehead auto-motive torpedoes, and on the 14th of the same month he destroyed the Turkish dispatch boat INTIBAKH by two of these torpedoes fired at a distance of 230 feet (70 m) by the torpedo launchers CHESME and SINOPE, the first successful operational use of this weapon." (Polmar and Noot 1991; 8)

The sinking of *Intikbah* by *Tchesma* and *Sinope* has entered the historical records as the first time an auto-motive or auto-mobile torpedo "fired in anger" hit and sunk a ship. However, this is a much disputed incident.

The Russian claims are energetically refuted by Admiral Hobart Pasha, who in fact, was present also during the first failed attack in December 1877. Lacking any unquestionable evidence capable of confirming this claim, this incident is generally deemed not to have occurred (Petrucci 2008; 141). The war ended one week later in armistice on January 31st 1878.

The first **confirmed** sinking of a ship with a self-propelled torpedo "fired in anger" should be considered to be the sinking of *Blanco Encalada* on the early morning of 23rd April 1891, when the frigate *Lynch* launched its second torpedo during the Chilean civil conflict (Petrucci 2008; 145).

3. ROBERT WHITEHEAD AND THE SELF-PROPELLED TORPEDO

3.1. "Demythifying" Luppis Conceived the *Salvacoste*

It is well described in numerous sources that Robert Whitehead's development of the torpedo spun off from the Austrian Navy's commander Johann Blasius Luppis who was introduced to Whitehead in Fiume in the Austrian Empire – today's Rijeka in Croatia.

It is, nonetheless, a common misunderstanding that it was Luppis who conceived the idea to be known as the *Salvacoste* – or in German: *Der Küstenbrander*.

…and, according to Edwyn Gray: "… it must be accepted that the concept of the self-propelled submerged torpedo sprang entirely from Robert Whitehead's fertile brain and owed nothing whatsoever to the anachronistic **Küstenbrander**." (Gray 2003; 98).

The basic idea of a small torpedo boat floating on the surface, supplied by an engine and boiler for generating steam or heated air by means of petroleum lamps, was conceptualized by an unnamed officer on-board the Austrian frigate Bellona. Luppis was the commanding officer between 1857 and 1859 (Barber 1874; 5).

Luppis came into possession of the papers and drawings after the death of the unnamed officer. He developed the concept further and made a small prototype about 1 meter long[5]. His first idea was to let the vessel be wind driven by means of a pair of perpendicular transparent sails, in order to make the vessel less visible compared to canvas sails (Silurificio Whitehead di Fiume 1936; 6-7). Eventually the prototype model was equipped with a tiller rope guided clockwork driven machine with a one screw propeller.

It is also worth mentioning that despite the objective to use a vessel filled with explosives for coastal and harbour defence against hostile ships, Luppis did not know how to trigger the detonation. The solution – a mechanical exploder device, detonating the main explosives when the vessel hit a solid object – was invented by the weapons smith on-board *Bellona* (Dehlgren 1905, 5).

Eventually, after Luppis had performed a series of unsuccessful trials with a prototype weapon, Luppis was advised by the prominent local businessman Giovanni de Ciotta in Fiume in 1863 to consult Whitehead who had come to Fiume in 1857 (Gray 2004; 7). Whitehead was the technical manager of 'Stabilimento Technico di Fiume', a company constructing and producing large steam engines for warships. Luppis and Whitehead, and de Ciotta, eventually signed a memorandum on 14th August 1864, after Whitehead had declined the offer repeatedly for 14 months. The objective for the cooperation was not necessarily perfecting the *Salvacoste*, but rather transforming the vessel concept

into a proper operational system that eventually could be accepted by the Austrian Navy (L'Associazone Culturale Whitehead 1999; 18). This author suggests it is likely that Whitehead used the 14 months to think about ways to turn the Salvacoste into a real underwater vehicle before signing the agreement.

3.2. Demystifying Whitehead's First Prototype Torpedo Test on 26th December 1864

Robert Whitehead's objective when he signed the memorandum was to invent a mechanism that could transport a sufficient mass of explosives from one vessel to another autonomously, under the water surface, such that physical contact would immediately detonate the explosives. The intention was that the damaged vessel should be prevented from participating in any further warfare action.

The memorandum contained these requirements for the device in order to fill the above objectives (von Witzell 1944):

1. *Does not require a boat to bring the device to its detonation position;*
2. *Travels to its destination by means of an internal engine, quite invisible to the enemy;*
3. *For this reason and to regulate the effect according to the vessel attacked, should be able to travel horizontally below the water at the set depth;*
4. *Should be able to aim at a target and should have a greater chance of hitting than a shell at a range of 3½ cables or 2000 Viennese feet* [~ 700 meters].

Robert Whitehead maintained strict secrecy with respect to the development of the underwater weapon derived from the *Salvacoste* concept. Hardly any information is available that describes the evolution of the initial prototype until the first official demonstration for the Austrian authorities 2 years later in December 1866.

According to Petrucci, Whitehead had in addition to the depth regulator in his first prototype:

> "… also provided for a vertical rudder, placed behind the propeller; this rudder was operated by Whitehead himself using two trailing ropes, as in Luppis' "coastsaver". This was the only detail the English inventor had kept of Luppis' original system, probably more as a form of regard for Luppis than because he was genuinely convinced of its effectiveness. The system proved impracticable right from the start, of course, when one of the cables broke during a test run, causing the torpedo to go off course and hit the coast. Whitehead thus decided, without hesitation and discarding the idea of carrying out a confirmation launch, to do away with the cables altogether, and to focus on how to control the torpedo's direction horizontally, to ensure that it kept a straight course." (Petrucci 2008; 34)

Von Witzell (1944) describes the solution to the initial requirements for the prototype torpedo that underwent sea trials on December 26th, 1864 as follows:

- 3.4 m (11 feet) long,
- Had a diameter of about 36 cm (14 inches).
- Total weight, including an explosive charge of 7 kg (15 lb), was 136 kg (300lb).
- The propulsion engine, rotating a single propeller, was operated on compressed air.
- The torpedo had a depth gear consisting of a hydrostatic diaphragm fitted to the wall of one of the torpedo's compartments.
  - The movement of the diaphragm was transmitted through wires to a pair of tilt- able horizontal fins for depth control.
- The vertical rudder for course control was fixedness mechanically bent; the correct setting (bending) for a straight course was obtained by experiment.
  - The reason for bending the rudder was two-fold:
    - to sustain a straight course throughout the run, and
    - to prevent torpedo roll due to a single propeller.

The performance of this first torpedo was 600-700 yards range with a speed about 7 knots (von Witzell, 1944). (Counter rotating propellers were first introduced in Whitehead's series produced torpedoes in Fiume more than 10 years later; in late 1875).

Compared to the accurate measurements of contemporary systems, the speed verification method of the first torpedo was as remarkable as it was rudimentary: a naval boat rowed at full speed alongside the torpedo upon launch, trying to keep pace with the torpedo. From this the speed was gauged at 7 knots. (von Witzell, 1944)

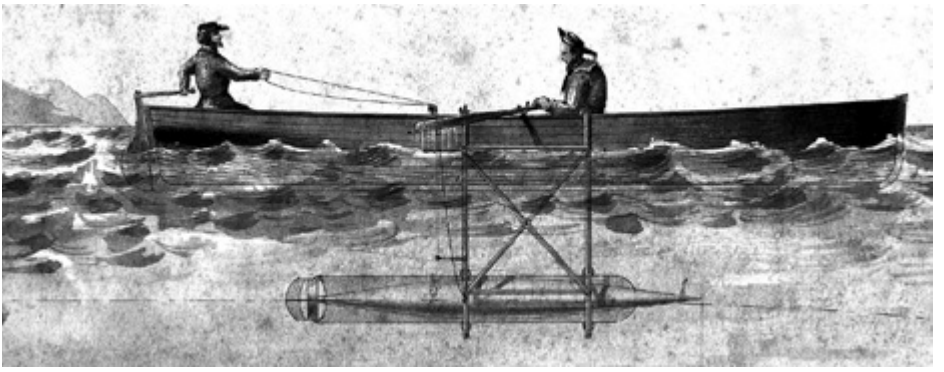


Figure 3. *The principle of a torpedo firing and speed assessment – according to von Witzell's description. The illustration is courtesy of Smokvina (2012).*

3.3. Demystifying the Undated Photo of Whitehead and an Early Torpedo

The undated photo below of Robert Whitehead (and an unidentified person) standing next to a torpedo was found in the Royal Naval Armaments Depot Museum (UK) by Edwyn Gray.



Figure 4. *This undated image of a torpedo and what is assumed by most known sources to be Robert Whitehead, was downloaded 14. October 2008 from http://en.wikipedia.org/wiki/Robert_Whitehead Copyright has expired.*

This author suggests that the above photo depicts Whitehead's prototype torpedo from late 1864 or early 1865. This chapter reviews the literature surrounding the speculation about this photo, and ends with a rationale supporting this hypothesis.

3.3.1. Whitehead Torpedo anno 1877

Branfill-Cook claims that Gray's dating of the picture as Robert Whitehead with a torpedo in 1866 (Gray 1991; 62) must be incorrect.

> "Closer inspection will reveal that this is a Whitehead torpedo dating from after the introduction of the contra-rotating propellers, and consequent suppression of the stabilizing fins top and bottom, which took place from 1874. The man on the right is too young to be Robert Whitehead in 1877, the most likely date for the photo. The author suspects that this is in fact a photo of Woods Pasha…" (Branfill-Cook 2014; 171-172).

Woods Pasha was a British officer seconded to the Turkish Navy. Branfill-Cook claims that the torpedo is one of the two 15-inch torpedoes that beached and was captured by the Turks after the Russian firing on 27th December 1877. He also argues that the torpedoes numbered 250 or 255 may be the ones in question. Though it is correct that the batch of 30 torpedoes numbered 246 to 275 was delivered to Russia 10th to 20th February 1877, these were 1876 models; in fact exactly the same type that were first delivered to Russia between 29th May to 20th September 1876 (torpedo serial numbers 171 to 190).

The first 350 torpedoes that were delivered from the Whitehead factory in Fiume, from 26th January 1875 until 12th July 1877, were all of the same type. The deliveries were made to Germany, France, Norway, Sweden, Russia, and Denmark. The dimensions of those torpedoes were 15 inches in diameter and 19 feet long (Petrucci 2008; 54).

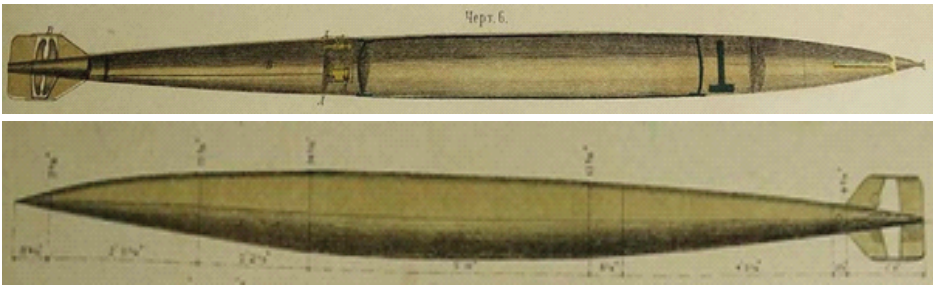


Figure 5. *Whitehead torpedo type from 1876 according to the Russian Navy's torpedo manual from 1889.*

Archives from the Russian navy from 1889 provide illustrations of their inventory of torpedoes including Whitehead torpedo type from 1876 (Imperial Russian Navy 1889). The dimensions from the illustration are consistent with the aforementioned shipments. Corroborating information can also be found in Korshunov & Uspenskiy (1993; 2-8).[6]

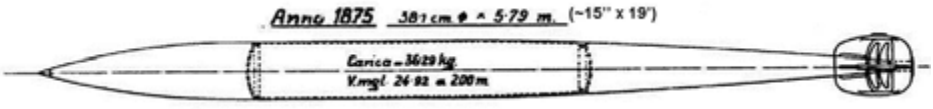
Thus it is very unlikely that Branfill-Cook is correct in his claim that the undated photo shows a Russian torpedo from 1877. The man on the picture

may be too old to be Robert Whitehead in 1877, however, if the picture is from a much earlier date, like the mid-1860s, Robert Whitehead is in his mid-40s (he was born in 1823), and it may very well be him standing to the right, as Edwyn Gray asserts.

Conclusion: The undated picture is **not** of the 1877 model. It must be an earlier model.

3.3.2. Whitehead Torpedo anno 1875

Unnamed sources claim the undated image is depicting the torpedo model built in 1875 and released on the market a year later (e.g. in Wikipedia).



■ **Figure 6.** *Whitehead torpedo longitudinal shape 1875; courtesy of WHITEHEAD ALENIA Sistemi Subacquei S.p.A. (WASS)*

Below is a photo of the Tail Section of the first Whitehead Torpedo, delivered in 1875 to Norway. The first batch of 25 torpedoes was delivered with a single 6 blade propeller. The slight bending of the vertical rudder, to keep the torpedo on a straight course during the run, can also be seen in the upper right corner on this photo.



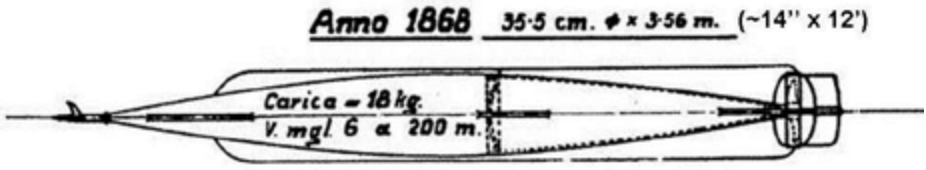
■ **Figure 7.** *Tail Section of the first Whitehead Torpedo delivered to Norway in 1875 at display in the Norwegian Naval Museum, Horten. Photo: Terje Fossnes ©*

The 1875 models and later models from Fiume had propeller guards as can be seen here. It was also around this time that the 2 counter rotating propellers were introduced in the Whitehead torpedoes. Comparing the tail section of the above torpedo with the torpedo in the undated photo, it is clear that the difference is significant.

Conclusion: The undated picture is **not** of the 1875 model. It must be an earlier model.

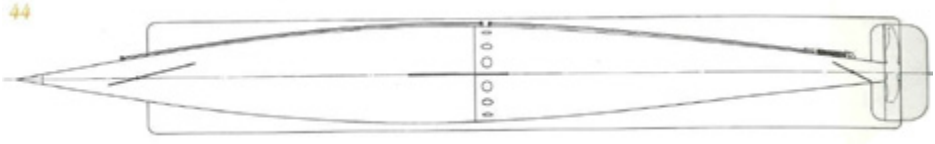
3.3.3. Whitehead Torpedo anno 1868

Looking at the 1868 version of the torpedoes, the single propeller in the undated picture is without the propeller guard introduced in the 1868 models as depicted below. The exterior longitudinal stabilization fins remained a characteristic of all the Whitehead models (ref. e.g. the first models sold to UK and Germany in the early 1870s) until a major redesign was made as shown in the 1875 representation.



■ **Figure 8.** *Whitehead torpedo longitudinal shape 1868; courtesy of WHITEHEAD ALENIA Sistemi Subacquei S.p.A. (WASS)*

Also the below sketch of the 1868 model, clearly bears no resemblance to the torpedo in the undated photo.



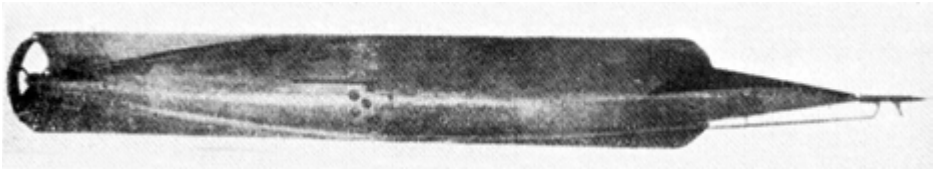
■ **Figure 9.** *Sketch of the Whitehead torpedo used for the sea trials in 1868. The torpedo is fitted with two pairs of rudders; at the fore end, controlled by the hydrostat, and at the rear end the depth rudders are controlled by the pendulum; courtesy of WHITEHEAD ALENIA Sistemi Subacquei S.p.A. (WASS) (Petrucci 2008; 40).*

Conclusion: The undated picture is **not** of the 1868 model. It must be an earlier model.

3.3.4. Whitehead Torpedo anno 1866

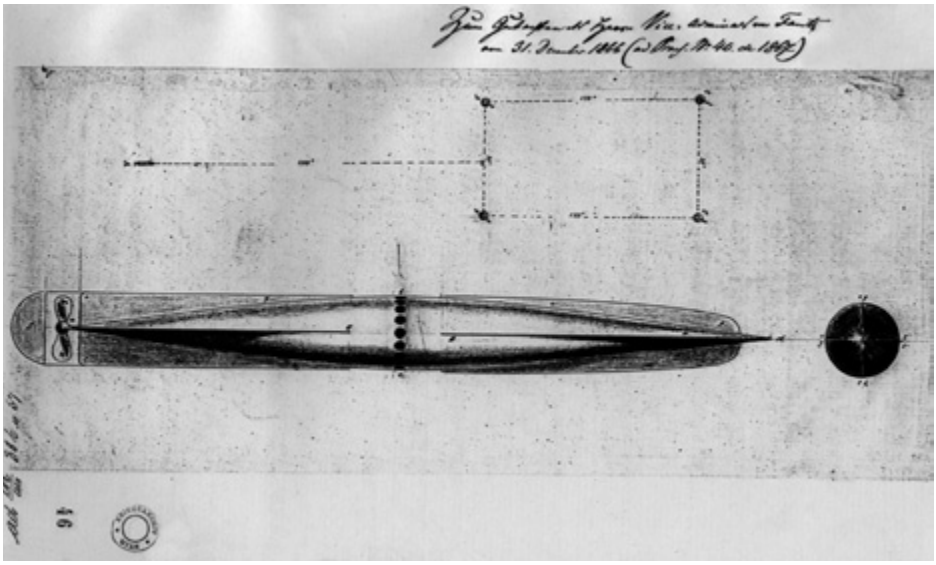
Edwyn Gray points out in '*The Devil's Device*' that the undated photo of Robert Whitehead and a torpedo may be the 1866 prototype (Gray 1991; 62).

However, looking at the picture below of the 1866 model of the Whitehead torpedo, as it appears in the book from the Whitehead torpedo manufacturer (Silurificio Whitehead di Fiume 1936; 12), the 1866 model bears no resemblance to the torpedo in the undated photo.



■ **Figure 10.** *Whitehead torpedo of 1866 – according to Silurificio Whitehead di Fiume in 1936*

It appears evident that the 1866 model of the torpedo had longitudinal stabilisation fins for keeping the torpedo on a straight course. The torpedo in the undated photo does not have this feature.



■ **Figure 11.** *Sketch of the Whitehead torpedo used in the sea trial on 31st December 1866. The illustration is courtesy of Smokvina (2012)*

Conclusion: The undated picture is **not** of the 1866 model. It must be an earlier model.

3.3.5. Whitehead Torpedo anno late 1864 – early 1865

An examination of the torpedo in the undated photo reveals resemblance to the description of the 1864 prototype described by von Witzell (1944), presented in section 3.2.

Associating the height of Robert Whitehead with the length of the torpedo, taking the slight angular offset from the photographer into consideration, the diameter (14 inches – nearly 36 cm) and the length (about 12 feet – 3.6 meters) matches the data given for the 1864 model.

As well, the dominant horizontal stabilization fins along the fuselage of the 1866 and 1868 torpedoes are not part of the portrayed model.

The most notable feature of the depicted torpedo is the aft of the torpedo. Gray and others may argue that it is a battered torpedo; however, this author is confident that the "dented" or "battered" aft is part of the intended design in the very early prototype model(s).

Comparing the torpedo shape / longitudinal profile in the undated photo with the shapes of the 1875-76 models, there is also a distinct difference. The later models were still 'javelin shaped' in the forward part of the torpedo for about ⅓ of the total length, while the depicted torpedo has this characteristic for about ½ the length. Also, in fact, the 1875-76 models are too long (19 feet) to be the one depicted in the photograph. In addition the single propeller in the undated photo is without a propeller guard – already present in the 1866 models.

According to von Witzell "The torpedo had a depth gear consisting of a hydrostatic diaphragm fitted to the wall of one of the torpedo's compartments. The movement of the diaphragm was transmitted through wires to a pair of tilt-able horizontal fins for depth control." (von Witzell 1944)

The diaphragm can be seen in the torpedo between Whitehead and the unidentified person in the photo. Examining the tail section of the torpedo, it is not really possible to conclude if there are (or not) tilt-able horizontal fins like the ones that are visible on the picture of the 1875 model. However, the wires (and possibly also rods) to the depth control rudders are inside the torpedo hull, and thus not visible.

This author has also had personal conversations with respect to the photo with Benito Petrucci in 2009; he was convinced that it is Robert Whitehead that is depicted. To-date there are no publically available photos of Whitehead as a younger man. Unfortunately Petrucci could not find any significant information available in the Historical Archives of WASS clarifying the year and make of the torpedo.

Conclusion: The undated picture is portraying a late 1864 or early 1865 prototype.

3.4. No Secret – Whitehead's Early Torpedoes subject to Depth Oscillations

Two years after the 1864 prototype tests, in December 1866, Robert Whitehead officially had demonstrated his invention of the self-propelled torpedo to the Austrian Imperial Naval Evaluation Commission. The date for the trial is not congruent in the available sources. December 20th (Smokvina 2006), 21st (Braun 1935), 26th (Rössler 2005; 12) and 31st December in Whitehead's sketch in section 3.3.4 are dates appearing for the official sea trials.

It is likely, however, that the dates are representative of the end time of the trials, which certainly lasted several days because the trial torpedoes were launched many times. The torpedoes were reportedly available for test preparations from December 3rd (Sieche 2004), and this readiness to carry out the test launches in the presence of representatives of the Austrian Imperial Navy was announced by Whitehead in November 1866 (Petrucci 2008; 34).

The depth oscillation is reported with a torpedo pitch between 20 and 30 degrees, frequently causing the test object to breach the surface (Silurificio Whitehead di Fiume 1936; 18). The torpedo was reckoned by the Austrians to have considerable possibilities, but it evidently needed a great deal more work, especially in the depth keeping mechanism (Gray 1991; 50).

The main problem with the depth keeping was that the torpedo oscillated quite steeply around the pre-set depth. Von Ehrenkrook wrote in 1878 that the control was achieved by means of a 'wonderful' guidance mechanism that was a secret to all, with very few exceptions. However, he continued, an American, William King[7], had described the device (von Ehrenkrook 1878; 19).

Von Ehrenkrook revealed King's description of the control apparatus' principle:

> The early torpedo's depth-control apparatus' principle was essentially an elastic bag, filled with compressed air and contained in a cylinder. Any longitudinal changes to the elastic bag would cause a rod inside the cylinder to move, and consequently affected the depth rudders of the torpedo (von Ehrenkrook 1878; 19-20).
>
> Von Ehrenkrook admitted that the power transmitted from the elastic bag through the rod to the rudders would not be large enough to directly influence the depth rudders because of the speed and the depth of the torpedo. Thus, he concluded, this could not be the way the mechanism was constructed. However, von Ehrenkrook offered no alternative design description.

3.5. Demystifying the Evolution of *The Secret* – Whitehead's Depth-keeping Mechanism

William King may not have been so far off in his description as von Ehrenkrook thought. Indeed, King did not describe *The Secret*, but gave a rather suitable description of what may have been the principle of the depth keeping mechanism embedded in the 1864 prototype torpedo. A careful study of the limited literature when it comes to the progression of the depth keeping device in Whitehead's torpedoes in the early days suggests to this author an evolution of the hydrostatic control mechanism, which was later combined with a pendulum, that were unique to the Whitehead torpedoes[8].

3.5.1. Hydrostatic bellows

The first prototype torpedoes in 1864 and 1865 used a simple bellows principle; a bag filled with compressed air and constrained so that it did not expand. The bellows was suspended in two metal plates and housed in an airtight cylinder (hence: 'contained in a cylinder'). One metal plate was placed in line with the outer hull of the torpedo, and it was influenced by the hydrostatic pressure at the actual depth of the torpedo at any given instant of time.

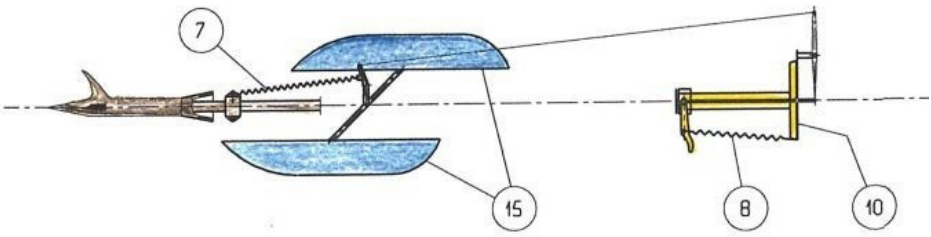
This is the principle that von Witzell referred to as "The torpedo had a depth gear consisting of a hydrostatic diaphragm fitted to the wall of one of the torpedo's compartments. (This is what this author claims can be seen in the undated photo of Whitehead and a torpedo – the plate towards the aft of the torpedo body.) The movement of the diaphragm was transmitted through wires to a pair of tilt- able horizontal fins for depth control." (von Witzell 1944)

The second plate may at some time also mechanically have moved the horizontal rudders (for depth control) by means of a rod and system of hinged levers (replacing, what was described by von Witzell: by means of wires). The depth setting was fixed based on the air pressure inside the bellows when the torpedo was launched.

This system always lagged in reaction time, because the rudders were not neutralized again until the torpedo had re-acquired, on its way up or down, the pre-launched set operating depth – then the same pattern recurred, but in the reverse vertical direction. Thus an oscillating effect creating a significant vertical sinusoidal curve with amplitude of several meters was inevitable – when it worked that is. Many times the torpedo hit the bottom.

3.5.2. Hydrostatic piston

Whitehead's descriptions of the torpedo used for the 1866 trials[9] were never revealed (Gray 1991; 46). However, Petrucci describes that the hydrostatic piston was first embedded into the 1866 prototype torpedo (Petrucci 2008; 33-34), and that up through the tests starting in February 1868, only the hydrostatic piston was embedded (Ibid; 38-39).



■ **Figure 12.** *A sketch of the hydrostatic piston depth-regulator principle embedded in the torpedo between December 1866 and February 1868. The numbers on the sketch indicate: 7) rudder restoring spring; 8) depth regulation spring; 10) the hydrostat; and 15) horizontal rudders (Petrucci 2008; 34, 40).*

The above sketch shows the manner of operation of the hydrostatic piston depth-regulator in the torpedoes demonstrated for the Austrian Imperial Naval Evaluation Commission in December 1866 and February 1868. The hydrostat (10) consisted of a rubber membrane subject to both the pressure of the seawater and the pressure of the depth regulating spring (8). The hydrostat was mechanically connected to a pair of horizontal rudders (15), on the right and left of the torpedo bow. Whitehead thought he had solved the depth keeping problem with this solution (Petrucci, 2008; 34).

The new torpedo (replacing the one lost in October 1867) was ready on February 7th 1868, but on February 19th the tests were put on hold because the depth-regulator was not reliable enough (Sifferlinger 2003). Peter Bethell reports the tests to be performed between October 1867 and May 1868 (Bethell 1944; 6).

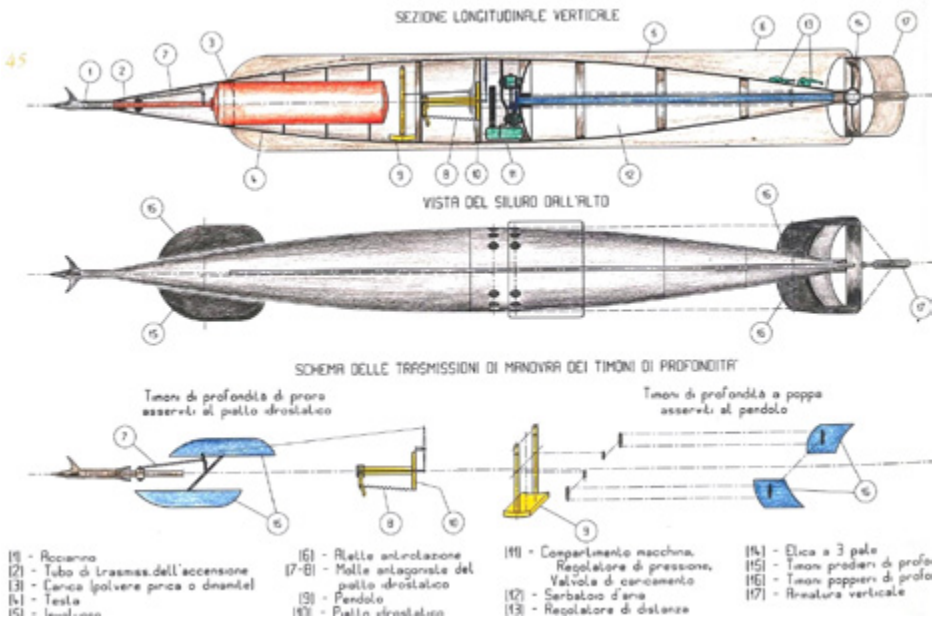
The hydrostatic piston enabled the possibility of mechanically pre-setting the torpedo depth (by adjusting the tension of the spring in the hydrostat) within a range from 5-15 feet – implemented in one-foot steps (Cumming 2002). Though the depth sensing accuracy of the mechanical spring solution was an improvement over the bellows, it did not change the cause for the oscillation and the necessary softening of the regulation arrangement. This is why the depth instability during the February 1868 trials still concerned both Robert Whitehead and the Evaluation Commission.

This author suggests that during the trials in December 1866 a total of 13 firings were conducted. This is deduced from a combination of the total number of firings for the Austrian Imperial Naval Evaluation Commission, 84 (this number must include the 1866 firings) described by Barber (Barber 1874; 86), and "a total of 71 test launches conducted" described by Petrucci (this number refers to the firings conducted from February through May 1868) (Petrucci 2008; 43).

3.5.3. Hydrostatic piston and pendulum operating on separate depth rudders

After the depth oscillation of the torpedo in the first 41 firings during the tests in February 1868, Whitehead added a pendulum to the existing hydrostatic piston solution in March (Sifferlinger 2003) and the tests resumed in April the same year (Petrucci 2008; 43).

However, in this first installation, the hydrostat and the pendulum operated on separate pairs of rudders, as can be seem in the sketch below. The pair installed at the fore end is controlled by the hydrostat, and the pair at the tail is controlled by the pendulum.



■ **Figure 13.** *The sketch shows the detailed configuration of the torpedo with two pairs of horizontal rudders (depth rudders) (Petrucci 2008, 40 (Fig.45)).The pair installed at the fore end is controlled by the hydrostat, and the pair at the tail is controlled by the pendulum. This configuration, implemented in the 30 torpedo firings that took place in April and May 1868, made it possible to stop the torpedo from oscillating.*

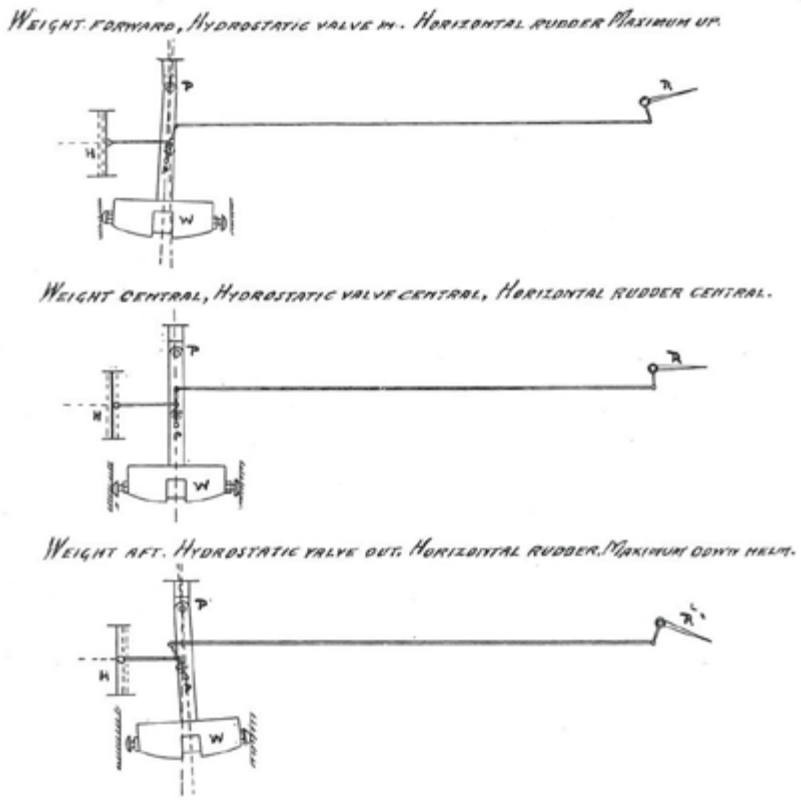
This new depth keeping solution with independent rudders operated by the separate hydrostat and pendulum respectively was demonstrated to the Austrian Imperial Naval Evaluation Commission from 16th April to 12th May 1868 (Silurificio Whitehead di Fiume 1936; 24). In 1868 a total of 71 test launches were conducted, with a high success rate, especially during the last 30 firings when the pendulum had been added (Barber 1874; 86). The Evaluation Commission made a positive assessment and one member notified Whitehead about this in a letter dated May 18th 1868 (Petrucci 2008; 43). The Whitehead torpedo was officially accepted by the Austrian War Ministry in a letter to Whitehead dated 13th June 1868 (Petrucci 2008; 43). Eventually the Austrian

Navy also ordered weapons to be produced – four 14 inch Whitehead torpedoes – in April 1869 (Sieche 2004)[10].

Edwyn Gray refers to "trials" that should initially take place in May 1868 (Gray 1991; 54) and states that: "For various reasons the trials were delayed until October …" (Ibid; 56). This cannot be correct, as described in the previous paragraph. Also the acceptance letter of 13th June 1868 undermines Gray's statement. Gray also states that: "*The Secret* was not devised by Whitehead until after the trials of October 1868 …" (Gray 1991; 50).

3.5.4. Hydrostatic piston and pendulum combined to operate on a single pair of rudders

The combination of the hydrostatic piston and the pendulum as an integrated solution is what is known as *The Secret* – Whitehead's depth regulating device that was implemented in his series produced torpedoes. Detailed description of the construction itself or any construction drawings have not been found in any materiel in the public domain. However general descriptions can be found, as in this example from Commander Murray F. Sueter (1907) of the Royal Navy (UK):



■ **Figure 14.** *The principle of the combined Hydrostatic Piston and Pendulum integrated as one device.*

The principle of the spring and piston sustained. However, a pendulum was added to the construction and it was all contained in an air tight compartment. The pendulum operated as a kind of counter weight to the hydrostatic pressure's influence on the horizontal rudders, through the piston with the rod and the hinged lever system. The piston and the pendulum balanced each other out in a so called 'angle of equilibrium' every time the horizontal rudders were flush (i.e. zero deflection). This equilibrium represented a calculated angular difference between the torpedo's length axis and the horizontal plane, at which the deflection of the rudders would shift from up to down, or vice versa. Typically this angle was between 0.75 and 1.75 degrees, and it was mechanically adjustable. Calibration was done if deemed necessary based on actual firings (after all, torpedoes were handcrafted and had slight variations influencing the horizontal and vertical balance in water during the run) (Sueter 1907; 303 and Fig. 82).

Whitehead first met with the British Admiralty in November 1868, and performed some torpedo test firings during the initial meeting. The British impression was positive, however it took until the beginning of August 1869 before the representatives from the Admiralty and Whitehead started the negotiations that would ultimately end in an agreement signed 23rd February 1871. The test firings conducted during the first UK meeting led to an invitation to Whitehead to perform tests of his torpedoes at Sheerness Sheppy in England. These tests proved lengthy and not without problems. Starting in June 1870, sixty launches were performed using 4 different torpedoes (two each of 14 and 16 inches), before the trials culminated in the sinking of the corvette *Aigle* on 7th October 1870 (Petrucci 2008; 46).

The two 14-inch torpedoes used for these trials contained the integrated hydrostatic piston and pendulum solution operating a single pair of rudders, a.k.a. *The Secret*. The device was installed in the aft part of the torpedo (Silurificio Whitehead di Fiume 1936; 24-25).

Whitehead was cautious not to reveal more information than he deemed necessary, even to his customers. As an example, the following text is translated into English from a Norwegian handbook describing the Whitehead torpedoes, issued by the Norwegian Torpedo Authority in 1885:

> "…the depth-regulator, of which both the device itself as well as the interconnections with the horizontal rudders, is kept secret, notwithstanding that the following is common knowledge, … [next follows a brief statement that the deflection of the rudders is moved upwards when the water pressure increases on certain devices due to a depth change of the torpedo; and vice versa] … More detailed knowledge of these parts is not necessary, however, for the handling of the torpedo" (Torpedovæsenet 1885; 6).

The introduction of the pendulum significantly helped dampen the amplitude of the depth oscillations – in the order of magnitude from more than 2 meters to less than ½ meter. Some sources are rather extreme in their specification of the depth anomaly and the resulting reduction; e.g. from ± 40 feet reduced to ± 6 inches (Kirby 1999).

In summary, this author offers the following of how the mechanism worked for a torpedo with positive buoyancy running closer to the surface than its pre-set depth:

> The depth control mechanism would be affected by the hydrostatic piston alone as long as the pitch was zero. The deflection of the rudders would correspondingly increase slightly and bring the torpedo downwards to the correct depth. If the torpedo's pitch pointed downwards as well, the pendulum would influence the rudders to deflect upwards as soon as the angle of equilibrium was reached. If the torpedo, on the other hand, for some reason pitched upwards when the rudders' deflection was downwards, the pendulum would immediately position the rudders to their maximum downwards deflection until the angle of equilibrium had been re-achieved. This mitigation of the extreme behaviour reduced the probability of occurrence of the torpedo hitting the bottom or breaching the surface.

3.5.5. The pneumatic servo – final enhancement to *The Secret*

Whitehead's customers constantly demanded increased speed in his torpedoes. For instance, the Russian Navy wanted torpedoes that could achieve 20 knots or more in order to catch a fast going ship in chase (Kirby 1999). He discovered during his work on the models used for the English trials in 1870 that the depth steering applied up to then was inadequate. The piston and pendulum solution alone could not sufficiently deflect the rudders. More mechanical power was needed. His solution was to connect the hydrostatic piston and the pendulum to the single pair of rudders amplified through a pneumatic servo device, initially called 'servo-motor' (Sleeman 1889; 181).

A comprehensive and overall description of the servo assisted operation of *The Secret* is found in Petrucci's description of the implemented solution in the series produced torpedoes.

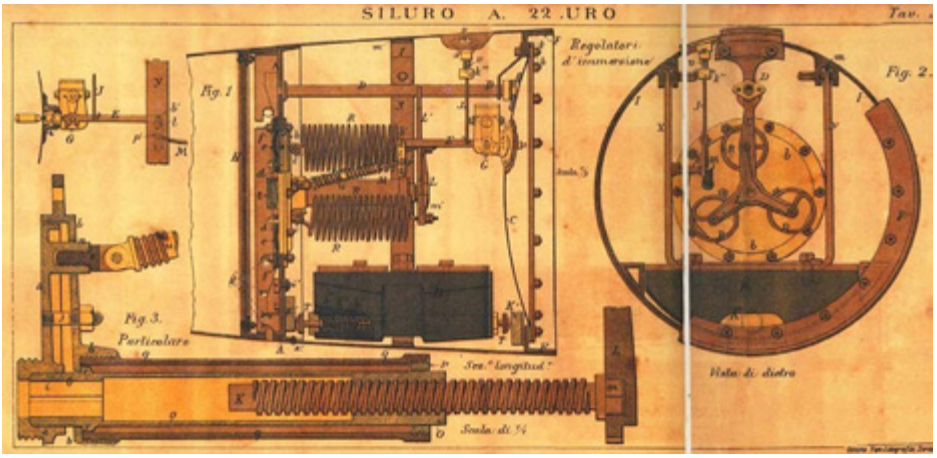


Figure 15. *A technical drawing of The Secret with a servo as implemented in Whitehead's 14-inch series produced torpedo from 1877 (Petrucci 2008; 42-43, Fig. 49).*

The drawing above shows the actual configuration of the "depth-regulator" (*The Secret* with a servo) in Whitehead's 2nd type of mass produced torpedoes from 1877. Fig. 1 (left) is seen from the side, and Fig. 2 (right) seen from behind.

> "The seawater entering through the holes (g) applied a pressure to the round hydrostat (a) through a flexible membrane (e). This pressure was opposed, on the hydrostat, by the three springs through the plate (b). Tightening the rod (K) by means of a special key and, therefore, determining the movement, in either one or the other direction, of the structure (L), the three springs (r), extending or shortening their length exercised a corresponding action on the plate (b) and, therefore, on the hydrostat (a). Thus, by tightening the rod (K) it was possible to control the depth of the torpedo. The pendulum (B), consisting of a heavy cast iron block, was suspended from the supports (m) on the upper part of the torpedo hull. The pendulum was connected to the springs on the hydrostat by means of the lever (l), the movements of which were the result of the combined action of the hydrostat and the pendulum. The lever (l), through the rod (E) and the terminal pin (s), transmitted its own movements to the servo-unit, which, by amplifying the power, transmitted them directly to the horizontal rudders. Thus, the movement of the rudders resulted from the combined action of the hydrostat and pendulum, ensuring the gradual control and sustainment of the predetermined depth, with no rocking movements" (Petrucci 2008; 43).

The servo-amplified pendulum and hydrostat control remained unchanged in basic form and was used in the generation of the Whitehead torpedo until the end of World War II (Gray 1991; 57); although roll control functionality, improving the depth stability even further, was added when World War I broke out.

3.6. Whitehead's Torpedo Technology Disclosed in the Public Domain

Any information pertaining to *The Secret* remained publicly undisclosed until 1889 when Sleeman published his updated edition of *Torpedoes and Torpedo Warfare*. Even after its release Whitehead tried to control accessibility and even visibility to the apparatus. At the same time, the number of customers and produced torpedoes increased rapidly. Though Sleeman did not include any illustrations of *The Secret* or its operating principles, his 1889 edition was the first commercially available book containing a description of this device (Sleeman 1889; 181-185).

Lieutenant Armstrong's book published in 1896 contains state-of-the-art general descriptions and drawings of Whitehead's torpedo technology, including *The Secret* (Armstrong 1896; 37-40). A contemporary of Armstrong, a German naval officer, Hermann Gercke, also reveals the functionality of Whitehead's torpedo depth steering mechanism in his book published in 1898 (Gercke 1898; 34-38).

Another book, by the Swedish lieutenant Dehlgren, should also be mentioned. Dehlgren is so eager to describe the essence of Whitehead's 'Secret' that he starts the book explaining the principle of how it works (Dehlgren 1905; 7-10). In Sweden (as in many other nations) there was rising awareness of, and curiosity about the new naval warfare capabilities: the torpedo as the main weapon for the submarine (U-boat) that many nations were introducing into their fleet in the first decade of the 1900s. Dehlgren's book was written during the creation of the Swedish Navy's Submarine Force in 1904 and published in 1905. The first navy to introduce the submarine into their fleet was the U.S.A. in the year 1900[11].

Perhaps the most concentrated reference to the Whitehead torpedo and its evolution is described in over 800 pages by Benito Petrucci, former CEO of *Whitehead Spa*, in the two- volume hardcover manuscript W*ASS 133 years of history*, printed in 2008. They are not, however, made for commercial sale. These volumes contain broad and in-depth analysis of the technical and historical sources, and a unique collection of pictures, drawings and historical records, found and written during Petrucci's enormous work of cataloging the Historical Archives of *Whitehead Alenia Sistemi Subacquei* (WASS), in order to transfer all relevant content to the torpedo section of *Archivio Storico Livorno* (the Livorno City Archives). The torpedo archives in Livorno opened to the public in November 2009, and this author and his wife were invited as the first visitors of the archives.

4. FILL IN THE HISTORY FOR THE HALPINE TORPEDO (BOAT)

In Edwyn Gray's book *19th Century Torpedoes and Their Inventors* he briefly mentions the "Halpine Storage Battery" torpedo and points out: "As this was clearly one of the antecedents of the modern electric torpedo, it is hoped that a diligent researcher will ultimately chance upon details of its design and history." (Gray 2004; 200-201)

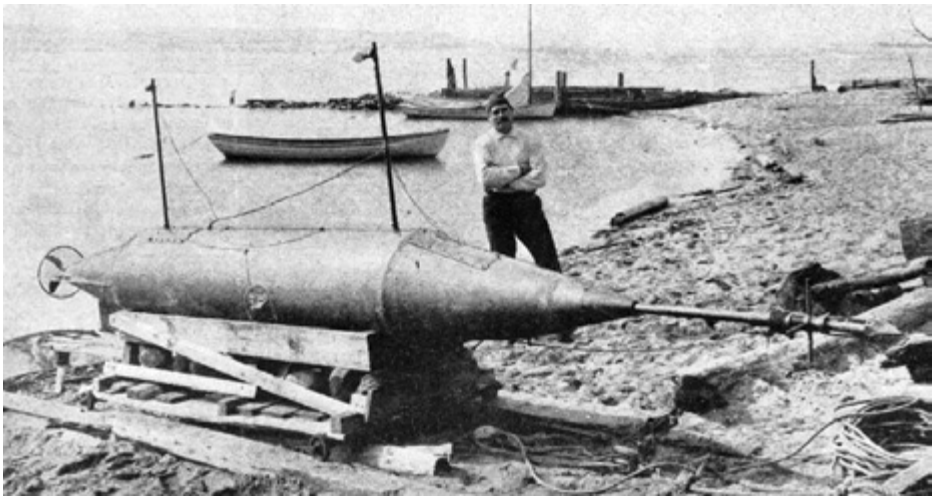
When this author examined the archives of the Norwegian Naval Museum in Horten, he found an article entitled "Halpins styrbare torpedo" which referenced the *Proceedings* of US Naval Institute (NTfS 1895-96; 230-235)[12].

The Halpine Dirigible Torpedo, as called by Cyrus S. Radford in 1894, was in reality a hybrid between a torpedo proper and a torpedo-boat (Radford 1894). He described it as a submerged boat steered electrically from the shore or from a vessel, and carrying, releasing and discharging an explosive cartridge (i.e., the torpedo) when the boat hit any obstacle. The boat, however, first automatically backed away from the torpedo, so as to be at a safe distance when the explosion took place, and possibly be reused for a later attack.

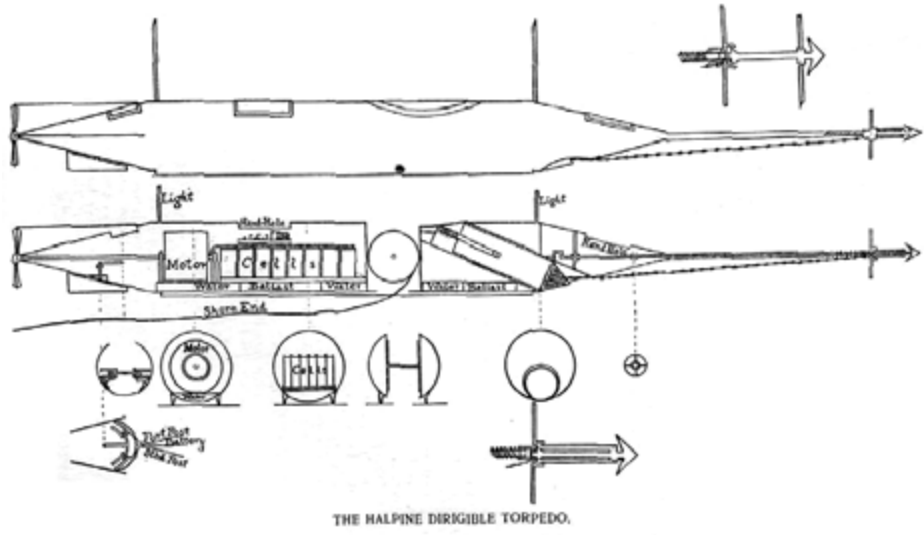
However, the Halpine Torpedo-Boat was first publicly described in *Science* on November 1st 1889. This article also provided a picture of the torpedo-boat (AAAS 1889). At least one prototype was build. It is claimed that the torpedo was adopted by the Brazilian Navy (Lee 2012; 132).

Nicholas J. Halpine filed an application for a US Patent of what he called *Marine Torpedo* on 2nd March 1889. It was granted US Patent No. 453861, dated June 9, 1891. His torpedo was patented in England, France and Germany in 1889 (Halpine 1891).

However, no documentation of its practical use or demonstrations has been found in available sources.



■ **Figure 16.** *Photograph of The Halpine Torpedo-Boat as it appeared in* Science *November 1st 1889.*



■ **Figure 17.** *Sketch of the Halpine Dirigible Torpedo (Radford 1894).*

The design is credited to Lieut. Nicholas J. Halpine of the United States Navy. But just as the plans of the lieutenant were about to materialize, he received orders to join the "*Tallapoosa*" in South American waters. It thus happened that the further carrying-out of the scheme was passed on to Mr. Arthur W. Savage, the inventor of improved small arms. In some of the electrical work Mr. Savage was assisted by Mr. Frank A. Brooklyn (AAAS 1889).

The weapon is also referred to as The Halpine-Savage Torpedo-Boat.

5. CLOSING THOUGHTS

This paper reports on an in-depth study of the literature covering the history of the naval torpedo. Over 100 artefacts have been studied and analysed to resolve some incongruities, and put straight events riddled with myths related to the early history of the torpedo. The books and manuscripts examined encompass international authors, printed in a variety of languages, and published over the 150 years of torpedo history. The contributions are summarized and analysed to provide a longitudinal perspective of this technology and the references provide a bibliography of rare and useful readings.

However, therein lies one of the great challenges faced in writing this paper – what are the original sources and which sources have merely compiled other sources? How much valuable information has been added by the later sources and what has been omitted? Could the missing information also have been valuable in puzzling the historical chain of events together? Therefore, it has been important for this author to trace the sources of information as far back as possible, and to examine the content based on the original information available and technical state of the art that this author can establish or extrapolate was the case a hundred years or more ago. Throughout this paper the exact dates of the tests, events and notifications are provided to correct information found in other sources.

A primary source of information has been Petrucci's book, compiled from information contained in the WASS Historical Archives – the collective archives of the torpedo producer since 1875. Though this reference does not cover the full time span of the content of this manuscript, this author has relied heavily on that information when other sources are ambiguous or stating differently.

This study has revealed that the early history of the torpedo contains quite a few discrepancies or anomalous descriptions, and even some mythical events that are still perceived as the truth today. This represents another great challenge; what is the correct information, the factual and traceable dates in the chain of events, and how did the technology actually evolve? Questions such as these motivated this author to pursue a five- step progressive analysis of the evolution of the depth steering control mechanisms that were unique to the Whitehead torpedoes. The result is based on a careful scrutiny of the very limited literature with the intention to uncover, for the first time, evidence concerning *The Secret*.

Acknowledgements

This paper would not be possible without the herculean efforts of Thomas Brevik, who is the librarian at the Royal Norwegian Naval Academy, and Thor Kristiansen, who is the librarian at the Norwegian Naval Museum. They spent many hours to seek out and make available to me all the original books with

torpedo content from the last half of the 1800s and the early books of the 1900s, which included numerous valuable sources of information.

This author is also deeply appreciative of the books and information kindly gifted to me by Benito Petrucci, and the personal conversations we had around the opening of his torpedo display in La Spezia in 2009. This information has been of crucial importance as a reputable primary source for dates and establishing a historical timeline of events surrounding the invention and development of the Whitehead torpedoes.

My thanks also go to friends and colleagues, and to Hans Petter Oset, the Director at the Norwegian Naval Museum, for valuable help. Finally, gratitude to Cecilia Haskins, for her help in the final proofreading and editing of this manuscript.

Endnotes

[1] The reason why some sources have used the misleading information, that Fulton was using Nautilus, may be the statement in the book *The Devil's Device* by Edwyn Gray, a historian on, among other topics, torpedoes of the late 1800s. The first edition is dated 1975; the updated edition was published in 1991. In both these manuscripts Nautilus is listed as the firing vessel (Gray 1991; 68- 9).
In 2004 Gray issued the book *19th Century* Torpedoes *and Their Inventors*. On page 130-134 Gray points out and amends his error printed in *The Devil's Device* (Gray 2004; 130-134).
Nevertheless, in a recent publication by Wildenberg & Polman in 2010, the error is still repeated: The text supporting the figure on page 6 states: "...shows the sinking of the target ship *Dorothea* after being attacked by his submarine *Nautilus*" (Wildenberg & Polman 2010; 6).

[2] For example Edwyn Gray (1991; 61, 67), and Wildenberg and Polmar (2010; 2), where the text supporting the figure states: "David Bushnell's submarine torpedo boat Turtle of 1776..." Most recently Roger Branfill-Cook (2014; 12) repeats the claim that Bushnell used the term *torpedo* to describe his explosive devices.

[3] The way contemporary torpedoes generally are classified, is based on the combined weight and diameter (i.e. mainly lightweight and heavyweight torpedoes) and the primary intended target type (i.e. essentially anti surface vessel, anti-submarine torpedo, and the so-called dual-purpose torpedo that is fit for both target types). Many other informative ways of distinguishing torpedo classes have been used during the 20th century, all typical of the divergent eras when new technologies were introduced (e.g., wet-heater, electric torpedoes, and homing torpedoes – by means of a sonar built into the torpedo it is autonomously able to detect a vessel and steer towards it until the torpedo detonates). Many of the earlier classes are obsolete by today's standards because the dividing characteristics are no longer present in torpedoes available for purchase, or have become widespread in (nearly) all torpedoes.

[4] The author of this manuscript favours the term *dubious honour* in lieu of EuroTorp's *formidable privilege*.

[5] The real vessel was never built, however it was conceptualised by Luppis to be about 6 meters in length.

[6] The *Imperial Russian Fleet Torpedoes* also includes an illustration of the earliest Russian invented torpedo model, the 1875 Alexandrovskiy Torpedo (Korshunov & Uspenskiy 1993; 3).

[7] The same William R. King published a book in 1866 called '*Torpedoes: Their Invention and Use From their first application to the Art of War to the Present Time*'; the description referred to by von Ehrenkrook does not come from this source as the entire content is about water- and land mines used in the American Civil War. However, King being an U.S. Army officer and a Chief Engineer during

the last 4 decades of the 19th century, was among others collecting information and experimenting on torpedoes, and would therefore most likely have access to some relevant information about Whitehead's "Secret". (Typical of the early torpedo literature, the authors were rarely specific with respect to references.)

[8] To the extent that explanations of mechanical constructions are contained in the descriptions of the different devices, those are highly simplified, and must as such not be regarded as an attempt to describe how the different depth steering devices actually were built, but rather what was achieved by the devices, and how the principle of the functionality made the achievements possible.

[9] Gray also stated in this context that "the torpedo itself was lost at sea during tests in 1866, and Whitehead chose not to publish its design details for reasons best known to himself." It is documented, though, that the 1866 prototype torpedo was lost on 30th October 1867 during the test firings from the *Gemse*. The torpedo was found on the sea bottom by a fisherman one and a half year later, and returned to Whitehead (Silurificio Whitehead di Fiume 1936; 20). Dehlgren correctly described the torpedo loss to have happened in 1867 (Dehlgren 1905; 10). PS: Edwyn Gray cites the name of the vessel (wrongfully) as *Genese* (Gray 1991; 54).

[10] Examining the references in his manuscript, the source of Sieche's information is the Whitehead Historical Archives, as described in the Italian language by Casali & Cattaruzza in the book *Sotto i mari del mondo – La Whitehead 1875-1990*. The year 1869 is also described in (Jolie 1978; 6), though no month is indicated.

[11] Just 3 days after a German torpedo had hit and destroyed the American cruise liner *Lusitania* in the early morning on May 7th 1915, a commentary was printed in The New York Times explaining to laymen some general information about 'modern' torpedoes. The necessity of carefully logging all information pertinent to each firing of every individual torpedo was also explained: "It is a curious fact that no two torpedoes have ever been constructed exactly similar. Each one is always found to have some little peculiarities when travelling through the water. One will turn slightly to the left, another to the right, or sink in the water lower than is usual. Every one of these peculiarities indulged in by the torpedo is noted in the history sheet and referred to before the weapon is again fired. By this means all the slight defects can be allowed for and much more accurate aim obtained." (NYT 1915)

[12] Norsk Tidsskrift for Sjøvesen (NTfS) (translates as Norwegian Magazine for Naval Affairs) is the publication of the Norwegian Naval Association (Sjømilitære Samfund). The title of the article translates to "Halpine's dirigible torpedo", and reported on the original source from USA.

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SAŽETAK

Ovaj rad prikazuje detaljno istraživanje literature koja obuhvaća povijest pomorskog torpeda. U stotinu pedeset godina povijesti torpeda mnogi su autori o tome napisali knjige i manuskripte koji su objavljeni na raznim jezicima. Njihov je doprinos sažet i analiziran kako bi se omogućila longitudinalna perspektiva ove tehnologije, a literatura daje bibliografiju rijetkih i korisnih tekstova za čitanje.

Ova je studija otkrila da rana povijest torpeda sadrži puno proturječja ili pogrešnih opisa, čak nekih mitskih događaja za koje se i danas smatra da su istiniti. Autor je analizirao više od stotinu artefakta kako bi identificirao relevantne izvore, riješio neka nepodudaranja i ispravio događaje koji se pobijaju mitovima, a odnose se na ranu povijest torpeda. U radu se prvi put otkriva u četiri koraka napravljen progresivan razvoj mehanizama hidrostatičke kontrole koji su bili specifični za Whiteheadova torpeda. Taj rezultat zasniva se na pomnom proučavanju jako oskudne literature u javnoj domeni, a tiče se „tajne", uređaja koji održavaju dubinu na Whiteheadovim torpedima iz ranih dana.

Ključne riječi: *rana povijest torpeda, bibliografija o torpedu, hidrostatička kontrola dubine,* tajni *uređaj, Whiteheadov torpedo*

"DAMN THE TORPEDOES!" – TORPEDO FAILURES CASE STUDIES

„Prokleta torpeda!" – Analiza slučajeva neuspjeha torpeda

Terje Fossnes*

SUMMARY

Torpedoes in underwater warfare have become an increasingly sophisticated threat over the past 150 years. Human ingenuity, creativity and advancements in technology have resulted in a very complex and intelligent system in its own right. This paper examines five cases of torpedo failures and their impacts on the users or the carrying platforms. The recent loss of the Russian submarine Kursk *is an example of the latter. The other cases deal with the German and American torpedoes' failures in World War II, the Argentinian torpedo failure on board the submarine* San Luis *during the Falkland conflict in 1982; the last case examines the over 40 years of speculation as to what caused the loss of the* USS Scorpion *in 1968. Each case references the sources used for the examination, and describes the problem, the technical causes, and the organizational context related to the respective torpedo failure. The paper derives the relevance of these cases as a form of cautionary tales, where the failures are largely attributed to inadequate systems engineering performance and badly executed enterprise performance during different stages of the systems' life cycle. Experiences gained from these failures are applied to the torpedo industry today; intelligent enterprises have discovered that responsible systems engineering provides the key to safer and more reliable product development and operations.*

Keywords: *torpedo malfunction, torpedo technical failures, loss of submarines, organizational failures*

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1. INTRODUCTION

The way enterprises do business and manage systems development has changed considerably since Admiral David G Farragut gave his famous battle order during the American Civil War Battle of Mobil Bay. On August 5th in 1864, when a ship had fallen out of position in the attack column, Farragut asked: "What's the trouble?" The reply "Torpedoes" made Farragut shout back: "Damn the torpedoes! Four bells, Captain Drayton. Go ahead!" (Harris, 1997; xiii)

Ever since Robert Whitehead (Figure 1) demonstrated his invention of the self-propelled torpedo to the Austrian Navy, in December 1866 (Gray, 1991), this weapon has been a constant threat that cannot be ignored in naval warfare scenarios.



Figure 1. *Assumed to be the first picture of Robert Whitehead with a prototype torpedo*

However, firing of war configured torpedoes, as a weapon in combat, after the end of WW2 has only been reported on a few occasions, among others during the Indian-Pakistan conflict in 1971 (2 torpedoes), and the British-Argentinean campaign over the Falkland Islands / Islas Malvinas in the South West Atlantic Ocean in 1982 (Naval Forces, 1985). It has come to light that during the decades of the Cold War that there were suspicions and accusations of torpedo attacks, but in the aftermath these have turned out to be torpedo related internal events.

Human ingenuity, creativity and advancements in technology have brought the torpedo from a straight short-running slow device (200 meters at 6 knots), to a 3 dimensional operating, very complex and intelligent system in its own right, with long range (>70 km) and high speed (>50 knots). A supercavitating torpedo (Figure 2) exceeding a speed of 200 knots under water has been available for the last two decades (Ashley, 2001).

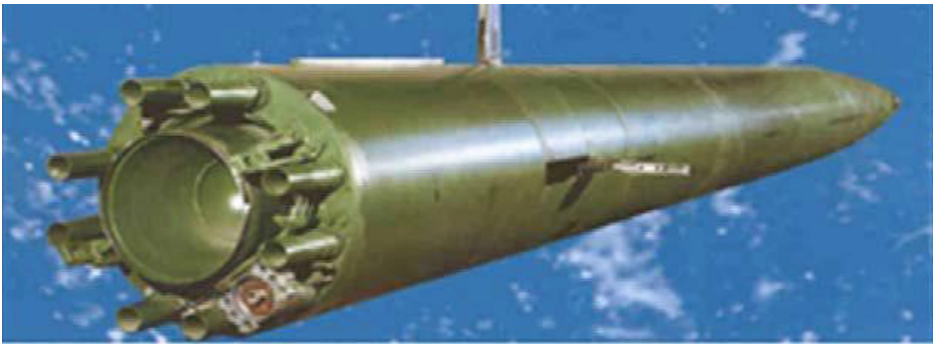


Figure 2. *The Russian supercavitating torpedo SHKVAL (Squall)*

Ironically, when the naval officers, especially submariners, around the world relied on the newest and most advanced torpedo technologies to give them a distinct advantage over the enemy in combat, the weapons failed and did not perform according to expectations and the engineers' promises. Quite a few commanding officers have been released from their duties because their superiors thought the reports of faulty torpedoes were just excuses for poorly executed missions (Parrish, 2004).

In Germany, naval strategy after WW1 called for a single torpedo (i.e. not a salvo of multiple torpedoes) that would be able to break the hull of even a battleship. According to Admiral Dönitz, far more money was spent on big gunnery research than on torpedo improvement. The result was that when the war broke out, the torpedo that the German Navy required existed only in the minds of the leadership of the Torpedo Department and the Torpedo Experimental Establishment; the monopoly producer and tester of the torpedoes, respectively. "Had they had more competition from private industry, we would have had a better torpedo." (Dönitz according to Nedelchev, 1999a)

This paper presents five cases of torpedo failures and discusses changes that have been incorporated in contemporary torpedo development programs, based on lessons learned from the past. Conclusions are drawn about how using systems engineering judiciously can result in better practices within an industry as well as individual organizations.

2. CASES: FAILURES, TECHNICAL CAUSES & ORGANIZATIONAL CONTEXT

The reasons for the torpedo failures have been described using words like crisis, scandal and disaster. The reasons are often attributed to inadequate systems engineering and capability development, as well as badly executed enterprise performance.

Following are five cases drawn from the literature. Each case begins with a short introduction, followed by descriptions of the failure and its documented technical causes; these represent the observable behaviors and their "technical" explanations. Finally the organizational context of the case is explained; this is the 'behind the scenes' knowledge, i.e. information that for the most part has emerged over time. Each case has been derived from several sources, and these are provided at the end of each case.

2.1. Case 1 – German torpedoes' failures in WW2

Some problems with the German torpedoes (Figure 3) had already been known for two years before new failures occurred during *Operation Weserübung*, the German invasion of Norway in April 1940. The (in)famous U-47 submarine commander Günter Prien fired a salvo of four torpedoes toward a group of eight stationary and overlapping British surface targets on April 16th: "Ships stretched in a solid wall before me" he explained later (Parrish, 2004; 217). Nothing happened after the torpedoes left the submarine, and nothing continued to happen – no explosion. Similar scenarios were repeated over and over again in the coming months, to Prien and many of his peers.



Figure 3. *A torpedo loaded into a torpedo tube onboard a German submarine during WW2*

The problem: The failures occurred in the German G7e (aka T2) torpedoes, the primary torpedo for their submarines in the early stage of WW2. This torpedo had an electric propulsion system, thus leaving no bubble trail (exhaust). The torpedo needed an exploder; the device triggering the main explosive charge in the torpedo's warhead to detonate. In this instance, the exploder installed was a Pi G7a, which is a combined impact (contact) and magnetic (influence/ proximity) device. The following problems were uncovered.

- The torpedoes were running too deep, thus passing under the target, and even not coming close enough for the magnetic exploder to activate.
- The magnetic exploder frequently experienced malfunctions (even when the torpedoes ran at a correct depth), often resulting in premature detonation.
- The impact exploder, supposed to trigger when hitting a ship at practically any hemispherical angle, basically proved unreliable at angles < ± 50 degrees (of horizontal inclination perpendicular to the targets heading).

Technical Causes:

- The hydrostatic valve, located inside the balance chamber of a torpedo, controlled the running depth relative to the pre-set commanded depth. Excess air pressure inside the balance chamber was discovered. The reason was leakage of compressed air into an otherwise supposedly air-tight chamber. When the torpedoes were launched, this established an error in the depth reference to the surface (the torpedoes needed this normative atmospheric pressure reference to keep their depth when they were fired from a submarine). During long periods of submersion, a considerable excess pressure thus accumulated due to frequent pressure regulations in the torpedoes on board the submarine.
- The failure of the impact exploders turned out to be caused by an unfavorable design, being highly susceptible to the roll angle of the torpedo during impact.
- The German Torpedo Department had been assured that despite the proximity of northern Norway to the (magnetic) North-Pole, this would not affect the magnetic exploders. Nevertheless it did; in particular in the fjords where the magnetic pull was considerable (simplistically one can say that the strength of the magnetic field at the Earth's surface is doubled close to the poles as compared to at the equator. In addition the mountains that circumference the fjords affect the magnetism due to the concentrations of magnetic rocks and minerals in the Earth's uppermost solid rock layer).

The effect was magnified by the fact that the magnetic exploder had been "improved"; including a new (less reliable) 4-blade propeller in lieu of the former 2-blade propeller. (The purpose of the exploder-propeller is to bring the

igniter in contact with the main explosive charge after launch, to retain safety for the crew and the submarine before firing the weapon.)

Organizational context: The mystery of the torpedoes' deeper-than-set-depth running was discovered by the submariners themselves. On January 30, 1942 the crew of *U- 94* made some extra effort and conducted an examination of their torpedoes onboard, while on patrol in the Atlantic Ocean. They discovered excess pressure in the torpedoes' balance chambers. When they communicated their findings, the inspector of the Torpedo Department ordered a check onboard all submarines in port. Half of the torpedoes examined were found to have the same problem. A truly effective impact exploder was not introduced until December 1942.

With respect to the impact exploder, only two torpedoes had been test-fired against a submerged metal plate in 1928. The inclination angle was supposed to be 20 degrees, and in neither test had the torpedo hit the plate, but rather the bars in the holding arrangements for the plate. Therefore, it was not possible to verify that the exploder functioned correctly based on these firings. Nevertheless, no more tests were performed, and the exploder was declared ready for series production. Ten years later it was discovered that a correct functionality of the exploder was highly dependent on the torpedo's roll and pitch at the time of impact. However, little attention was paid to the problem, since use of the magnetic exploder was now considered to be the primary mode of operation.

For the magnetic exploder it turned out that the problem domain was not sufficiently understood. In fact, during the week from 11th – 18th April 1940 the orders to the fleet for how to program the torpedoes changed three times. The magnetic sensitivity of the exploder had been changed in 1938, during an improvement activity, in order to increase the operations area where the magnetic exploder would work. For deployment in the northern areas of Norway during the invasion, and in particular in the fjords, no adjustments were deemed necessary nor had any tests been performed. Assumptions that the earth's magnetic field in these waters would not affect the functionality had been made by the Torpedo Directorate without sufficient knowledge of the subject matter or supporting documentation. A commission, which was established to find the reasons for all the 'duds', concluded that magnetic interference in the polar region and in the fjords did affect the magnetic exploder, after all. In 1942 a combined impact and magnetic exploder were introduced, however at that time an active transmitter was embedded in the exploder, which was independent of the target's magnetic properties or state of degaussing (de-magnetization).

The search for the persons to blame for the failures was hard and unpleasant. The problems were traced mainly to actions taken by the torpedo experts to circumvent their devices being subject to realistic and rigorous

testing before the components were submitted to the fleet. In December 1941 court -martial proceedings were held against the leadership (2 Admirals and 2 Chief Engineers) of the Torpedo Directorate and the Torpedo Experimental Establishment that had designed and tested the weapons. Three of the four leaders were convicted for lack of essential preparatory activities (i.e. for not testing the device properly, and for not investigating any potential influence the environments might have on the magnetic exploder).

Hardly any verification of the exploders had been performed. The few skimpy tests documented, were performed under highly unrealistic conditions. Furthermore, the leaders were convicted for not acting upon the numerous failure reports they had received, as well as for suppressing results of the unsuccessful tests that were performed. Three of them where sentenced to prison terms between 2 and 4 years, while the fourth (the Admiral in charge of the Torpedo Directorate) was acquitted (Rössler, 1984; 96).

Sources used to present this case: (Dönitz, 1959), (Nedelchev, 1999a), (Parrish, 2004), (Rössler, 1984).

2.2. Case 2 – American torpedoes' failures in WW2

Shortly after the US Submarine Force entered the war in the Pacific Ocean at the end of 1941 they faced torpedo failures similar to those of the Germans. Commanding officer John Coye Jr. reported returning from a 15,000 km (8,500 miles) round trip to enemy waters where several torpedoes had detonated prematurely 30-40 meters (yards) before they should have reached the target: "This not only gave our position away, and it not only didn't sink any ships, but it was bad for morale." (Parrish, 2004; 351)



Figure 4. *A US Mark XIV torpedo displayed in the museum in Pearl Harbor*

The problem: The failures experienced by the Americans were related to the US Mark XIV torpedo (Figure 4), their primary weapon on board the submarines operating in the South Pacific. The torpedo, entering service in 1931, has a steam turbine propulsion system, and was equipped with a Mark VI

exploder which is an assembly of an impact exploder and a magnetic exploder, developed separately in the early 1920s. The torpedo ran at an average of about 11 feet (3.5 meters) deeper than the specified depth.

- The impact exploder often simply jammed when hitting the target. According to reports (Parrish, 2004; 323; Gannon, 1996; 89) one could hear the thud sound of a hit, however, no explosion followed.
- The magnetic exploder exhibited premature detonation or none at all. So ineffectual had some attacks been, that the targets did not even appear to know that anybody had fired at them (Parrish, 2004; 351).

Technical Causes: The fact that the torpedo fulfilled its mission as intended just as often as it failed caused confusion in the search for a systemic failure. One may say that the most reliable feature of the torpedo was the unreliability.

- The Mark XIV torpedo depth failure was due to several independent reasons, each one of them alone sufficient to cause an unsuccessful attack. The correctness of the depth control mechanism is complicated and affected by quite a few factors that were not considered for the torpedoes:

  a) The difference in weight and balance between calibration/exercise shots and service/war shots requires the rudders to be adjusted differently for sustaining a horizontal run. However, no measurements were made to verify that the prescribed rudder tilt angle adjustments for the war-shot configuration were correct.

  b) Even if the correct rudder tilt angle had been prescribed, the torpedo would still have failed because the equipment that calibrated the running depth measurement component was faulty. This caused erroneous values to be entered into the log shipped with the torpedoes to the fleet. Again, no measurements verifying the actual running depth of the torpedoes were ever done.

  c) The Americans also suffered from inadequate understanding of the impact of physical laws on their technology, and the environmental impact on sensor depth. The depth sensors were apparently tested in still water, but never in moving water. Thus the figures used did not take into account the Bernoulli Effect (i.e. the pressure drops as the speed increases. This is due to the effect of the hydrodynamic flow caused on the torpedo body during high speed. The value is also affected by where on the torpedo body the depth measurement sensor is installed and if there is any local turbulence). This means that even if points a) and b) had been corrected, failure to consider the Bernoulli Effect would have still caused the torpedo to run at the wrong depth.

  d) The pendulum-based depth control system was placed at a slight angle to the torpedo's axis, for reasons of space. The engineers believed that it did

not matter. It did. The control system needed to be placed in a location that allowed it to remain level with the horizontal axis of the torpedo.

e) Sustained use of the same torpedoes for exercise shots did not take into account all the effects of wear and tear on the mechanical parts due to extensive use, the environment, and the maintenance activities. This impacts the accuracy of the torpedo control mechanisms and therefore, the validity of test results.

f) One other factor greatly affected the torpedo depth stability over time: as a response to the fleet's demand for more "punch", more and more explosives had been added by the manufacturer; over time a total of 160 pounds (72 kg) were added to the original 507 pounds of explosives. This created a corresponding shift of the torpedo's center of gravity, which was never accounted for.

g) In addition at least half a dozen mechanical gadgets frequently malfunctioned, though most of them were discovered and corrected in the field.

- The failure of the impact exploder turned out to be a simple mechanical problem; the firing pin jammed, before it could complete its intended function. It did not penetrate far and fast enough to strike the igniter of the explosives with enough energy.
- The magnetic field under a ship was presumed by the engineers to be hemispherical. The torpedo (i.e. its magnetic exploder) would intersect directly under the keel. In reality, the magnetic field from a ship is shaped much more like a thick disc. The warhead, therefore, often detonated before it arrived under the keel. In addition the exploder calibrations were performed for conditions in the North Atlantic Ocean, where the Earth's influence on a ship's magnetic field is different (more vertical components) from that in the operational area in the Pacific Ocean close to the equator (where the horizontal components dominate). In May 1943, the Navy issued a directive that the magnetic exploder only was to be used north of 30 degrees north latitude; elsewhere, it was to be deactivated.

Organizational context: The Americans faced the same difficulty with understanding the magnetic field problem domain as the Germans, only in a different part of the world. At one point in time, an Admiral (who earlier had been heavily involved in the development of the magnetic exploder) forbade the crew to tamper with the magnetic exploder mechanism, and he also ordered the torpedo workshop to put paint on the screws needed to deactivate the device. Some workers in the torpedo workshop allied with the torpedo men onboard and gave them a small tin of paint of the color of the day, such that the submariners could touch up the screws after deactivating the magnetic exploder.

Extreme secrecy surrounded the magnetic exploder. Hardly any commanding officer of a submarine knew anything about the principles of the device; they were merely told how to set the depth, but they were not told why. The secrecy consequently prohibited failure reports to emerge or to be acted upon. In some cases a submarine commander reported successful attacks, however concealing the fact that they had to deactivate the magnetic exploder in order to achieve the success. Lack of open and candid discussions made it difficult to identify the cause of the problems and address appropriate measures.

The US Navy Bureau of Ordnance (BuOrd) responsible for introducing the torpedoes to the fleet, and their partner, the Naval Test Station in Newport, the monopoly torpedo developer and manufacturer, were neither able nor willing to identify the real problem. The US Navy therefore had to take matters into their own hands. Several test firings were performed in the South Pacific Ocean, providing concluding evidence for the problems faced with respect to the depth failure. The organizations, however, criticized the methodology used and were reluctant to accept the results of the test firings.

The verification process was highly inadequate and insufficient. The magnetic exploder was developed in the early 1920s. The exploder was subject to only two tests before the war broke out: installed in a warhead torpedo it was fired against an obsolete submarine on May 26th 1926 with the following results: one run passed under the submarine, but failed to detonate (Figure 5); a second attempt was successful. However the conditions, under which the tests were performed, were ideal and incomparable to the reality of war. The magnetic exploder was later integrated with an impact exploder apparatus and the new device was designated the Mark VI exploder without any further testing of the assembly. BuOrd used their "statistics" in a shameless way in 1942, when announcing the exploder had only one unconvincing test behind it in sixteen years.



Figure 5. *The exploder test in 1926. The torpedo's bubble trace clearly depicts passing under its target without detonation*

When it came to the initial depth settings for each torpedo, BuOrd relied on the given values from Newport, while the Naval Test Station relied on their erroneous logs from the calibrations. It took a long time to work out the depth related engineering problems sequentially before the fleet could rely on their weapons in October 1943. The magnetic exploders were finally deactivated, but not until January 1944.

Engineers and managers were impaired in their judgments and decision making by being overconfident in their own abilities (omniscience), and tended to over-rely on the information most readily available to them, i.e. the information and test results they themselves had invested time and money collecting. The British Navy communicated experience with their malfunctioning magnetic exploders to the US, but BuOrd completely ignored the British advice of using the exploder in a contact only mode. In addition similar reports from many submarines were ignored. BuOrd continued their infallible confidence in the torpedoes, and insisted the submariners operating the weapons were incompetent.

Sources used to present this case: (Gannon, 1996), (Gerken[1], 1989), (Milford, 1996), (Nedelchev, 1999b), (NUWC, 1998), (Parrish, 2004).

2.3. Case 3 – The loss of USS *Scorpion*, 1968

Norfolk, Virginia, USA – May 27th 1968: The submarine USS *Scorpion* (Figure 6) was expected home after a mission. The weather was stormy, and the waiting families of the 99 crew members had just been told the submarine was delayed. In fact the last time it was heard from had been six days earlier; not in itself an unusual situation during the Cold War. The unusual fact in this situation was that secretly the Navy had been searching for the submarine for four days; and ultimately, that it would never come home.

[1] Gerken, Louis C. *Torpedo Technology*. American Scientific Corp., Chula Vista, CA, USA, 1989. The author of this paper (Terje Fossnes) is not impressed of Louis Gerken's book. This is because Mr. Gerken's book has zero references (none what so ever has been found – applies both to textual content and figures (the latter are as well of extremely poor quality)). Mr. Gerken's contribution has no academic value. E.g. Chapter 1, and a large part of Chapter 3 in Mr. Gerken's book is clearly compiled from "A Brief History of US Navy Torpedo Development" by E.W. Jolie, 1978; however without referring to the original work. Also the text on "British Thermal Propulsion Torpedo Effort" on page 231, is unmistakably based on Brian R. Longworth's "Torpedo Propulsion: Then, Now, Tomorrow" published in Military Technology (MILTECH) no 9, 1988, page 123, published by the Mönch Group in Germany; again without Mr. Gerken referring to the original work.



■ **Figure 6.** *USS Scorpion (SSN-589)*

The submarine was so long overdue for maintenance that it was called by some of the shipmates "USS *Scrap Iron*" (Dunmore, 2002; 142). As examples of onboard problems, about half a year earlier two events had occurred:

1. the entire submarine had begun vibrating wildly during high-speed maneuvers;
2. a torpedo had accidentally been activated in the torpedo tube; referred to as a "hot run." The successful remedy would have been to immediately turn the submarine 180 degrees to make the torpedo shut itself off (by means of the inherent anti-circling device) before it left the tube. An alternative remedy would have been to release the torpedo immediately. In both circumstances it is important to cool down the torpedo battery compartment, to prevent the torpedo from overheating by the activated battery.

At the end of May 1968, a group of experts – Technical Advisory Group (TAG) – was summoned to locate the submarine and subsequently tasked to find the reason for the loss. Five months later the remains of the submarine were found, in over 10,000 feet (3000 meter) of water in the Atlantic Ocean, 400 nautical miles south west off the Azores. The submarine had imploded and crushed at a depth deeper than 2000 feet (600 meters) and was nearly broken in two. The conclusions drawn by the TAG were classified by the Navy. But it was leaked to the press that no one was ever likely to conclusively determine the cause of the sinking.

The problem: Several theories for what happened onboard the lost submarine have been discussed among experts over the years, both in official inquiries and otherwise. No official ruling was made for over 40 years. This caused speculations and the top three most probable causes all involved torpedo accidents.

Technical Causes: One of the theories was that *Scorpion* experienced another "hot run" with an unsuccessful remedy, resulting in an explosion inside the submarine.

The second most popular hypothesis was that the *Scorpion* was hit by a torpedo; including one of its own as advocated by among others Gray (Gray, 1996).

But, the theory of the "hot run" was by many believed to be the reason for the loss of the submarine, until additional information became available.

An alert issued in 1968, just days before the *Scorpion* was lost, was declassified 25 years later in 1993, and then brought to the attention of one of the experts from the TAG. The alert describes events during a land-based vibration test of a MK-46 torpedo battery used in for the electrically driven MK-37 Mod 2 torpedo (Figure 7).



Figure 7. *MK-37 Mod 2 torpedo in the museum in Pearl Harbor*

The MK-46 Silver-Zink battery, weighing nearly three hundred pounds (125 Kg) had exploded in flames and ruptured. Until the torpedo is launched, the electrolyte (in this case potassium hydroxide – KOH) is kept separate from the dry Silver-Zink cells by a flimsy thin metal foil / diaphragm. The tendency of this type of battery to overheat and occasionally to cause fires or explosions had been previously documented. The alert concluded with the withdrawal of all the MK-46 batteries of the lot under test. They were unsafe. However, fourteen of these batteries were contained in the torpedoes onboard the USS *Scorpion*.

The third, and most believable theory by this author, was that the diaphragm in one of the torpedoes in a rack onboard (i.e. not inserted into a torpedo tube) punctured slightly, due to vibration in the submarine itself. The slow flow of the electrolyte resulted in an unwitting and slow activation of the battery causing sparking and overheating, but without generating enough power to activate the motor or make the propellers turn. There was no built-in feedback loop to indicate to the crew that this had happened, so the torpedo was not cooled or jettisoned; which would have been the only preventive action for the further development; the battery overheated, caught fire and exploded. The uncontrollable flooding that would result from such an explosion would cause the submarine to sink in a matter of minutes.

The torpedoes in the storage racks onboard submarines are in a rather confined space, as illustrated by (Figure 8) where the aft of a MK-37 torpedo is

seen in front of a sleeping mattress for a crew member. There was some disagreement as to whether the explosives in the warhead combusted spontaneously due to the heat, or if it was solely the explosion of the battery that occurred onboard the *Scorpion*. In this case it was insignificant (author's opinion[2]) as both cases would have knocked out the crew in the area, and created enough damage to cause leakage in one or more of the pressure hull penetrations or hatches in the torpedo room.



Figure 8. *MK-37 torpedo in stowage rack in the torpedo room onboard a submarine*

Organizational context: On June 5th 1968, the Navy considered the submarine "presumed lost." The remains of the submarine were found October 30th the same year. The Navy convened a formal Court of Inquiry to investigate the loss. This court produced a 1345 page report and concluded the most likely

[2] The author of this manuscript has seen the effect of an explosion of a similar battery under test (different brand) and the damage it caused.

cause was that the crew released a hot-running MK-37 torpedo, and that it accidentally became armed and struck the submarine (see the alternative remedy for a hot -run described above). In 1970, the original TAG disavowed the Court of Inquiry findings as they could not find anything in the photos and video recordings (made by a deep sea submersible vehicle) of *Scorpions* wreck, that supported the 'hit by a torpedo' theory.

After most information related to the loss of the USS *Scorpion* was declassified (except e.g. geographical fix data) in 1993, the public learned that the TAG believed, as early as 1970, that *Scorpion* was lost due to a malfunction in one of their own torpedoes, but had no conclusive evidence. The alert had not been made available to them. Instead of sharing this important information with the TAG, the Naval Ordnance command consistently insisted that an onboard detonation was impossible.

The reason for the Naval Ordnance's secrecy may have been that they had bypassed their own safety procedures. Due to a high demand for weapons from the submarine fleet commands, the torpedoes had been rushed into production. Two torpedo battery producers had been contracted by the Naval Ordnance for serial deliveries of MK-46 batteries after a number of test batteries had passed the type testing (extensive quality assurance (QA) testing for shock, heat, vibration and other specifications). Despite this general approval of their battery production, both manufacturers experienced repeated failures during the QA testing of randomly selected batteries produced in the series. This resulted in a huge backlog of torpedo batteries. To compensate for this backlog the Naval Ordnance brought in a third manufacturer. The third company never passed any type test of batteries they produced; nevertheless, they were still allowed to deliver 250 batteries to be installed in the torpedoes. The battery in question in the alert was one of the third manufacturer's batteries.

As early as two years prior to the loss of USS *Scorpion*, engineers from the Naval Test Station had pointed out dangerous flaws in the basic design of the MK-46 battery, and warned the Naval Ordnance that the battery had no margin of safety. This warning was based primarily on the ultra-thin diaphragm. Redesign of the batteries had been recommended by the test engineers, but the Naval Ordnance had been unwilling to do so. It took the Naval Ordnance yet another year after this tragedy, before a redesign of the battery was ordered.

Sources used to present this case: (Craven, 2001), (Dunmore, 2002), (Gray, 1996), (Johnson, 1993, 1995), (Offley, 1998), (Sontag et al, 1998).

Addendum: The final conclusion, published in August 2010, was that the main battery of the submarine, the TLX-53-A had 2 cells that exploded due to hydrogen gas ignition, which caused the crew to loose control of the submarine, and it ultimately crushed at a depth of 1530 feet. (http://www.burtonsys.com/USS_Scorpion.html)

6 August 2010

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Subj: **Why the USS SCORPION (SSN-589) Was Lost on 22 May 1968**

Ref: (a) Originator's ltr of 14 Mar 2009 (b) SCORPION SAG Report: "EVALUATION OF DATA AND ARTIFACTS RELATED TO THE USS SCORPION (SSN-589) (U)" of 29 June 1970, prepared for presentation to the CNO SCORPION Technical Advisory Group by the Structural Analysis Group: Peter Palermo, CAPT Harry Jackson, Robert Price, et al. (c) Originator's ltr of 28 Oct 2009 Encl: (1) Enclosure (1) to Originator's ltr of 14 March 2009

ASSESSMENT

The USS SCORPION was lost because hydrogen produced by the 65-ton, 126-cell TLX-53-A main storage battery exploded in two-stages one-half second apart at 18:20:44Z on 22 May 1968. These events, which did not breach the pressure-hull, prevented the crew from maintaining depth-control. As discussed by reference (a), the SCORPION pressure-hull collapsed at 18:42:34Z at a depth of 1530-feet. Noted times are actual event times on board SCORPION.

This assessment is NOT the generic attribution of the loss of a submarine to a battery-explosion advanced as a default explanation in the absence of any more likely construct. This assessment is based on (1), the results of examination and microscopic, spectrographic and X-ray diffraction analyses of recovered SCORPION battery material that confirm an explosion occurred, and (2), the July 2008 reanalysis of the SCORPION "precursor" acoustic signals that identified these signals as explosions contained within the SCORPION pressure-hull. Collectively, these findings indicate battery explosions were the initiating events responsible for the loss of SCORPION on 22 May 1968.

2.4. Case 4 – The Falkland Islands / Islas Malvinas conflict, 1982

When Captain Azcueta, the commanding officer of the Argentinean submarine *San Luis*, had managed to locate a British target he fired first one torpedo, then another against it. This took place during the conflict between the two nations in April – July of 1982. He later fired more torpedoes against different targets as well "… but none of my torpedoes ever hit anything. We had too many technical problems." (Gill, 2002; 10th subheading) Captain Azcueta had taken command of his submarine less than two weeks before the conflict materialized. He found a variety of technical problems and shortcomings onboard due to neglect or bad maintenance. In addition, the crew had inadequate training for the mission they were given.

The problem: The torpedoes under consideration in this case are the German SST-4 torpedoes (Figure 9), first delivered to Argentina in 1972. The torpedo is able to automatically acquire a surface target after a long transit that may be several kilometers (several 1000 yards). The propulsion system is powered by a large battery, which also supplies power to the electronics and the gyro after firing.

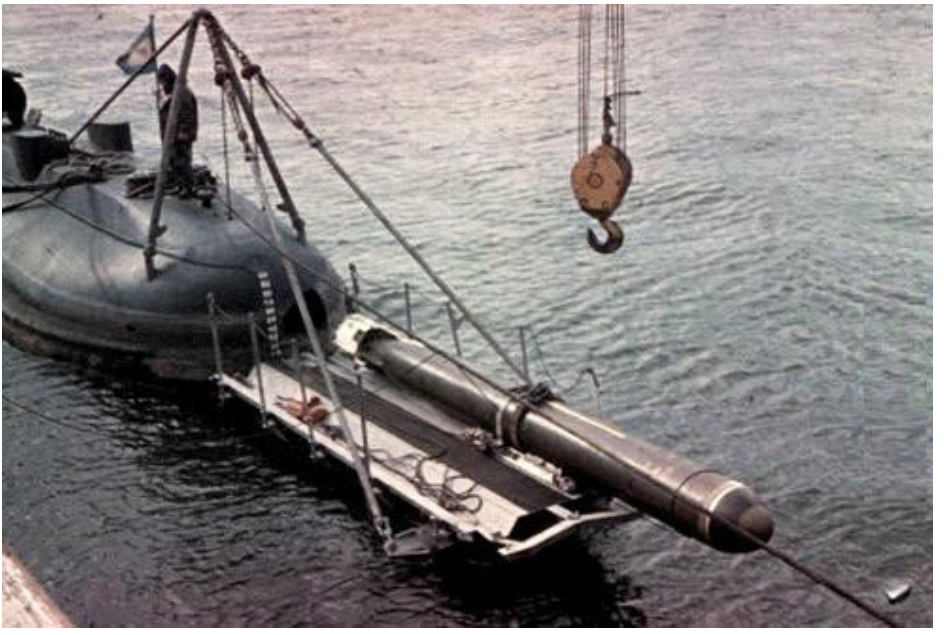


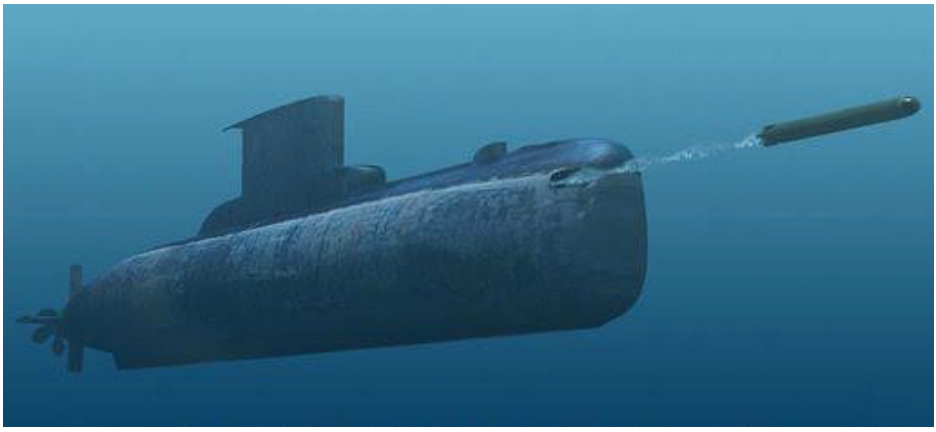
Figure 9. *An SST-4 torpedo being loaded onboard a submarine*

Technical Causes: San Luis' torpedoes took on an incorrect course, not even heading for the vicinity of the target. Switching to manual guidance control did not solve the problem for the inexperienced crew. (By transmitting signals through a thin and 35 km (20 miles) long insulated copper wire from

the submarine to the torpedo, course corrections and other commands can be given to the weapon).

Sources (Swartz, 1998; Børresen, 1984) tend to blame the failures on errors in data transmission during firing or in a faulty weapon control system. It is commonly accepted that these devices were erroneous or faulty onboard *San Luis* (Captain Azcueta according to Gill, 2002).

After the war, Argentinean torpedo maintenance personnel were observed consistently misconnecting the three wires connecting the power supply to the electronic gyro in their torpedoes (Anon, 1990). Consequently the gyro wheel would spin the incorrect way after firing (e.g. counter clock-wise versus clock-wise). Normally, when the torpedo is turned on, and prior to issuing the firing signal to the torpedo, the gyro is set spinning by power supplied through a cable connected to the torpedo via the tube of the submarine. When the firing signal is issued and subsequently the battery is activated, the gyro is fed by torpedo internally supplied power sustaining its high RPM (approximately 20,000). A high-RPM spinning gyro is necessary to establish a stable course reference. Due to the erroneous connection of the wires, when the firing signal activated the torpedo, the gyro faced retardation through zero RPM in order to begin accelerating in the opposite direction. It was during these critical seconds of a low-RPM spinning gyro, that the torpedo left the tube and established an incorrect course reference. The error would vary from case to case, but it would always be significant.



■ **Figure 10.** *An artist's impression of an SST-4 torpedo fired from ARA* San Luis *(S-32)*

Organizational context: Errors in the maintenance activities in the workshop caused the erratic behavior of the torpedoes onboard (Figure 10). Lack of maintenance training and failure to follow written procedures zealously, as well as the absence of appropriate post maintenance control led to a systematic technical error in all the SST-4 torpedoes. When the conflict arose, it

was "come as you are," to the extent that there was no time to train people, or to perform corrective maintenance before deployment. Badly maintained equipment onboard contributed to the inability of the crew to execute a complete chain of required activities during the attacks. Inadequate operational training prevented the operators onboard from taking control of the situation as it evolved. Exercise torpedoes were not launched, either for technical verification reasons, or for training purposes. Failures and problems would definitely have been discovered under these circumstances.

The German torpedoes after WW2 were well reputed as infallible. Nevertheless, a good reputation can be lost in seconds – and takes years to rebuild. The Falklands conflict immediately resulted in noticeably reduced German torpedo exports, and the statistics for the competitors' sales improved comparably (Walden, 1998). The German manufacturer, however, undertook great efforts and investments to keep their Argentinean customer. The Argentinean Navy and the torpedo producer cooperated very closely in the years to follow. At the same time the vendor also successfully pursued new markets in other parts of the world.

Sources used to present this case: (Anon, 1990), (Børresen, 1984), (Gill, 2002), (Preston, 1998), (Swartz, 1998), (Walden, 1998).

2.5. Case 5 – Explosion onboard the Russian submarine Kursk, 2000

The Barents Sea, August 12th 2000 at 11:28 AM: An explosion occurred onboard the Russian giant submarine *Kursk*, creating a powerful shock wave that registered 1.5 on the Richter scale and was easily detected by all the ships participating in, and monitoring, the Russian naval exercise taking place. Two minutes later, when the 23,000 ton submarine crashed into the seabed, another explosion, nearly 250 times more powerful, took place. This blast registered 3.5 on the Richter scale. *Kursk* is a so-called Oscar Class submarine, commissioned in the 1980's (Figure 11). A submarine that had taken a decade to design, and a further three years to build, was destroyed in just 135 seconds.



Figure 11. *The Russian submarine* Kursk

The problem: The official Russian investigation report was concluded on July 19th 2002. A four page summary of the 133-volume final report was published in the Russian government daily "Rossiyskaya gazeta" on August 29th the same year. Except for this four page summary, details of the exhaustively comprehensive report have been withheld from the public (Feifer, 2002). The official Russian probe into the *Kursk* disaster reveals that the first explosion occurred in torpedo tube number four of the submarine's bow compartment during preparations to fire a non-warhead version of the Russian super heavy weight torpedo type 65-76 (Figure 12) (Moore 2003; 32).



■ **Figure 12.** *A 650 mm caliber Russian torpedo of type 65-76 onboard* Kursk

The fuel in this torpedo type is a blend of kerosene and a highly concentrated form (85%) of hydrogen peroxide (H_2O_2); known as high-test peroxide (HTP). The two chemicals should only be joined in a controlled way inside the torpedo when launched. The properties of HTP make it highly efficient as a propellant and, unfortunately, at the same time create a huge safety challenge.

When HTP comes in contact with certain chemicals, materials and metals like Copper or brass, it breaks down to oxygen and water, the latter immediately takes the form of steam due to the massive heat created in the process. The heat sets on fire anything in the vicinity that will burn in the extreme temperature. The volume of the oxygen and steam created increases more than 5000 times in a split second. Within the controlled environment inside the torpedo, this expansion propels the torpedo.

When the second explosion onboard *Kursk* happened at least half of the remaining 23 torpedoes, most of them with war heads each containing several hundred kilos of explosives, and their fuel ignited almost simultaneously. The explosion was either a result of the submarine hitting the seabed, and/or a consequence of the inferno created by the fire from the initial explosion; the temperature now in excess of 2000°C / 3700°F.

Technical Causes: One of the torpedo fuel components (HTP) leaked due to the corrosion of metal, rubber and plastic components, including a bad welding on a casing and gaskets for the fuel components. HTP seeped out of faulty rubber gaskets or rusty cracks in the torpedo casing, and came in contact

with kerosene in the torpedo or brass (an alloy of Copper and Zink) in the torpedo tube. This started a violent and unstoppable chemical reaction. The fire created high heat resulting in the melt down of parts in the torpedo room. Explosives suffer spontaneous combustion at around 400°C / 725°F and eventually the heat affected the stored warhead torpedoes onboard.

The ensuing explosion caused flooding through the pressure hull of the submarine. Had the aft (inner) torpedo tube door been properly locked, it would most likely have been strong enough to withstand the explosion, because the shock wave would have been directed forwards to the front (outer) hatch that is deliberately made less shock resistant, and therefore would have allowed the explosion to be directed away from the boat. As investigators conclude, the inner tube door was only partially closed, because the crew members had to clean the electrical connector between the torpedo and the submarine, in order to be able to launch the practice torpedo. These electrical connectors were infamous for clotting with dust and dirt.

The explosion due to the fuel leakage happened during this period when the door was not closed and locked properly. The resulting consequences could have been remedied by the crew, had they not immediately been knocked unconscious or died instantly from the shock wave from the torpedo room. The shock wave from the torpedo tube affected many of the submarine's compartments due to the inadequate design of the ventilation ducts; they were not pressure proof as they were supposed to be, and acted as a conduit through which the shock wave could travel. The structural damage to the hull caused rapid flooding, and the submarine sank.

Organizational context: Investigations have concluded (Moore, 2003; 250) that a large number of the torpedoes in the fleet, suffered from corrosion and inadequate servicing. Worn gaskets, perilously close to the HTP tank, long overdue for replacement, were found in many weapons of the same type as carried onboard *Kursk* during the naval exercise. In fact the particular practice torpedo in question had not been subject to maintenance for 6 years; i.e. since the fleet came in possession of the torpedo in 1994. Neither had the torpedo been used before, unlike most other practice torpedoes the fleet possessed.

Examination of the maintenance records of the type 65-76 torpedo, specifically the production lot from 1990 that were loaded onboard Kursk, shows that six out of ten war head torpedoes where rejected during the post production quality control. The reason for the rejection was shoddy welding of these torpedoes. There are no indications that the rejected torpedoes were used without first being fixed and passing a new quality inspection. However none of the practice shot torpedoes (like the one in tube number four onboard *Kursk*) were ever checked; it was argued that it was not necessary because they would not be equipped with a war head.

Unauthorized personnel had allowed re-use of old gaskets despite the fact that maintenance records document leakage from previously used gaskets (Polyarnaya Pravda, 2002). Some of the parts in the specific torpedo onboard Kursk (manufacturer's number of the torpedo: 298A 1336A PV; made by the Mashzavod factory in Kazakhstan in 1990) were still in use many years after the end of their recommended service life.

Kursk's crew had not been trained to use HTP torpedoes and had not previously handled them. Specialist training for *Kursk*'s torpedo personnel was practically non- existant; a one year training program was condensed to two weeks in the period May 30th – June 14th 2000 (Polyarnaya Pravda, 2002).

The official Russian investigation report uncovers a stunning degree of negligence on almost all levels of command (Feifer, 2002). E.g. the release order allowing the crew to use the type 65- 76 torpedoes for the exercise was signed by officers who did not have the authority to do so. Another matter is that even though the Fleet Command's standing order dictated firing of at least one practice torpedo yearly, the crew onboard *Kursk* had not done so in 12 years (last firing was performed in 1988).

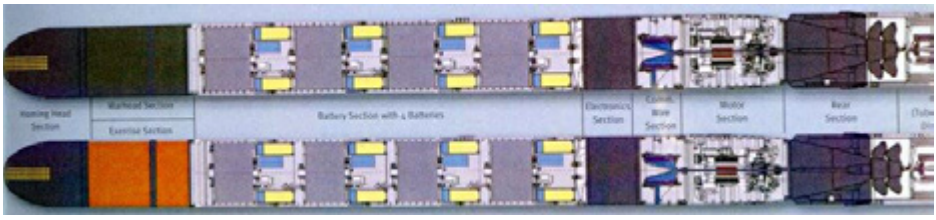
The Russian Navy, as a consequence of the findings, has removed all of its HTP fuelled torpedoes from their submarines, as did the Royal Navy (UK) in 1955, after the accident onboard the submarine HMS *Sidon*, where a HTP fuelled torpedo (known by its nickname "Fancy") exploded without warning.

Sources used to present this case: (Feifer, 2002), (Moore, 2003), (National Geographic Society, 2006), (Polyarnaya Pravda, 2002), (Preston, 2001).

3. LESSONS LEARNED – THE TORPEDO INDUSTRY TODAY

These cases share some serious issues that are interesting for us today. Together they provide a historical representation, over nearly the last century, of torpedo failures that occurred when a flawless weapon performance was needed and expected. This section classifies the attributes of torpedo production and operation and summarizes changes that have taken place in the industry as a result of past errors.

Evolutionary product development. For more than 100 years, improvements in the torpedo technology and performance have followed the evolutionary development concept. As an example, the latest German torpedo, DM2A4 designed in the late 1990s (Figure 13), is a result of an evolutionary development starting with DM2A1, a surface target torpedo designed in the late 1960s, and DM1, an anti-submarine torpedo.



■ **Figure 13.** *The German DM2A4 torpedo; war configuration (top) and exercise version*

First, the dual purpose functionality (being able to attack both surface and sub-surface targets) was built into the DM2A1. Thereafter, the newly developed sonar, control electronics and the exploder were introduced into the torpedo in the late 1980s, under the designation DM2A3 (i.e. the warhead and propulsion system were inherited from DM2A1). The next version, DM2A4, currently on the market, focused on higher speed and longer range. In addition a fiber optic communication wire was introduced in lieu of the former copper wire. The only part of the torpedo remaining from the late 1960s is the warhead containing the explosives.

Similar evolutionary methods for technology updates were also implemented in the torpedoes discussed in the five cases presented above. However, the organizations might have been too eager to introduce a new torpedo model or component before the knowledge of the subject matter and technology was mature enough. Clearly, the rationale for early adoption was to gain a competitive advantage; but the results were disastrous.

Product verification. A typical contemporary torpedo in service has been through verification of all its subsystems, in an evolutionary way by real torpedo firings in sea trials in more than 200 test runs, before declaring operational readiness for the fleet. As an example, Best Management Practices, followed by the

Naval Undersea Warfare Center (USA) and others, require strict adherence to policy for acceptance testing on the part of both the contractor and the government (NUWC, 2003). These practices improve the communications between all parties and result in a quality system that meets performance and reliability requirements.

The amount of verification and testing of both individual components and the full system, in each of the five cases, was sacrificed partly because of the engineers' strong belief in their own abilities, and partly because of the pressure exerted by the decision makers to deliver a product in an environment of high demand and limited funding.

Stakeholders' involvement. Involvement of the primary naval stakeholders, such as the submarine flotilla, the procurement agency and the navy's subject matter experts, are part of the organizational standard practice today. This cooperation is essential during requirements development for both submarines and torpedoes alike, and continues through the verification activities (see above), often followed by an extensive operational evaluation of the combined submarine and one or more torpedoes as a single system.

This is in contrast to the earlier situation where e.g. only one stakeholder was involved in the decision-making after qualification testing; i.e. the same stakeholder that planned and performed the tests. This made it possible to disregard the results of the quality assurance (QA) and safety testing, especially when the frustration over the repeatedly failed QA tests results grew, or to accept a statistically insufficient number of tests. Meeting the demands for deliveries in a timely manner became more important than the requirements for delivering a safe system. A closed-loop process between developer/tester and customer/user was missing. The designers had no contact with the ultimate users of the weapon, nor were the needs of the users really considered during the few and unrealistic verification activities that were performed. The users were not aware of the assumptions embedded in the design, or of the dangers they faced, caused by the rush to get the torpedoes delivered to the fleet.

Cooperation and information sharing. Cooperation between the primary naval stakeholders and the Procurement Agencies as well as the torpedo developer/manufacturer is general practice in NATO navies. Cooperation between different navies is also in place; regular meetings in so-called "Navy-to-Navy talks" are quite common, and torpedo related topics are frequently addressed. Constructive dialogues are held continuously through all the life cycle stages of the weapon and information is exchanged on a regular basis. Continuous involvement of the torpedo producer via through-life support agreements is quite common.

The five cases, on the other hand, illustrated a complete lack of collaboration between concerned parties; in the sense of sharing information and knowledge, working together in making decisions and interacting in a way that could

minimize the time it took to find why the failures occurred and fix them. As a consequence, the crew and maintenance staffs were never told about potential work-around that would allow the weapon to be used as effectively as possible when the failures were a fact. Rather they were blamed for being incompetent. In addition, feedback from operational crews was not given to designers, as is instituted practice today.

Maintenance and training. Modern technology enables us to live in a world of simulators. This applies to underwater warfare. Operator training in a variety of dedicated tasks can be performed under different degrees of difficulty and environmental conditions. Behavior of torpedoes can be simulated with surgical precision and full tactical team trainers (some of them even on moving platforms to give a real feeling of being at sea) are both an asset and a necessity for many submarine flotillas today. The tactical training simulators save money in a time of tight military budgets; at-sea training is expensive, not to mention the launching of expensive exercise torpedoes. However, most navies see the value and occasional need for the latter as well; you will never get an excellent crew by just training in a simulator, no matter how sophisticated.

However, when it comes to maintenance there is still a potential for improvement; the fifth case proves that beyond a doubt. Backup procedures will not work if there is more than a single point of failure. Wear and tear, and postponed maintenance on one system element can have significant consequences on another component or the entire system.

The bottom line in Case 4 is that even if everything had been technically ship-shape onboard the submarine itself, the torpedoes would probably have missed their targets anyway because of errors introduced in the workshop. Training in handling erroneous torpedo behavior, though, might significantly have helped e.g. resolving the anomaly of a wrong reference system. The lack of training and awareness of what to do when the technology, the environment and the operational procedures did not coincide with expectations, basically left the users confused and unable to cope with the situation at hand.

It is not enough to have the technology available; one must also be well trained in maintaining and using it effectively.

Tailoring the SE processes and activities. No evidence has been found that the events and failures discussed in the cases are the result of explicit tailoring – deliberately choosing not to execute processes or activities because they do not add value – of the systems engineering processes. The events and failures were rather results of **accidental** tailoring – where cost and schedule dictate what is done. The issue of tailoring is an important issue in the INCOSE Systems Engineering Handbook, version 4 which states that one does not "dictate" which processes or activities to perform. Rather, users of the handbook are encouraged to balance between the risk and processes performed for each project individually (INCOSE, 2015).

The causes of Case 2 are attributed, for the most part, to lack of funding prior to and during the American Great Depression in the 1930s. It was easy to decide not to expend expensive torpedoes in destructive tests. However, in hindsight the consequences experienced by the American submarine crews suggest that the wrong decision was made, even taking into consideration the limited development budgets. Realistic identification of the consequences over time is important when deciding which processes and activities to include and exclude during tailoring. The Russian Navy was also operating under budget constraints at the time of the *Kursk* disaster as described in Case 5, and the maintenance of the torpedoes is just one of many sacrifices the Russian Fleet made in the years following the Cold War.

4. DISCUSSION AND CONCLUSIONS

Lessons learned in perspective. Many producers compete to deliver the new and modern torpedoes demanded by today's Navies. A strong supplier / customer relationship requires mutual benefits for both parties, and many torpedo manufacturers today have life cycle support agreements with their customers. Contemporary organizations that would like to stay in business cannot afford to disregard the lessons learned from history as illustrated by the five cases.

Robert Whitehead considered the interests of a variety of stakeholders when he started to design and test his new invention 150 years ago. The success of Robert Whitehead's self-propelled torpedo was recognised worldwide. Virtually all torpedoes produced up to and beyond WW1 (i.e. into the 1920s) were a monopoly of Whitehead's torpedo company (Gray, 2004). He maintained his longevity in the industry despite challenges from quite a few inventors who used very creative engineering. Approximately 70 different torpedo types were prototyped in these years; the most of them were unsuccessful during demonstrations.

After WW1, most of the torpedo development and production was undertaken by governmentally controlled enterprises. The (monopoly) industry within the different countries was blooming; at one time about 100 different types/models existed simultaneously, though some never made it beyond experimentation and prototyping. The failures described in the first two cases occurred during this time period.

During the Cold War money was not an issue. However, when the Cold War ended, competition increased as less money became available from the stakeholders and the development cost increased. The US Secretary of Defense, issued a memorandum in 1994 (the so-called Perry Memorandum): "To meet future needs, the Department of Defense must increase access to commercial state-of-the-art technology and must facilitate the adoption by its suppliers of business processes characteristic of world class suppliers … that is capable of meeting defense needs at lower costs." (Perry, 1994; 1) Implementation of the

essence of this memorandum represents a shift of paradigm in which the traditional military (and aerospace) enterprise operated on the cutting edge of technology, to the defense now benefiting in its systems from the technology improvements in the commercial industries, using so-called commercial-off-the-shelf (COTS) components. This is not unique to the USA, and it has affected the torpedo industry while sustaining the evolutionary development principle. The Perry-Memorandum fuelled, if not triggered, fusions and business collaborations among the torpedo-producing and other defense vendors. Today several multinational corporations offer their products and services in the torpedo market alongside other defense products.

Concluding remark. Very often explanations offered as to why systems fail blame individuals, a team, an organization, or the inherent complexity of the system. If any of these factors alone can be attributed as being the sole reason for any of the failures discussed in this paper, it is unintentional. "System complexity, team structure and beliefs, and cognitive limitations are not alternative explanations for failures, but rather complementary and mutually reinforcing concepts." (Roberto 2002) Contemporary systems are often complex; future systems even more so. The challenge to firms is to be smarter in the way they work, collaborate and bring new systems into being. The lessons learned from the selected cases demonstrate the potential of judiciously applied systems engineering to contribute to the success of an enterprise. As practitioners we can encourage the use of systems engineering in our own business contexts and rally to the command "Full speed ahead!"

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SAŽETAK

U podmorskom ratovanju torpeda su posljednjih stotinu pedeset godina postala rastuća sofisticirana prijetnja. Ljudska ingenioznost, kreativnost i napredak tehnologije rezultirali su jako složenim i inteligentnim sustavom. Ovaj rad analizira pet slučajeva neuspjeha torpeda i njihov utjecaj na korisnike ili platforme koje ih nose. Skorašnji gubitak ruske podmornice Kursk *primjer je ovoga drugog. Drugi slučajevi odnose se na njemačke i američke neuspjehe torpeda u Drugome svjetskom ratu, argentinski neuspjeh torpeda na podmornici* San Luis *za vrijeme Falklandskog sukoba 1982., a posljednji slučaj bavi se već više od četrdeset godina nagađanjima o tome što je uzrokovalo gubitak nuklearne podmornice* USS Scorpion *1968. Za svaki slučaj navode se izvori korišteni u ovom istraživanju, opisuje problem, tehnički uzroci te organizacijski kontekst vezan uz pojedini neuspjeh torpeda. U radu se važnost ovih slučajeva iznosi u obliku upozoravajućih priča u kojima se neuspjesi uglavnom pripisuju neodgovarajućim sustavima inženjerske izvedbe i loše izvedbe pothvata tijekom različitih stupnjeva životnog ciklusa sustava. Iskustva dobivena iz tih neuspjeha danas se primjenjuju u industriji torpeda. Inteligentne tvrtke otkrile su da je odgovorno inženjerstvo sustava ključ za sigurniji i pouzdaniji razvoj proizvoda i njegova funkcioniranja.*

Ključne riječi: *neispravnost u radu torpeda, tehnička greška kod torpeda, gubitak podmornica, organizacijske pogreške*

A DIFFICULT HERITAGE: THE INDUSTRIAL-MILITARY HERITAGE IN GERMANY – EXAMPLES OF ITS PRESERVATION

Problematična baština: Dokumenti o arhitekturi njemačkoga vojnog kompleksa

Axel Föhl*

SUMMARY

Over the last period in historic monuments preservation practice a new field has opened, that with Norbert Huse's 1997 book title can be called "Unbequeme Baudenkmale – Uncomfortable Monuments".

Per definition these are monuments and sites that convey historic facts that can be regarded as negative, mirroring phenomena like war, destruction, the Holocaust and similar causes that mankind is not necessary eager to commemorate. This contribution gives a few exemplary objects in Germany that fulfil this definition. In the countries' heaviest concentration of the steel industry, the Ruhrgebiet, we find thus many architectural witnesses for the expansion of the armaments industry in preparation of the Second World War. Of gigantic scale then is the Peenemünde complex on the Baltic Sea, dedicated to the development and testing of the infamous "V 2" rocket weapon. At the other end of the republic, on the Dutch border, the remains of a night hunter airport tell of the air warfare towards the end of the war. Further South, the now partly opened complex of the subterranean government command bunker system tells the story of the Cold War.

After long debates, the decision fortunately was reached not to destroy the so-called "Reichsparteitags-Gelände" to give eternal testimony to the megalomaniac spirit of the Third Reich. What all these objects have in common, is their capacity to inspire memory, in this case of historical facts of a negative character as part of an overall memory culture that must not curve around uncomfortable memories. Unesco some time ago set up a program of commemorating negative historical facts such as memorial places linked to the slave trade. Basically, "the project encourages countries that wish to nominate sites of major importance to the collective memory and to the history of humanity for inclusion in the UNESCO World Heritage". It is such kind of sites that you find listed here as examples of a coherent culture of memory in Germany.

Keywords: *monuments of German military production, Peenemunde V2 production, places of forced labour, naval site*

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Everybody involved in the field of the preservation of the industrial heritage cannot ignore that fact that many sectors of past industrial activity, and therefore also its remains, are massively related to military history. In 1997, the Munich art historian Norbert Huse, gave them the name of "Unbequeme Baudenkmale" – "Uncomfortable historic monuments" and asked "Dispose of? Protect? Preserve?"[1]

For the critical observer, there is hardly a single field of industrial activity not related to the military complex. From the iron and steel industry via the armament production in a narrower sense up to textile mills or shoe factories – they all have heavily profited from military activities and war actions. Since the 1960s, mainly in the United States of America, the term "industrial-military complex" came into use, outlining the close relation between national military forces and the so-called "defense industry".[2]

Regarding preservation aspects, it has to be stated that since roughly the same time, the late 1960s, the basic ideology in the preservation of historic monuments profoundly changed: from the art monument and style representative, mainly exemplified by feudal and clerical architecture, to the historic monument as a witness to historic processes, be they considered good or bad in retrospect, be they aesthetically appreciated or not.

Before this background, slowly objects began to appear in the circle of preservation efforts that represented doubtful or even outright evil testimonies of events past. Sites like concentration camps, the Berlin Wall or military installations were regarded worth preserving and step by step a wider public learned to "tolerate" their existence in contemporary life. It was and still is frequently difficult to achieve an acceptance, which was widely demonstrated after 1990, when the German Democratic Republic ceased to exist.

In the following, a few examples from all parts of Germany shall demonstrate what has been done to keep alive the memory of past historic conflicts and their physical remains.

Bunkers as air raid shelters come to mind here. Many exemplars within industrial sites or railway areas have been preserved, equally some larger mid-town exemplars, some of them converted into housing projects, mainly due to the difficulty to destroy them without harming the surrounding area. In the Ruhrgebiet city of Essen for example, 12 from originally 27 high-rise bunkers are preserved, many serving as dwelling houses.

The Ruhrgebiet as Germany's biggest concentration of heavy industry is also generally a good example for the profitable situation mainly the steel industry found itself in, since Hitler in the 1930s prepared for war. Many concerns

[1] Huse, Norbert: Unbequeme Baudenkmale. Entsorgen,? Schützen? Pflegen?, Munich 1997

[2] Melman, Seymour, (ed.) The War Economy of the United States: Readings in Military Industry and Economy, New York 1971

built or enlarged work sites, such as Mannesmann with an administration building and a large work complex. Both by prominent architect Hans Vaeth, they clearly demonstrate the increased importance of heavy industry in the run up to World War II in a modernist architectural idiom. (Figure 1)

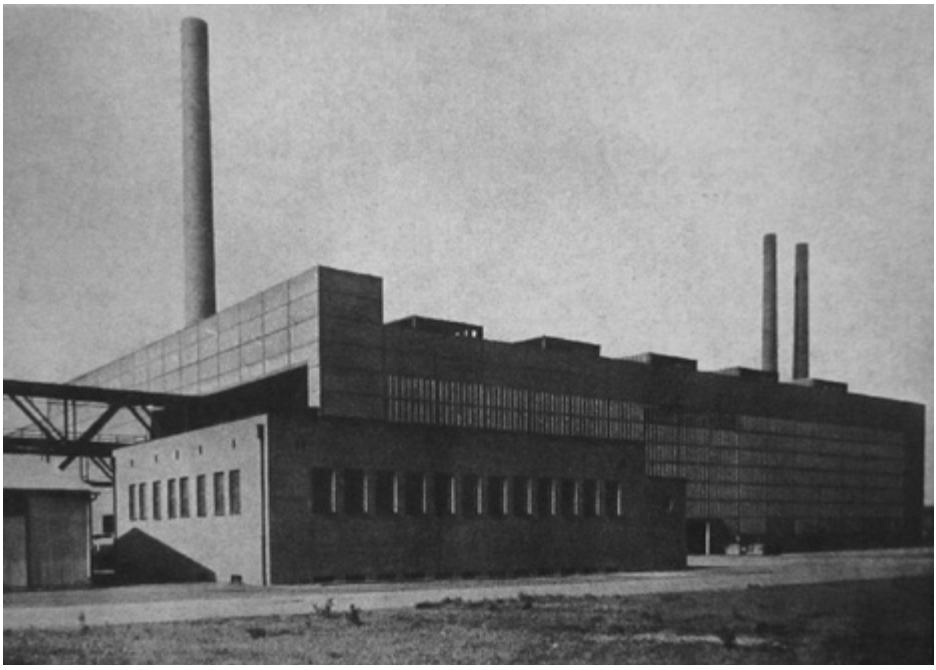


Figure 1. *Mannesmann iron works, Duisburg. Architect: Hans Vaeth*

The quickly developing air industry was another field that produced many structures in the years before WW II. In Berlin, we find the impressive 1934-1936 campus of "Deutsche Versuchsanstalt für Luftfahrt" – "German Aeronautical Testing Institute" with its uncompromisingly pure geometrical concrete buildings for wind tunnel, trundle tower and aero engine test station . (Figure 2)[3]

[3] Staroste, Hubert: Bauten der deutschen Versuchsanstalt für Luftfahrt in Berlin, in: Vereinigung der Landesdenkmalpfleger in der Bundesrepublik Deutschland (Ed.): Denkmale der Industrie und Technik in Deutschland, Berlin 2016, p. 394-395



Figure 2. *Berlin-Adlershof. Air Ministry Testing ground 1934-1936*

The East German firm of Heinkel in Rostock since 1935 produced aeroplanes for the German air force, since 1939 the first rocket-driven planes. All that was left of the Rostock premises after 1945 was the so-called "Heinkel Wall", a brick monument left over as a reminiscence of the once powerful industrial enterprise of Heinkel. It was a protected monument since 1993, but after a long and heated debate was demolished in 2018. As an ornament on one of the Heinkel buildings a stone sculpture survived that is very typical for art inspired by Nazi ideology: although Heinkel was characterized by state-of-the art hypermodern technology, the sculpture of a muscular, half-naked worker swings a heavy sledgehammer, standing in front of a steel factory hall – all the antagonistic contradictions of the years between 1933 and 1945 are manifest here. Firm owner Ernst Heinkel had become a member of the National Socialist party in May 1933. (Figure 3)



Figure 3. *Sculpture at the Rostock administration building of Heinkel Werke*

Linked to the Rostock production site of Heinkel (the first jet plane of this firm was started here in 1939) is a legendary part of the Usedom insula in the Baltic sea, named after the village of Peenemünde. Since 1936, the German Reich army concentrated on 25 square kilometres its research and production of new weapons that led to the development of the notorious "V2" rocket that was to terrorize Europe. Before 1936 a forerunner site south of Berlin, called Kummersdorf, had served several purposes of testing weapons since 1875. Here, the first trial runs of Wernher von Braun's rockets took place, before the activities were moved to Peenemünde for reasons of available space and concealment possibilities. Since 2007 the area is a protected monument, in 1990 a "Technical Museum" was opened that rather uncritically presented military vehicles in a slightly nostalgic context till 2012. Today near the 800-hectare area of the former weapon's testing place that is not accessible to the public, a more critical "Museum of History and Technology" interprets the numerous remains of buildings of the complex. (Figure 4)



Figure 4. *Remains of buildings in the Kummersdorf compound of the former artillery testing ground*

After 1936, Peenemünde took the place of Kummerdorf and was developed to the world's largest military testing ground. Until 1990 this space stayed the no-go area that It had been since 1936. After the Third Reich it had been used by the Soviet and East German armies. After long debates and a scandal in the 1990s, when former co-workers of the leading technical director Wernher von Braun who together with him were "confiscated" by the Americans in 1945 and developed since the rocket technology of the USA,

made the proposal to simulate the start of a V2 rocket, the very one that terrorized European cities like London or Antwerp, the discussion what to do with the place came to a rest for a while. The University of Cottbus has since published a thorough inventory of the remains of a military-industrial site, where up to 16.000 workers were employed, many of them in forced labour, housed in concentration camps.[4]

After the scandalous events of the 1990, that involved many "innocent" former specialists who had been working in Peenemünde to develope deathly weapons but after their own testimony had only been interested to "conquer outer space", the debate what to do with the Peenemünde was developed along more responsible ways. Today, there is an official "monumental landscape" with the former power plant (1939-1941) of the weapon production serving as an historical-technical information centre. (Figure 5) The gigantic oxygen works is preserved but so far standing unused. (Figure 6) The area can be visited except the parts that are still infested by mines, posters are giving information.



Figure 5. *Siemens power plant of the Peenemünde rocket V 2 plant, 1939-1942*

[4] Schmidt, Leo, Uta K. Mense (Ed.): *Denkmallandschaft Peenemünde. Eine wissenschaftliche Bestandsaufnahme – Conservation Management Plan*, Berlin 2013



Figure 6. *Peenemünde, remains of the oxygen works, 1939-1942*

There is an even more darker side to the rocket weapon production of Peenemünde in another German place: Under the name "Dora Mittelbau" the SS erected in 1943 in rural Thuringia a subterranean production plant, to which in 1944 a concentration camp was added, to take over mass production of the rocket weapons. Of the 60.000 workers that had to labour there, 20.000 died. Since 1964 Dora Mittelbau is a memorial site, erected by DDR, since 1995 it is possible to reach the authentic subterranean places of production and suffering (Figure 7), in 2006 a permanent exhibition opened.[5]



Figure 7. *Mittelbau Dora. Place of the V 2 production, documentation centre*

A place of smaller scale related to air warfare of the Third Reich can be found on the German-Dutch border near the city of Venlo: the night fighter airfield of Venlo-Herongen containing more than a hundred buildings. Since 1941, up to 15.000 Dutch workers, aided by concentration camp prisoners, erected it after the German occupation of the Netherlands. Since the start of the Allied air attacks the airfield served as a base mainly for Heinkel night fighters, as part of a system of airfields and lines of flak searchlights. Preserved in a rather neglected shape are the former control tower and a reinforced concrete arched hangar (Figure 8). A bilingual information centre informs Dutch and German visitors about the history of the place and serves as a place of common memory of World War II.[6]

[5] Wagner, Jens-Christian: *Produktion des Todes*. Das KZ Mittelbau-Dora, Göttingen 2015

[6] Hubatsch, Herbert: Vom Nachtjäger zum Naturschützer, Nettetal 2014



■ **Figure 8.** *Herongen-Venlo, hangar of the night fighter airfield, 1941-1943*

A long line can also be finally drawn between the Peenemünde complex and an area near Bonn in the West of Germany, spanning war and post war history. The common theme is the production of the "Vergeltungswaffe" – "Vengeance Weapon" the "V 2 rocket". In two abandoned railway tunnels under the vineyards of the valley of the Ahr River in the Eifel mountains, built as a war-relevant line for World War I, a couple of arms manufacturers in the 1940s started the production of parts for the V 2 rocket, again using the forced labour of concentrations camp inmates. Using this underground system, after fifteen years of subterranean mushroom growing in Bad Neuenahr near Bonn, the West German government decided in 1960 to establish a typical cold war structure: an atomic-bomb-safe place for the emergency-phase-administration centre of the government in nearby Bonn. Complete with autonomous supply of water, electricity and fresh –filtered – air. More than seventeen kilometres of tunnel were dug between 1960 and 1972 in an intricate pattern of five parts 100 to 60 meters below ground (Figure 9).

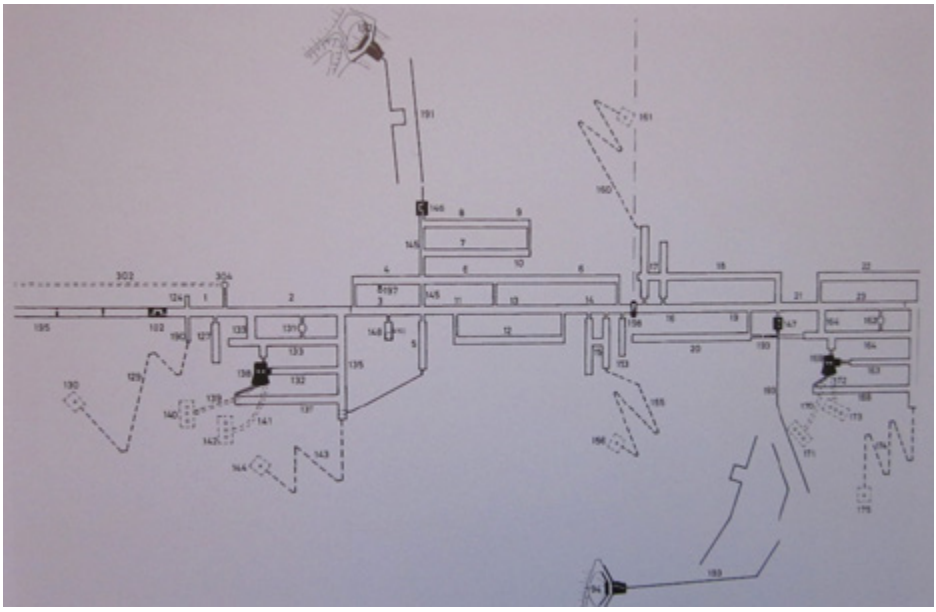


Figure 9. *Ground plan of the atomic shelter for the German government, 1962-1970*

25-ton steel/concrete door separated the individual segments. 3000 people could be provided for for a span of thirty days. (What the outside world looked like after thirty days, nobody seemed to care about, notwithstanding radiation and nuclear contamination) From 1966 till 1989 NATO used the bunker system in field manoeuvres simulating war situations. In 1997 the decision was made to abandon the bunker system, the tidying up lasted until 2006 and cost 16 million Euro. In 2008 a rudimentary stretch of not more than 203 meter of the originally 17,3 kilometre system with its 936 sleeping and 897 office rooms opened as a visitor's centre (Figure 10) and manifesto of cold war ideology.[7] In 2009 the site was declared European Cultural Heritage.

[7] Bundesamt für Bauwesen und Raumordnung / Stiftung Haus der Geschichte der Bundesrepublik Deutschland (Ed.), Schäfer, Ralf: Der Regierungsbunker, Tübingen 2006



Figure 10. *Entrance to the 203-meter tunnel of the documentation centre of the German government shelter*

The rather weird concept of believing an elite safe from atomic attacks applied both to the Western and Eastern world in the 1960s and seventies: In deeply rural Bosnia-Herzegovina, in the middle of the countryside near Konjic fifty kilometres from Sarajevo, as early as 1953 the construction of a 6500 square metre atomic bunker was begun at the cost of 4.6 billion dollar that, finished in 1979 was meant to contain general Tito's 350 government members during armed conflicts for a duration of up to a half a year. The pictures are similar to the German example: concrete tunnels, whose entrances were concealed in dwelling houses and garages, and spartan, weirdly furnished living and working rooms (Figure 11) for the ruling elite, technical equipment for water, air and electricity. In the conflicts of the 1990s, a demolition of the whole system was considered by the Serbs but is was prevented by Bosnian forces. For some time now, it is possible to visit the tunnel system, since 2011 a Serb/ Bosnian art biennale is held here.



Figure 11. *Communication room of the Bosnian atomic shelter for the Yugoslav government, 1953-1979*

What has been presented here so far is of course just a very limited overview of exemplary sites and structures related to military-industrial activities of the 20th century and the way they have been integrated into contemporary uses and turned to memorial sites. This was made possible by a profound turnaround in the way historic monuments were interpreted that happened around 1970, after the academic historical science started to consider every day events as important historic topics and the so-called "history from below" replaced the traditional consideration of the sphere of the high and mighty. The historic monument no longer served as an example of the aesthetically exemplary but as a document throwing light on the totality of historical events. With this attitude, places of production and technological development came into focus. Monuments no longer represented the arbitrarily chosen positive aspects of the past but were seen as representatives of a comprehensive picture of times past, standing for the totality of historic developments, be they "positive" or "negative". With this it became possible to postulate the preservation of objects that represent massively negative features of the past such as for example concentration camps, prisons, factories demonstrating the tough character of industrial production and its social implications in the past and, to come back to our topic, places of military contexts with their connotations of war and death – in short what Norbert Huse in 1997 called "inconvenient" monuments".



Figure 12. *Congress hall of the Empire Party Meeting Ground, 1937-1939*



Figure 13. *Günther Doemenig's addition to the congress hall, 2001*



Figure 14. *Former arsenal building from 1877, later Army Museum with additions by Daniel Libeskind in 2011*

All over the world, places throwing light on the sphere of military aggression and its technological manifestations have been made part of our cultural heritage, thus enlarging and completing our awareness of the history at the root of contemporary conditions and maybe in some cases giving a certain didactical admonition of a "never again".

As exemplary one can take the way specific remains of the Third Reich have been treated in the post World War II history of Germany. It can be exemplified by the decision not to do away – as was for a long time intended – with the remaining buildings of the Nuremberg "Reichsparteitagsgelände" – "Empirical Party Meeting Ground" of the National Socialists, not a place of military activity as such but one of the places where the military aggression that was to catapult the world into World War II had been prepared. The Austrian architect Günther Domenig in 2001 shot an architectural "arrow" through the absurdly gigantic building of the congress hall (Figure 12), built between 1937 an 1939 but never completed, giving access to a documentation centre. (Figure 13) In a very similar way Daniel Libeskind in 2011 made an architectural comment on the 1877 arsenal building of the later (1914) Saxonian Army Museum that today serves as a central museum of "The Cultural History of Violence". (Figure 14)

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Figure 13: raboe001-at-web.de

Figure 14: Von User:Kolossos – Eigenes Werk, CC BY 3.0

SAŽETAK

U Njemačkoj je mnogo tvornica povezano s proizvodnjom oružja i ratnih vozila te mjestima za razvijanje vojne tehnologije i u Prvome i u Drugome svjetskom ratu. Postoje i tragovi rasta u proizvodnji nečega što ima „dvojnu upotrebu", kao što je to čelik u industriji Ruhrgebiet regije. Od istaknutog je značenja veliki kompleks vojnog centra za istraživanje Peenemünd u kojem se razvijala V2 raketna tehnologija, područje u koje se „nije smjelo ići" od 1937. do 1990. (njemačka vojska, ruska vojska, vojska DDR-a). Drugi lokalitet „teškog tipa" su, naravno, mjesta prisilnog rada, tamo gdje su zatvorenici koncentracijskih logora bili prisiljeni raditi u njemačkoj vojnoj proizvodnji, poput logora Dora Mittelbau u kojem su se proizvodile rakete, ili ruševina tvornica aviona gdje su radili zatvorenici iz koncentracijskog logora Dachau pokraj Münchena.

Dugo nakon rata priznata je njihova nekadašnja namjena pa su u skladu s time i integrirani u projekte očuvanja i prezentacije. Mornarički lokaliteti još su jedan oblik industrijske baštine, poput novoobnovljenoga grada Wilhelmshavena koji je služio Njemačkoj mornarici od njezinih pruskih početaka od sredine 19. stoljeća, s brzim rastom nakon 1900. do kojega je došlo zbog rastuće važnosti njemačkog ratovanja na moru pod carem Wilhelmom II. Godine 1918., pobunom njemačkih mornara u Wilhelmshavenu, počeo je politički proces demokratizacije u Njemačkoj.

Ključne riječi: *spomenici njemačke vojne proizvodnje, V2 proizvodnja u Peenemündeu, mjestu prisilnog rada, mornarički lokaliteti*

IMA LI MJESTA ZA DIVERZANTSKU PODMORNICU *VELEBIT P-01* U TEHNIČKOM MUZEJU *NIKOLA TESLA*? – STUDIJA SLUČAJA

Is there a room for the commando submarine *Velebit P-01* in the Nikola Tesla Technical Museum? – Case study

Davor Fulanović*

SAŽETAK

Džepna (diverzantska) podmornica Soča P-914*, u sastavu bivše Jugoslavenske ratne mornarice iz druge polovice 80-ih godina 20. stoljeća, redizajnirana je (produžena s poboljšanim karakteristikama) i preuzeta u flotu Hrvatske ratne mornarice (HRM) 1996. pod nazivom* Velebit P-01*. Do 2001. bila je u sastavu HRM-a, kada je otpisana zbog isteka trajanja pogonske baterije za napajanje. Godine 2005. izvađena je iz mora na suhi vez (kopno) u luci Lora, Split. Projektirana je u Brodarskom institutu u Zagrebu, a sagrađena u splitskom brodogradilištu* Brodosplit *– BSO (izvorna i modificirana verzija). Podmornica* Velebit P-01 *bila je namijenjena obavljanju diverzantskih zadataka: polaganju ležećih mina na dno, prijevozu diverzanata, obavljanju ophodnje i izvidničkih zadataka, površinskoj obuci mornara te različitim specijalnim zadacima.*

Tehnički muzej Nikola Tesla *kao matični muzej za tehničke muzeje u Republici Hrvatskoj zainteresiran je za trajno očuvanje podmornice* Velebit*, predstavnika visoke tehnologije hrvatske industrije i potencijalnoga tehničkog kulturnog dobra od nacionalnog interesa. Optimalan je smještaj za podmornicu* Velebit *zatvoreni prostor jer ju je na otvorenom prostoru moguće održati u zadovoljavajućem stanju bez trajnih posljedica i devastacije jedino u ograničenome vremenskom razdoblju. U muzejima se često prisutne dvojbe o uvođenju velikih predmeta u funduse za koje se ne mogu jamčiti odgovarajući uvjeti smještaja.*

Godine 2010. razmatrana je mogućnost povećanja fundusa Tehničkog muzeja Nikola Tesla *podmornicom* Velebit*. Provedenom analizom ustanovljeno je da u zatvorenim prostorima stalnoga postava i depoa kojima se Muzej koristi nema slobodnog prostora za njezin trajni smještaj.*

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Na otvorenim površinama Muzeja kao jedina moguća opcija utvrđen je uski pojas zelene površine između ograde Muzeja (Tratinska ulica) i niske upravne zgrade. Za tu je lokaciju, na temelju izrađenog projekta o smještaju podmornice Velebit*, ishođena protupožarna suglasnost te suglasnost konzervatora.*
Zbog prijeko potrebnih, izrazito velikih, novčanih sredstava za demontažu, transport, montažu i konzerviranje podmornice Velebit P-01*, moralo se odustati od njezina preuzimanja u fundus Tehničkog muzeja* Nikola Tesla*.*

Ključne riječi: *podmornica, kulturno dobro, tehnička baština, restauracija, muzej*

1. UVOD

Tehnički muzej *Nikola Tesla* osnovan je 1954. u Zagrebu kao Tehnički muzej. Muzej je otvoren za javnost 1963. i do danas je ostao nacionalni muzej znanosti i tehnologije. Za razliku od specijaliziranih tehničkih muzeja ne obrađuje pojedino područje tehnike, već sveukupnu znanost i tehniku. Muzej čuva, obrađuje i prikazuje muzejsku građu važnu za tehničko-tehnološki razvoj u svijetu, a osobito u Hrvatskoj. Na taj način prikazuje znanstveno-tehnički razvitak u prošlosti, njegove dosege u sadašnjosti te moguće daljnje pravce razvitka u budućnosti.



Slika 1. *Pogled na izložbenu halu Tehničkog muzeja* Nikola Tesla *(foto: arhiv Muzeja)*

Muzej se od 1958. nalazi u kompleksu zgrada koje potpisuje arhitekt Marijan Haberle. Središnja izložbena hala u cijelosti je izgrađena od drva, uključujući nosive elemente te sve zidne i stropne plohe. Kompleks muzejskih građevina od 2005. upisan je u Registar kulturnih dobara Republike Hrvatske kao zaštićeno nepokretno kulturno dobro.

Fundus Muzeja nastao je na temelju darovnica velikih proizvodnih i infrastrukturnih sustava: poduzeća *Rade Končar*, Hrvatskih željeznica, elektroprivrede, hrvatskih brodogradilišta i ugljenokopa, obrazovnih institucija (zagrebačkoga Strojarskog i Prirodoslovno-matematičkog fakulteta), vojske i drugih institucija (Narodne tehnike – danas Hrvatska zajednica tehničke kulture), muzeja (Muzej za umjetnost i obrt, Etnografski muzej u Zagrebu) te kontinuiranim brojnim donacijama i otkupima od pojedinaca.



Slika 2. *Odjel prometnih sredstava (foto: arhiv Muzeja)*

Prvi odjeli (1963.) Muzeja bili su: Transformacija energije, Prometna sredstva, Rudarstvo-geologija s modelom rudnika u naravnoj veličini. Nakon toga slijede Nafta (1964.), Astronautika s planetarijem (1965.), Demonstracijski kabinet *Nikola Tesla* (1976.), odjel Osnove poljodjelstva (1981), odjel Vatrogastvo (1992.), Park skulptura velikana hrvatskog prirodoslovlja i tehnike na otvorenom (1993. – 2004.), Apisarij s oglednim košnicama (1994.), Katastarski ured (1994.) te zbirka modela toplinskih strojeva *Pokretna moć vatre* (1999.). Izložba *Otvorena vrata* (2004.) o zbirkama iz čuvaonica Muzeja postaje dio stalnog postava. U povodu 150. obljetnice rođenja Nikole Tesle (2007.) obnovljen je Kabinet *Nikola Tesla*, a velike izmjene postava ostvaruju se u odjelu Prometna sredstva. Odjel Info centar Obnovljivi izvori i energetska učinkovitost otvara se 2013., a obnovljen postav o nuklearnoj energiji 2014. U stalnom postavu izloženo je 2500 predmeta, a u depoima je pohranjeno više od 10.000 predmeta.

Muzej je od otvaranja za javnost djelovao s obrazovnom i popularizatorskom funkcijom, po čemu se razlikovao od ostalih muzeja u okruženju; posjetitelja je bio više od 100.000 godišnje, da bi posljednjih godina taj broj narastao na više od 160.000.

U razdoblju od početka 20. stoljeća do danas opremljena je restauratorsko-preparatorska radionica, obnovljeni su kapitalni izlošci (podmornica, zrakoplovi, lokomotive, tramvaji, parni strojevi), a od 2002. Muzej provodi matičnu djelatnost za sve tehničke muzeje i zbirke u Republici Hrvatskoj.

Na inicijativu gradonačelnika Grada Zagreba Milana Bandića, a odlukom Skupštine Grada, Muzej je 2015. preimenovan u Tehnički muzej *Nikola Tesla*.

2. PODMORNICA CB-20, *MALIŠAN,* U TEHNIČKOM MUZEJU *NIKOLA TESLA*

Jedan je od atraktivnih odjela stalnog postava Tehničkog muzeja *Nikola Tesla* odjel Prometna sredstva. Smješten je u središnjem prostoru izložbene hale (visine središnjeg unutarnjeg prostora 15 m). U odjelu se prikazuje povijesni razvoj prometala na kopnu (cestovna i na tračnicama), vodi (moru, rijekama) i u zraku. Postav je znatno unaprijeđen 2007. uvođenjem novih izložaka i prerazmještajem postojećih. Sastavni dio postava je tramvaj M 24 iz 1924. (pohranjen u remizi Zagrebačkog električnog tramvaja – ZET) koji nedjeljom vozi posjetitelje Muzeja zagrebačkim ulicama. U postavu su, uz ostale izloške, i džepna podmornica CB-20, *Mališan*, iz 1943., uskotračna parna lokomotiva *Gabor* iz 1890., parna lokomotiva *Samoborček* iz 1930., dubrovački tramvaj iz 1912., automobil *Mercedes-Benz S* iz 1927., zrakoplov *Fizir,* FNH, hrvatskoga konstruktora Rudolfa Fizira iz 1944. te javni sat s Kvaternikova trga u Zagrebu iz 1925. godine.





Slika 3. *Podmornica CB-20,* Mališan *(foto: arhiv Muzeja)*

Najzanimljiviji je i dakako najveći izložak u Prometnim sredstvima podmornica CB-20, *Mališan*. U opisu podmornice *Mališan* na web-stranicama Muzeja navodi se sljedeće: talijanska obalna podmornica CB-20 (dvadeseta jedinica serije *Costiero*, tipa B) izgrađena 1943. u brodogradilištu *Caproni*. Za pogon na površini koristila je dizelski pogon, motor tvrtke *Isotta Fraschini*, snage 88 KS (65 kW), a pod vodom električni pogon, elektromotor tipa *Brown Boveri*, snage 44 kW. Površinska brzina iznosila je 7,5 čvorova, a pod vodom 7 čvorova. Maksimalna dubina ronjenja iznosila je 55 metara. Istisnina podmornice u površinskoj plovidbi iznosila je 36 tona. Od naoružanja raspolagala je s dva torpeda kalibra 450 mm, čije su se cijevi punile izvan podmornice na vanjskom prostoru vojne baze. Posadu su sačinjavali jedan časnik i tri mornara.

Podmornica *Mališan* dopremljena je i postavljena u odjel Muzeja 1963. bez prethodnih nužnih konzervatorskih zahvata (odsoljavanje, antikorozivna zaštita i drugo). U proteklih pedeset godina dolazi do daljnje devastacije podmornice zbog različitih korozijskih procesa. Stoga je podmornica temeljito obnovljena na licu mjesta (*in situ*) od 2008. do 2010. godine. Nakon izrade projekta obnove te provedenoga javnog natječaja, obavljeni su radovi na dijelovima unutrašnjosti podmornice: stijenki, armatura, instrumenata i instalacija. Potom je odsoljen vanjski i unutarnji trup te obavljeni restauratorski radovi vanjštine. Podmornica je podignuta za 80 cm od poda, postavljena na nove nosače i ugradnjom mosta posjetiteljima je omogućen pristup njezinoj unutrašnjosti od galerije izložbene hale do zapovjednog tornja.

3. PODMORNICA *VELEBIT P-01*

Diverzantska podmornica *Velebit P-01* bila je prva i jedina podmornica u sastavu flote Hrvatske ratne mornarice i karakterističan je predstavnik hrvatskoga proizvoda visoke tehnologije. Projektirana u Brodarskom institutu u Zagrebu, sagrađena je pod nazivom *P-914 Soča* nakon 1985. u splitskom brodogradilištu *Brodosplit* – BSO (brodogradilište specijalnih objekata). U razdoblju 1984. – 1989. za potrebe Jugoslavenske ratne mornarice proizvedeno je šest džepnih podmornica tipa MD-100, klase *Una* (prema nekim izvorima klase *Tisa*): *P-911 Tisa* (*Una*?), *P-912 Una* (*Tisa*?), *P-913 Zeta*, *P-914 Soča*, *P-915 Vardar* i *P-916 Vrbas*. Pri projektiranju navedene klase podmornica rabila su se iskustva britanskih džepnih podmornica tipa *X* i talijanske klase *CA*.

Na početku Domovinskog rata džepna podmornica *P-914 Soča* zaostala je na remontu u brodogradilištu *Brodosplit* – BSO te postaje sastavnica Hrvatske ratne mornarice (HRM), a ostalih pet podmornice iz klase *Una* ostalo je ukotvljeno u Boki kotorskoj, Crna Gora.

Radi poboljšanja karakteristika podmornice *P-914 Soča* Brodarski institut iz Zagreba 1993. radi na projektu osmišljavanja ugradnje dizelskog agregata i novog sustava upravljanja. Takvo poboljšanje povećava autonomiju plovidbe

punjenjem akumulatorskih (aku) baterija za podvodnu plovidbu bez vanjskog izvora napajanja. Splitsko brodogradilište *Brodosplit* – BSO obavlja potrebne radove rekonstrukcije podmornice, među ostalim i produljenje trupa za 1,4 m radi smještaja dizelskog agregata. Primopredaja HRM-u redizajnirane podmornica pod novim imenom *Velebit P-01* obavljena je 16. siječnja 1996. godine.



■ **Slika 4.** *Podmornica* Velebit P-01 *na suhom vezu u luci Lora, Split, ožujak 2010. (foto: arhiv Muzeja)*

Idućih je pet godina *Velebit P-01* u uporabi (do 2001.), kada istekom trajnosti aku-baterija podmornica više nije mogla biti operativna pod morem. Zbog toga se posada obučavala samo na površinskoj vožnji, a *Velebit* nije ostao u operativnoj uporabi HRM-a. Godine 2005. podmornica je izvučena na suhi vez (kopno) u luci Lora u Splitu.

Dugoročnim planom razvoja Oružanih snaga Republike Hrvatske (OSRH) za razdoblje 2006. – 2015., odlučeno je da se podmornički segment u HRM-u ugasi.

4. OPIS PODMORNICE *VELEBIT*

Podmornica *Velebit P-01* bila je namijenjena obavljanju diverzantskih zadataka: polaganju ležećih mina na dno, prijevozu diverzanata, obavljanju ophodnje i izvidničkih zadataka, površinskoj obuci mornara te različitim specijalnim zadacima.





Slika 5. *Podmornica* Velebit P-01 *na suhom vezu u luci Lora, Split, ožujak 2010. (foto: arhiv Muzeja)*

Velebit je jednotrupna podmornica vretenasta oblika s tupastim pramcem i šiljastom krmom, kao i sve moderne konstrukcije podmornica danas, bez obzira na dimenzije. Podmornica se sastoji od čvrstog i lakog trupa.

Čvrsti trup pregrađen je dvjema teškim nepropusnim pregradama i podijeljen u tri dijela: pramčani ili upravljački, srednji ili izlazna komora i krmeni ili pogonski. Pramčani ili upravljački odsjek dijeli se na tri funkcionalna prostora: upravljački i diverzantski prostor te prostor aku-baterija. Srednji dio ili odsjek izlazne komore je naplavljiv, u donjem dijelu nalazi se regulator, u gornjem su diverzantske mine, dva ležaja, oprema izlazne komore i drugo. Krmeni ili pogonski odsjek sadržava dizelski generator, spremnik goriva, elektromotore, sustav ispuha te cjevovode i armature hlađenja dizelskog motora, klima-uređaj, kompresor, kemijski WC i drugo.

Laki trup podmornice čine pramac, krma i nadgrađe, koji zajedno daju trupu povoljniju hidrodinamičku formu. Oni su zasebni dijelovi lakog trupa i odvojivi su od čvrstog trupa zajedno sa svom pripadajućom opremom na njima i ispod njih.

Vanjski elementi podmornice su most (toranj), kormila, hidroplani i krmeni stabilizatori, zaštita periskopa, kobilica i drugi.

Osnovni podaci o diverzantskoj podmornici *Velebit P-01*

Dužina	
– preko svega	21,1 m
– čvrstog trupa	15,4 m
Širina	
– preko oplate	2,70 m
– preko pomoćnog hidroplana	3,64 m
– promjer čvrstog trupa	2,70 m
Visina	
– do gornjeg ruba palube	3,38 m
– do vrha poklopca tornja	3,68 m
– do gornjeg ruba – svoda mosta	4,41 m
– do glave izvučenog periskopa	5,30 m
Istisnina	
– podvodna	98,5 t
– površinska, osnovno stanje	88,0 t
Ostali podaci	
Pogon:	
– za podvodni vožnju (porivni elektromotori)	Končar (2 x 18 W)
– za površinsku i „šnorkel“ vožnju (dizelski agregat)	64 kW (105 kW)
– aku-baterije (ukupna masa 24 t)	2 x 128 članaka

Brzina:	
– ekonomska podvodna brzina	4 čv
– ekonomska brzina na površini	6 čv
Posada:	
4 ili 6 članova i 6 diverzanata	
Podvodna autonomija:	
– za šest članova posade	160 sati
– radna dubina ronjenja	105 m
Naoružanje:	
4 ronilice i 6 diverzantskih mina ili 4 podvodne (ležeće) mine	

5. STANJE PODMORNICE *VELEBIT*

Snimanje stanja podmornice *Velebit P-01* (izmjera, pregled dokumentacije, dijagnosticiranje stanja izvana i iznutra te videosnimanje i fotografiranje) obavilo je u ožujku 2010. stručno osoblje Tehničkog muzeja, Zagreb: ravnatelj Davor Fulanović, muzejska savjetnica Neda Staklarević, viši restaurator Zoran Kirchhoffer i viši preparator Franjo Strugar. Podmornica je prema izjavama osobe iz HRM-a (gospodin Kazimir Šuper, nekadašnji prvi strojar na podmornici) u plovnom stanju i cjelovita, a svi viđeni elementi su u ispravnom stanju. Od opreme nedostaju punjive aku-baterije i aktivni sonar.

Podmornica *Velebit P-01* smještena je od 2005. na suhi vez, na molu pokraj mora, u luci Lora u Splitu. Udaljenost od morske površine s lijeve strane podmornice je oko 10, a od pramca oko 20 metara. Sa zadnje i desne strane podmornice je kopno. Udaljenost od same površine mora vrlo je važna zbog atmosferskih utjecaja (slana i vlažna atmosfera) na materijale i antikorozivnu zaštitu tijekom višegodišnjeg stajanja na toj poziciji. U *Ekspertizi stanja diverzantske podmornice Velebit P-01* (Tehnički muzej, Zagreb, 2010.), navedeno je sljedeće mišljenje o stanju podmornice:

5.1. Mjerenja i opažanja o stanju vanjskih zaštitnih prevlaka i premaza

Na metalima su prisutne metalne prevlake i premazi. Cinčane prevlake su debljina 25 – 60 μm, kromirane 80 – 100 μm, a debljina višeslojnog (dva sloja boje i jedan sloj temeljne boje) vanjskog premaza trupa je 650 – 800 μm. Uočen je troslojni premaz crne epoksidne smole (visokozapaljive), debljine oko 600 μm, nanesene na čvrsti trup na mjestima bez površinske boje ispod lakog trupa (pramca i krme).



Slika 6. *Korozija na vanjštini podmornice, ožujak 2010. (foto: arhiv Muzeja)*

5.2. Primijenjena antikorozivna zaštita

Antikorozivna je zaštita elektrokemijska, kemijska i metalurška. Elektrokemijska zaštita je katodna zaštita s cinčanim anodama (protektorima) na više mjesta izvana i iznutra podmornice. Kemijska zaštita izvedena je nanošenjem raznih premaza u više slojeva: temeljnom bojom, osnovnom maskirnom bojom, epoksidnom smolom. Metalurška su zaštita metalne prevlake, kao što su cinčane i kromne.

5.3. Stanje vanjštine podmornice

Laki trup (LT) – pramac. Unutarnje su stijenke jako nagrižene korozivnim produktima, kao i spoj prirubnice i čvrstog trupa (ČT), koji su nastali zbog

razlike u potencijalima metala i nefunkcionalne katodne zaštite. Vanjske stijenke također su nagrižene korozijom, osobito na spoju prirubnice LT-a i ČT-a. Hidroplani su bez vidljivih znakova propadanja. I boce i instalacije boca oštećene su korozijom.



Slika 7. *Korozija na vanjštini i unutrašnjosti pramčane oplate, ožujak 2010. (foto: arhiv Muzeja)*

Laki trup (LT) – krma. Stanje je vrlo slično onom na pramcu. Plitve su pojačano korodirale zbog boravka na suhom jer je podmornica nekoliko godina (do 2005.) bila na mokrom vezu – plutajući, kada je izvađena i smještena na suhi dok. Zbog toga su gornje plitve, koje nisu bile zaronjene, više oštećene od donjih koje su u tom razdoblju bile zaronjene i katodna je zaštita na njima bila u funkciji. Nakon vađenja iz mora na suho podmornica je neadekvatno zaštićena katodnom zaštitom, a nije kvalitetno isprana od slane morske vode.

Laki trup (LT) – nadgrađe. Izrađeno je od stakloplastike i u razmjerno je dobrom stanju bez uočenih znakova konstrukcijskih oštećenja, osim izblijedjele i „izribane" boje, čemu su uzrok primijenjene neodgovarajuće mjere održavanja.

Pogon – peterokraki propeler nepovratno je oštećen „ribanjima" i drugim mehaničkim djelovanjima. Uočena je korozija na cijeloj površini propelera i neka vrsta rupičaste *pitting* ili interkristalne korozije (vjerojatno zbog koncentracije klorid-iona).

Čvrsti trup (ČT) – stijenke čvrstog trupa su na pojedinim mjestima korodirale, a naročito uz prirubnice na spoju s LT-om. Oslonci podmornice su kao i LT jako nagriženi korozijom, a boja je izblijedila.

5.4. Stanje unutrašnjosti podmornice



Slika 8. *Unutrašnjost podmornice, ožujak 2010. (foto: arhiv Muzeja)*

Upravljački je dio u dobrom stanju u usporedbi s vanjštinom podmornice. Većina je elemenata cjelovita i navodno funkcionalna, osim nedostajuće opreme (aku-baterije i aktivni sonar). Pogonski i središnji ulazno-izlazni dio u dobrom je stanju kao i upravljački dio.

Zaključak: U *Ekspertizi stanja diverzantske podmornice Velebit P-01* navodi se: „…Na podmornici je nužan opsežan konzervatorsko-restauratorski zahvat na vanjštini, što podrazumijeva detaljno rastavljanje, mehaničko i kemijsko odsoljavanje, sanaciju svih oštećenja zbog degradacije materijala uzrokovane korozivnim produktima. Nepopravljivo oštećene pozicije potrebno je zamijeniti radi osiguranja integriteta podmornice. Potom je nužno stabilizirati korozivne procese uz primjenu odgovarajuće antikorozivne zaštitu ovisno o vanjskim atmosferskim i drugim uvjetima budućeg trajnog smještaja podmornice (morska obala ili kopno). Završna faza obnove podmornice bila bi bojenje prema zatečenom stanju te uputama proizvođača. Unutrašnjost podmornice je u relativno dobrom stanju i uz izvođenje konzervatorsko-restauratorskih radova na vanjštini preporučuju se obaviti konzervatorski radovi u unutrašnjosti…“

6. TRAJNI SMJEŠTAJ PODMORNICE *VELEBIT*

Kao što je navedeno, odlukom OSRH-a bilo kakva eksploatacija podmornice *Velebit P-01* u vojne svrhe trajno je završila te je predstojalo donošenje odluke o njezinu trajnom smještaju. Uzimajući u obzir sve okolnosti, na temelju prijedloga, pregovora i analiza međusobnih pravnih subjekata, a ovisno o mogućnostima i interesu zainteresiranih, u *Ekspertizi stanja diverzantske podmornice Velebit P-01* definirane su opcije budućeg smještaja i zaštite podmornice:

A. Donacija podmornice jedinici lokane samouprave uz prethodnu konzervaciju i obvezu izlaganja na odgovarajućoj lokaciji (površini) u Splitu, Zagrebu ili kojemu drugom gradu na obali.
B. Donacija podmornice jedinici lokalne samouprave i upis u registar nacionalnih dobara uz obnovu i konzervaciju te obveza čuvanja i njezina izlaganja u zatvorenom ili otvorenom prostoru hrvatskih muzeja kao što su npr. Pomorski muzej, Split, Vojni muzej, Tehnički muzej i drugi.
C. Izlaganje podmornice na lokacijama Hrvatske ratne mornarice, npr. u luci Lora.

Predloženi su koraci (poslovi) radi sprječavanja daljnjeg propadanja podmornice:

- Imenovati investitora – institucije/ju koji će financijski poduprijeti projekt premještanja podmornice i njezine obnove.
- Odabrati lokaciju trajne pohrane (smještaj u zatvorenom prostoru optimalan); na vanjskom prostoru moguć s ograničenošću izlaganja od dvadesetak ili više godina, bez trajnih oštećenja.

- Ovisno o kojoj je lokaciji riječ, uz morsku obalu ili u unutrašnjosti, potrebno je što prije pristupiti konzervatorskim radovima. Ako se podmornica smješta uz morsku obalu, uključujući sadašnji smještaj u ratnoj luci Lora, nužni su cjeloviti radovi obnove.
- Ako se podmornica premješta u unutrašnjost (kontinentalni dio), potrebno je obaviti temeljito odsoljavanje na licu mjesta u luci Lora, a potom bi slijedile složene pripreme transporta. Riječ je o odvajanju dijela nadgrađa podmornice od trupa radi prohodnosti i manipuliranja tijekom transporta.
- Priprema lokacije prihvata – trajnog smještaja, pri čemu se misli na osmišljavanje i uređenje eksterijera te izradu odgovarajuće konstrukcije nosača podmornice.
- Smještaj podmornice na novu poziciju uz montažu prethodno demontiranih dijelova nadgrađa.
- Odabir načina prezentacije te obavljanje poslova koji bi omogućili javnosti razgledanje vanjštine i unutrašnjosti podmornice. Potrebno je spomenuti da je zbog konstrukcije podmornice praktično neizvediv obilazak njezinih unutarnjih segmenata većem broju posjetitelja u kraćem vremenskom razdoblju.

Zaključak: U *Ekspertizi stanja diverzantske podmornice Velebit P-01* navodi se da je podmornica *Velebit* predmet visoke tehnologije, čiji je razvoj i proizvodnja isključivo rezultat nacionalne (hrvatske) pameti i domaćih proizvodnih resursa, a izravno je povezana s Domovinskim ratom i Hrvatskom ratnom mornaricom. Stoga je primjereno pronaći trajno rješenje njezina smještaja. Podmornica ima svoju povijest i svoju priču te je vrijedno i značajno dobro hrvatske tehničke baštine.

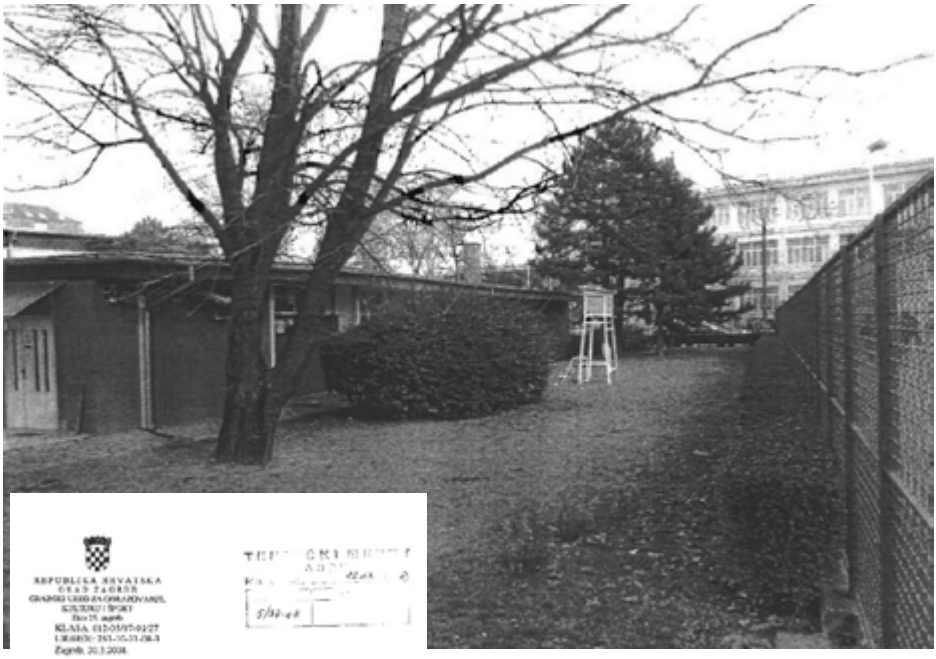
7. SMJEŠTAJ PODMORNICE *VELEBIT* U TEHNIČKI MUZEJ *NIKOLA TESLA*

Tehnički muzej *Nikola Tesla* matični je muzej za tehničke muzeje u Republici Hrvatskoj i kao takav zainteresiran za trajno očuvanje podmornice *Velebit,* predstavnika visoke tehnologije hrvatske industrije iz druge polovice 20. stoljeća i potencijalnoga pokretnog kulturnog dobra od nacionalnog interesa.

Optimalan je smještaj za podmornicu *Velebit* zatvoreni prostor. Prema mišljenju konzervatorske službe Tehničkog muzeja *Nikola Tesla,* podmornicu na otvorenom prostoru može se održati u zadovoljavajućem stanju bez trajnih posljedica i devastacije jedino u ograničenome vremenskom razdoblju (dvadesetak ili više godina).

Mogućnosti smještaja podmornice Velebit u prostore Tehničkog muzeja *Nikola Tesla* bitno su ograničene.

- U zatvorenim prostorima stalnoga postava i depoa kojima se Muzej koristi nema slobodnog prostora za trajnu pohranu podmornice *Velebit*. U središnjem prostoru hale A stalnoga postava Muzeja (odjel Prometna sredstva) središnje mjesto zauzima džepna podmornica CB-20, *Mališan* (manjih dimenzija od podmornice *Velebit*).
- Analizom mogućnosti smještaja podmornice *Velebit* na otvorenim površinama Tehničkog muzeja *Nikola Tesla*, kao jedina moguća opcija ostaje uski pojas zelene površine između ograde Muzeja na Tratinskoj ulici i niske upravne zgrade.



■ **Slika 9.** *Pozicija u dvorištu Muzeja (foto: Ž. Kovačić)*



REPUBLIKA HRVATSKA
GRAD ZAGREB
GRADSKI URED ZA OBRAZOVANJE,
KULTURU I ŠPORT
Ilica 15, zagreb
KLASA: 612-05/07-01/27
URBROJ: 251-10-01-08-3
Zagreb, 20.3.2008.

TEHNIČKI MUZEJ
NIKOLA TESLA
Savska cesta 18
10000 ZAGREB
5/04-08

n/p Ministar obrane
gospodin Branko Vukelić
Ministarstvo obrane Republike Hrvatske
Trg Kralja Petra Krešimira IV
10 000 Zagreb

PREDMET: Podmornica "Velebit"

Poštovani,

Grad Zagreb, Gradski ured za obrazovanje, kulturu i šport, putem Tehničkog muzeja u Zagrebu, izrazio je interes za preuzimanje podmornice "Velebit" tzv. džepna podmornica "Velebit" P-01, koja se nalazi u luci Lora u Splitu.

Kako trenutno nemamo saznanja o gore navedenoj, zamolno Vas da nas izvijestite o definitivnoj odluci o sudbini navedene podmornice.

Ovim putem izražavamo i naš interes da nam se navedena podmornica ustupi kao iznimno vrijedan spomenik tehničke baštine, a koji bi se smjestio i promatrao u sklopu Tehničkog muzeja u Zagrebu, Savska cesta 18, Zagreb.

S poštovanjem

PAVLO KALINIĆ
pročelnik

O tome obavijesti:
- Tehnički muzej u Zagrebu, Savska cesta 18, 10000 Zagreb

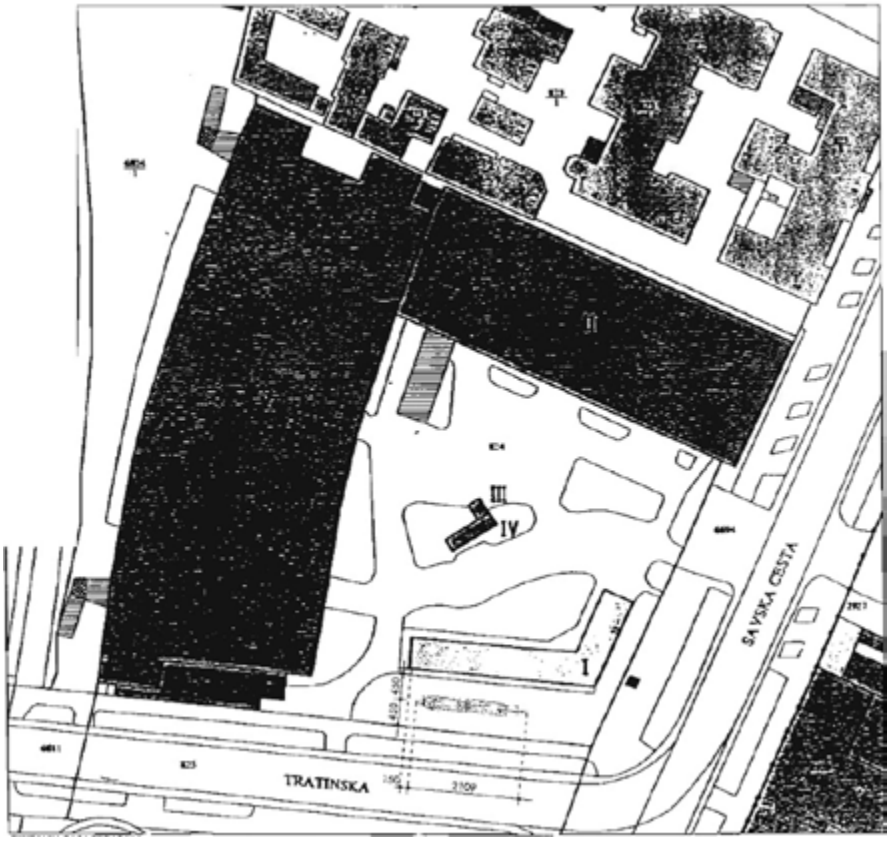
■ **Slika 10.** *Dopis Gradskog ureda od 20. ožuka 2008.*

Dvije godine prije snimanja stanja podmornice, Grad Zagreb ponudio je potporu i izrazio želju za preuzimanjem podmornice *Velebit* i njezin smještaj u Tehnički muzej *Nikola Tesla*. Namjera je službeno iskazana u dopisu Pavla Kalinića, pročelnika Gradskog ureda za obrazovanje, kulturu i šport Grada Zagreba, od 20. ožujka 2008., Branku Vukeliću, ministru Ministarstva obrane Republike Hrvatske. Provedena procedura i korespondencija rezultirali su

darovanjem podmornice *Velebit,* odnosno prenošenjem vlasništva s Republike Hrvatske na Grad Zagreb (odluka Povjerenstva za imovinu Vlade RH od 5. veljače 2009.). Gradski je ured za obrazovanje, kulturu i šport o tome obaviješten dopisom Ureda Vlade od 3. ožujka 2009.

U Tehničkom muzeju *Nikola Tesla* poduzimaju se sve potrebne predradnje za smještaj podmornice *Velebit* u dvorište Muzeja: izrada arhitektonskog i građevinskog projekta. Arhitektonski projekt *Postava i temelj za podmornicu Velebit u krugu Tehničkog muzeja* (11. svibnja 2009.) izradio je Željko Kovačić, tvrtka Baština, projektiranje i oblikovanje d.o.o, a građevinski projekt *Građevinski projekt – projekt konstrukcije* (14. svibnja 2009.) tvrtka *Škoro d.o.o.*

Na temelju projektne i izvedbene dokumentacije zatražene su i dobivene suglasnosti MUP-a, odnosno vatrogasaca (rigorozni protupožarni propisi za drvene građevine Muzeja) i nadležne službe za zaštitu spomenika – Gradskog zavoda za zaštitu kulture spomenika i prirode (kompleks Muzeja je kulturno dobro) za smještaj podmornice *Velebit* na otvorenom, u pojasu zelene površine u dvorištu Muzeja (između ograde Muzeja na Tratinskoj ulici i niske upravne zgrade).



Slika 11. *Tloris smještaja podmornice u dvorištu Muzeja (iz Arhitektonskoga projekta Željka Kovačića)*

Potom je u Tehničkom muzeju *Nikola Tesla* provedena analiza željezničkog i cestovnog prijevoza podmornice *Velebit* iz luke Lora u Muzej.

Prijevoz željezničkom prugom pokazao se neizvedivim zbog nemogućnosti pristupa dvorištu Muzeja. Pri prijevozu cestovnim pravcima osnovna je poteškoća dopreme podmornice u Muzej vezana uz ograničenje visine ispod željezničkih nadvožnjaka koji zatvaraju sva tri transportna pravca prilaza Muzeju. Nazivna slobodna mjera visine ispod sva tri podvožnjaka je 3,7 m (izmjereni slobodni prostor na najvišemu mjestu ispod podvožnjaka u Tratinskoj ulici je do 3,9 m). Uz osnovnu visinu podmornice od 4,41 m, nužno je skidanje njezina nadgrađa da bi se omogućio transport. Takvo demontiranje nadgrađa značilo bi demontažu lakog trupa pramca do pramčane pirubnice i demontažu lakog trupa kod strojnog mosta (tornja), demontažu periskopa, opreme ventilacijskoga stupa i drugih dijelova, sve kako bi se dimenzije visine podmornice svele na visinu čvrstog trupa od 2,7 m i kobilice od 0,3 m. Ukupna visina od 3,0 m omogućila bi transport podmornice labudicom ispod navedenih podvožnjaka. Po dopremi podmornice u Muzej bilo bi nužno ponovno obaviti montažu skinutih dijelova.



Slika 12. *Nadvožnjaci na Savskoj cesti, sjeverno i južno od Tehničkog muzeja Nikola Tesla (foto: arhiv Muzeja)*



■ **Slika 13.** *Nadvožnjak na Tratinskoj ulici (foto: arhiv Muzeja)*



■ **Slika 14.** *Pogled na željezničku prugu uz Muzej (foto: arhiv Muzeja)*

Zatražene su ponude za transport, demontažu i montažu nadgrađa podmornice. Zanimanje za navedene radove bilo je izrazito malo, što se moglo protumačiti zahtjevnošću (kompleksnošću) problema i/ili nedovoljnim znanjima. Prema dobivenim informativnim ponudama: *Epo* – energetsko-procesna oprema, Oroslavlje, *Končar* – montažni inženjering, Zagreb, *Trgošped*, Zagreb, za transport podmornice iz luke Lora u Splitu do navedene lokacije u Tehničkom muzeju potrebno je oko 850.000 kuna. Za demontažu i ponovnu montažu dijelova nadgrađa podmornice (zbog transporta – provlačenja ispod podvožnjaka bilo bi potrebno osigurati oko 1.100.000 kuna. To, međutim, ne znači da bi ti novčani iznosi bili dosegnuti u postupku javne nabave.

S obzirom na izrazito visoke financijske troškove ukazano je na potrebu valorizacije stanja podmornice *Velebit.* Nakon niza održanih sastanaka između Ministarstva obrane, Grada Zagreba i Muzeja dogovoreno je snimanje stanja podmornice, koju Tehnički muzej *Nikola Tesla* obavlja u ožujku 2010. Na

temelju provedenog uviđaja, odnosno obilaska terena, napisano je mišljenje *Ekspertiza stanja diverzantske podmornice Velebit P-01* (svibanj 2010.).

Na temelju iskustva iz prethodnih godina na obnovi velikih predmeta iz postava Tehničkog muzeja *Nikola Tesla* (podmornica CB-20, tramvaji, avioni, parni strojevi), konzervatorska služba Muzeja procijenila je trošak obnove podmornice na iznos od oko 1.200.000 kuna.

Usprkos izrazito pozitivnom pristupu i želji za trajnim postavom podmornice *Velebit* u prostore Tehničkog muzeja *Nikola Tesla*, Grad Zagreb, zbog iznimno visokih troškova transporta i smanjenja proračunskih sredstava, odustaje od darovnice. Službeni dopis o tome uputio je 23. veljače 2011. Ministarstvu obrane Republike Hrvatske Ivica Lovrić, pročelnik Gradskog ureda za obrazovanje, kulturu i šport Grada Zagreba.

Tako je završio višegodišnji proces, odnosno definiranje modaliteta transporta podmornice *Velebit P-01* iz Splita u Zagreb i njezina trajnog smještaja u prostore Tehničkog muzeja *Nikola Tesla*.



■ **Slika 15.** *Obnovljena podmornica u Lori (foto: MORH/D. Podrug – Slobodna Dalmacija)*

Četiri godine potom (2015.), prema napisu iz medija (*Slobodna Dalmacija*), podmornica *Velebit* obnovljena je na licu mjesta u luci Lora u Splitu. Iz novinskog izvješća riječ je zahtjevnijoj restauraciji, ali bez detaljnih informacija o opsegu obnove.

SUMMARY

Migget (commando) submarine Socha P-914 was made during the mid 80ies for the assembly of the former Yugoslavian Navy. In 1996 it was redesigned – extended with improved characteristics – and renamed Velebit P-01 by the Croatian Navy Fleet. It was part of the Croatian Navy until 2001 when it was written-off due to the driving battery supply going out of date. In 2005 it was pulled out of the sea on the so called "dry berth" in the harbour Lora in Split. It was designed in Brodarski Institute in Zagreb, and built in Brodosplit – BSO shipyard in Split (both the initial and the improved version). The submarine Velebit P-01 was intended for commando tasks: minelaying, transfer of commandoes, patrol and vanguard, surface training of the marines and other specialist tasks. Technical museum Nikola Tesla as the main museum of technology in Croatia is interested in the longterm conservation of this submarine, for it represents the high technical accomplishment of the Croatian industry and the potential cultural heritage of national importance. The ideal storage for the Velebit submarine is a closed space. In the open space it can be stored for a limited time only, otherwise permanent devastation can occur. In museums there is often a dilemma about such large objects becoming a part of the permanent collection, as it is almost impossible to guarantee adequate storage conditions. In 2010 it was considered for the Velebit submarine to become a part of the Technical museum Nikola Tesla permanent collection. Implementing analyses appointed that within the closed spaces of the Museum permanent collection display as well as the storage area, there was no free space to accommodate the submarine.

In the open space Museum areas as an option identified was a green surface between the fence of the Museum towards Tratinska Street and the administrative unite of the Museum. Based on the project elaboration for the accommodation of the submarine, procured were the fire and the conservation department conformation.

Dismantlement, transport, assembling and the conservation of the Velebit P-01 submarine would require exceptionally high financial funds. Hence, unfortunately the Technical Museum Nikola Tesla had to decline taking over of the submarine for its permanent collection.

Keywords: *submarine, heritage, restauration, museum*

DEVELOPMENT OF THE WHITEHEAD TORPEDO PISTOL DESIGN FROM 1866-1918

Razvoj upaljača Whiteheadova torpeda 1866. – 1918.

Drew Gee*

SUMMARY

The original concept of Giovanni Luppis's "Salvacoste" – a floating unmanned device controlled from land for destroying ships, eventually lead to the invention of the self-propelled underwater torpedo. It was a quantum leap in naval weapons technology, changing naval tactics and strategy forever. No longer did ships have to tow explosive devices such as Harvey's Sea Torpedo into enemy ships, or ram the explosive head of a Spar Torpedo into an opponent's hull. In 1866 Robert Whitehead invented the self-propelled"locomotive" or fish torpedo that traveled along a predetermined path at a predetermined depth to its intended target.

Upon reaching the target, a successful detonation relied solely on one key torpedo component – its pistol or fuze. As with its artillery counterpart, the fuze is the nucleus of the projectile and controls the explosion.Without a reliable firing /pistol mechanism, the torpedo will fail in its mission leading to its inevitable lost into oblivion.

The design of the torpedo pistol underwent radical re-design where the original spring pistol mechanism based on a rifle's percussion design was replaced by a simpler contact one once the velocity of the torpedo reached a point where the inertia of the torpedo could detonate the explosion. With the introduction of safety fan mechanisms, the torpedo could be launched and only to be "armed" at a safe distance away from the ship. Numerous pistol designs were implemented to increase the "angle of bump" providing a higher success rate of detonation if the torpedo stuck the target at an off centre angle. The introduction of extended pistol levers or "whiskers" could only increase the "angle of bump" up to an effective 30-35 degrees from off centre.

Finally with the introduction of the Universal Bell and the later Universal Pendulum inertia type pistols, the final reliance on having a pistol mechanism solely attached to the tip of the torpedo was overcome and the era of the modern torpedo was born. This research of early Whitehead Pistol Design takes an exciting look into the development of the early torpedo pistol mechanisms, how they evolved to overcome obstacles, ongoing challenges and the progressive improvements which lead to consistent reliability.

Keywords: *Luppis, Whitehead, torpedo, pistol, design*

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1. INTRODUCTION

There are two interesting aspects to being a Collector – the first naturally is the thrill of collecting as one never knows what is going to turn up around the corner and this curiosity is the primary driving force why Collectors tend to spend countless hours, days, weeks and yes even years continuously searching through antique shops, second hand stores, flea markets, junk yards, auctions, online and so on. Of course this collecting obsession is normally completely alien to one's family and therefore frowned upon and often discouraged.

The second interesting aspect to collecting is once we have found our treasure, how do we actually know what we have? The majority of Collectors have spent small fortunes over the years in order to armed themselves with a comprehensive library of reference books, enabling them to both "spot" the rarity at hand and confirmation of their newly prized acquisitions. Like the first, this second aspect of collecting is time consuming involving hours of research, reading and investigation – another collecting activity which seems to be frowned upon and discouraged by one's family…..especially when there are "jobs" around the house waiting to be done!

Unfortunately not everything can be found in books, on the internet or even assumed to have ever been documented. Take for example experimental inert ordnance – these items are infrequently found & normally there is never any associated documentation leaving the collecting community to only speculate in some instances as to their origins and purpose.

A couple of years ago I had acquired an unknown phosphor-bronze fuze body which eventually became the catalyst for undertaking this research paper. At the time it didn't appear to be even a bonafide military /naval fuze as it more closely resembled a fire hose nozzle, especially with a bayonet style base attachment – certainly not something that one would have expected to have been attached to the tip of an early vintage torpedo and therefore a key component to ensure that detonation occurred once the torpedo had reached its intended target.

Initial investigation indicated that it was indeed a torpedo pistol – in fact it turned out to be a German Schwarzkopf torpedo pistol body – but to which torpedo was it used on? When was it used? What does the 4-digit stamped number represent? Too many questions, not enough answers!

Although my initial quest was for seeking any information I could locate on early German Schwarzkopf torpedo pistols, it was soon surpassed for seeking information on early Whitehead torpedoes having discovered that Louis Schwarzkopf's first torpedo was a direct copy of Whitehead's A22 torpedo in 1877. In addition it became increasing apparent the extreme absence of any torpedo related literature, especially pre-1900. Apart from a very small number of naval related torpedo manuals that still exist from the late 1890s, there is

virtually no in-depth documentation covering the early years from 1866 onwards. One explanation of course was Whitehead's paranoia with patents reasoning that his invention could easily be copied if he had patented his 'fish torpedo'.

This apparent lack of suitable reference material eventually led to the following research undertaking to document the chronological development of early Whitehead torpedo pistol design. It was always intended to be a solely personal reference project, however would be appreciated by any naval historians & collectors alike that have an interest in early vintage torpedoes.

2. DEVELOPMENT OF PISTOL DESIGN

2.1. Whitehead 1st Spring Pistol Type (1866-1876)

The original Whitehead torpedo pistol design was based on a spring loaded percussion mechanism similar to percussion firearms of the same period. It was first introduced in 1866 and in service over the next decade during which the speed of the torpedo increased to a level where the inertia of the torpedo was sufficient to cause detonation using the later "contact pistol" designs.

Not only did the overall shape of Whitehead's torpedo undergo radical changes during this period (e.g. the removal of the longitudinal stabilizer fins), in addition the spring pistol design also went through several design variations.

The initial design introduced in 1866 is shown in Figure 1 below.[1]

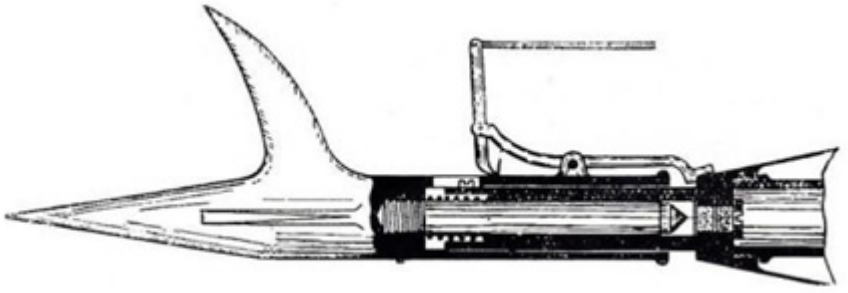


Figure 1. *Whitehead's Spring Pistol Mechanism*

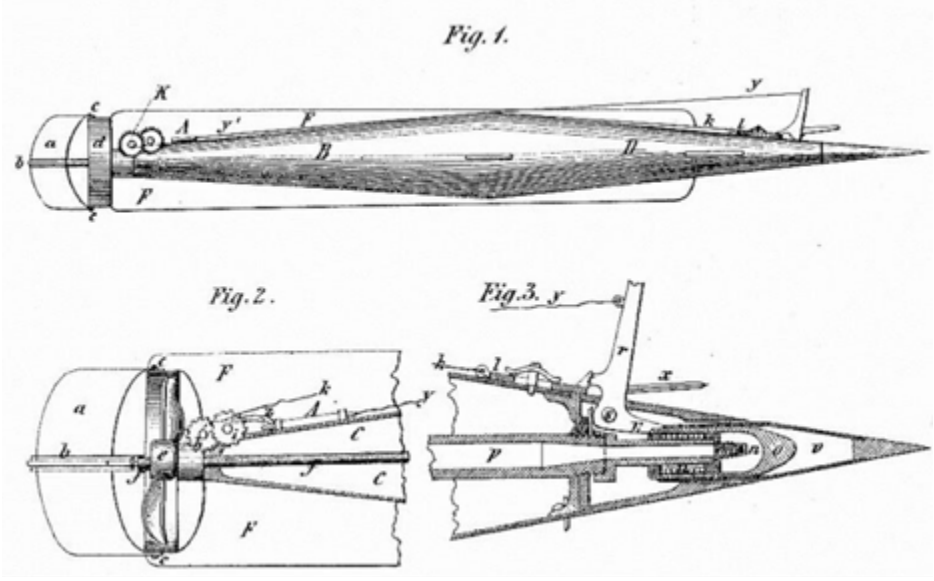
The design incorporates a simply "arming" mechanism where after the torpedo has transverse a set distance, a wire connected to the vertical lever is drawn tight removing the safety lock lever thereby permitting the tip of the pistol to move freely and is now in the "armed" position with only the spring tension holding the striker away from the detonation cap. Upon striking the

[1] Whitehead & Company, *La Storia Del Silurio*, 14

target, the spring is compressed and the striker contacts the detonation cap to explode the torpedo.

What is intriguing about the spring pistol designs is the engineering creativity that was used to devise a safety feature to arm the torpedo once a safe or minimum distance has been reached. An analysis of the later spring pistol designs (early 1870s) provides more in-depth view of the arming functionality.

The mechanical ingenuity did not stop with just pure arming type functionality. Rather the following design also incorporated a "self-destruct" mechanism (in case the torpedo missed the target) as shown in Figure 2 below:[2]



■ **Figure 2.** *Whitehead's Spring Pistol Arming and Self Destruction Mechanism*

According to the accompanying text description[3], this spring pistol had the following functions:

1) Arming:
   a. Wire (k) is worm-gear to shaft (f) by toothed wheels (h) & (i). After traversing a set minimum distance, wire (k) draws locker (l) backwards until lever (r) comes to rest by (t).
   b. Therefore arming sequence: f-h-i-k-l

[2] Malnig, *Die Torpedo in der k.u.k Kriegsmarine*, 39

[3] Berkerhinn, *Die unterseeischen Angriffs – und Verteidigungsmittel*, 1875

2) Self-Destruct:
   a. The self-destruction mechanism is also worm-geared – here small lever (z) in contact with gear wheel (i) releases spring (A), pulling wire (y'y) and in turn lever (rr') backwards / upwards.
   b. Therefore self-destruct sequence: f-i-z-A-y'y

3) Impact:
   a. The final triggering by impact of pointed nose (v) and /or contact (x) aka "whiskers" overcoming a shear pin screw (not shown), and therefore releasing spring (u) in order to strike the detonator cap (n).
   b. Therefore impact sequence: v/x-u-n

A later variation of the above pistol design is highlighted in Figure 3 below where it appears that the "self-destruct" mechanism has been removed by the lack of a tie wire to vertical lever (L).[4] Having the torpedo "explode" after it has missed the target would certainly eliminate any further element of surprise.

Note: The drawings included in this research paper only serve as illustrations to explain the functional system and therefore cannot be considered as detailed technical drawings. The "missing" safety wire as shown in Fig. 1 above may be in fact present, however not shown in Figure 3 below. However in the Author's subjective opinion, the self-destruct mechanism was absent in later pistol designs (replaced by an internal "self-immobilization" mechanism shutting off the engine's compressed air supply) and the vertical lever (L) is now implemented as a graze function (similar to the later extended "whiskers").

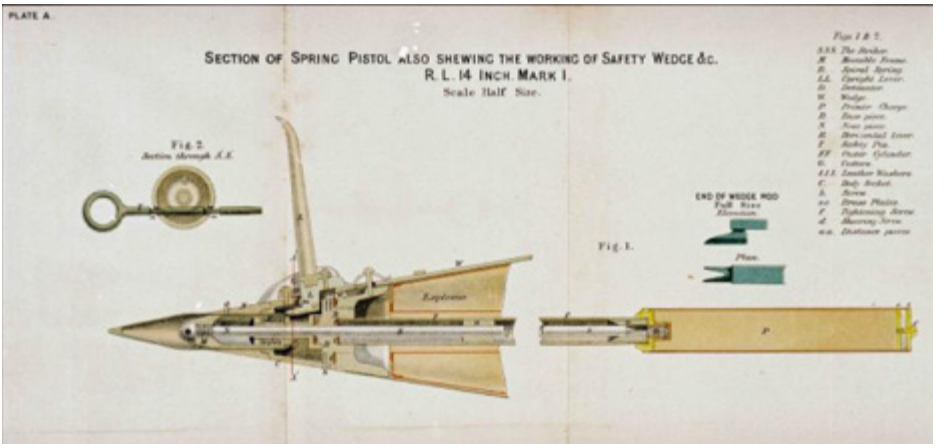


Figure 3. *Later Stage Spring Pistol Variation*

[4] Torpedo Manual, *Volume III Whitehead Torpedoes*, 1887

The functionality of the Royal Laboratory (RL) 14" Mk 1 pistol is very similar to that shown in Figure 2 above, except there is now the lack of a self-destruct mechanism as only a single pull wire is connected via worm gear to the torpedo's propeller shaft.

4) Arming:
   a. The wedge rod (W) is extracted backwards after the minimum set distance thereby permitting the backend of lever (L) to come in contact with a spring tension pin at (l). The pistol is now in the arming position and the movable frame (M) is held in place by the shearing screw at (d)

5) Impact:
   a. The final triggering by impact of movable frame (m) and /or contact lever* (L) aka "whiskers" overcoming the shearing screw (d), and therefore releasing spring (R) in order to strike the detonator cap (D) via striker (S).
   b. Therefore impact sequence: M/L-d-R-S-D

***Note:** In addition to the spring pin tension acting on the lower rear of vertical lever (L) at (l), there also appears to be flat spring providing tension on the lower front-end side of lever (L), balancing the tension around the bottom of the lever (L) pivot point. The purpose of which seems to stabilize the vertical lever in position (ie against water pressure as the torpedo travels through the water until it strikes an object (graze /whisker functionality) where the mechanical leverage overcomes both spring pressures to tilt backwards and permits the movable frame (M) to strike the percussion cap (D).

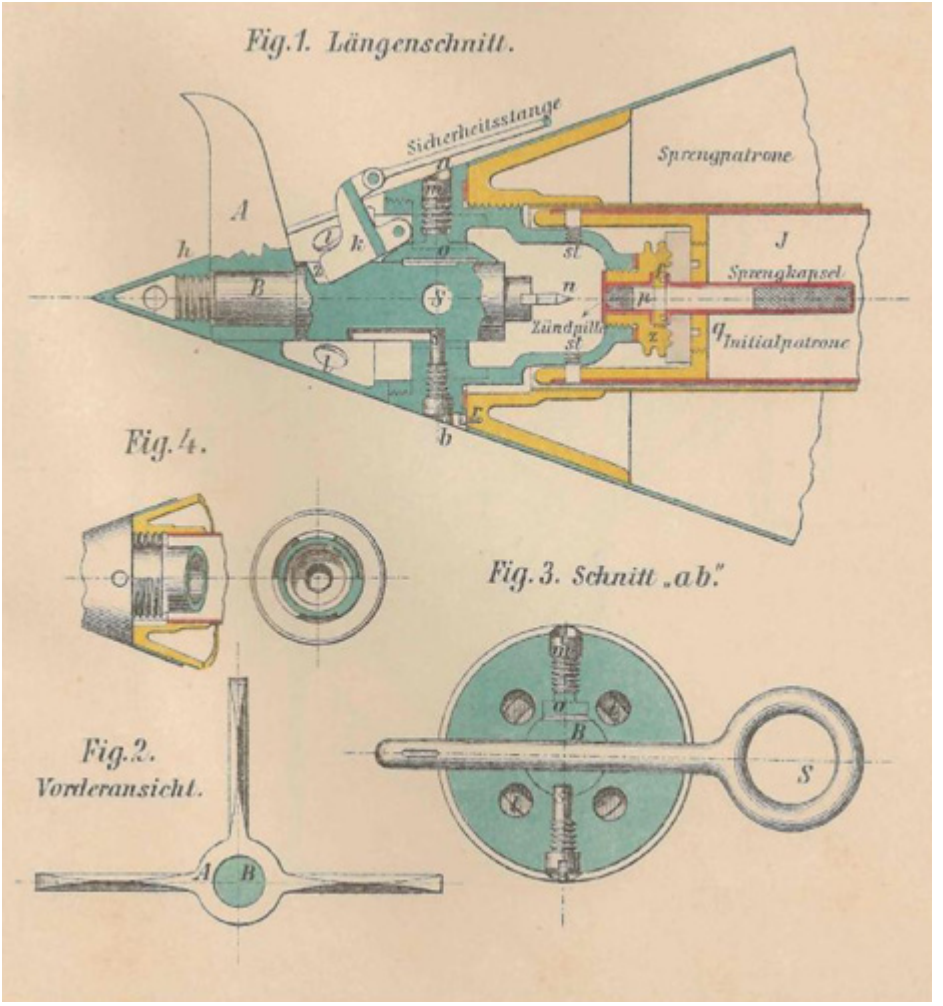
2.2. Whitehead 1st Contact Pistol Type (1876)

As torpedo development advance producing higher speeds, Whitehead intended to utilize the higher inertia of the torpedo to directly cause the triggering of the pistol and detonate the torpedo. Towards 1876 he designed and built the first contact pistol as shown in Figure 4.[5]

The striker (A, B) is held forward by safety pin (S) which is removed when the torpedo is introduced into the torpedo launcher. The arming wire /tie rod (sicherheitssange) with the distance adjuster located at the rear, was released once the safe minimum distance had been travelled (~30m). Once released, the striker assembly (A, B) is held only in place by a cotter pin (not clearly indicated). On impact, the striker assembly (A, B) was forced backwards, shearing the cotter pin and detonation of the torpedo.

[5] Whitehead & Company, La Storia Del Silurio, 55

Interesting enough, this model still employs the external transmission for the arming functionality which due to practical reasons was completely removed by Whitehead towards 1879.



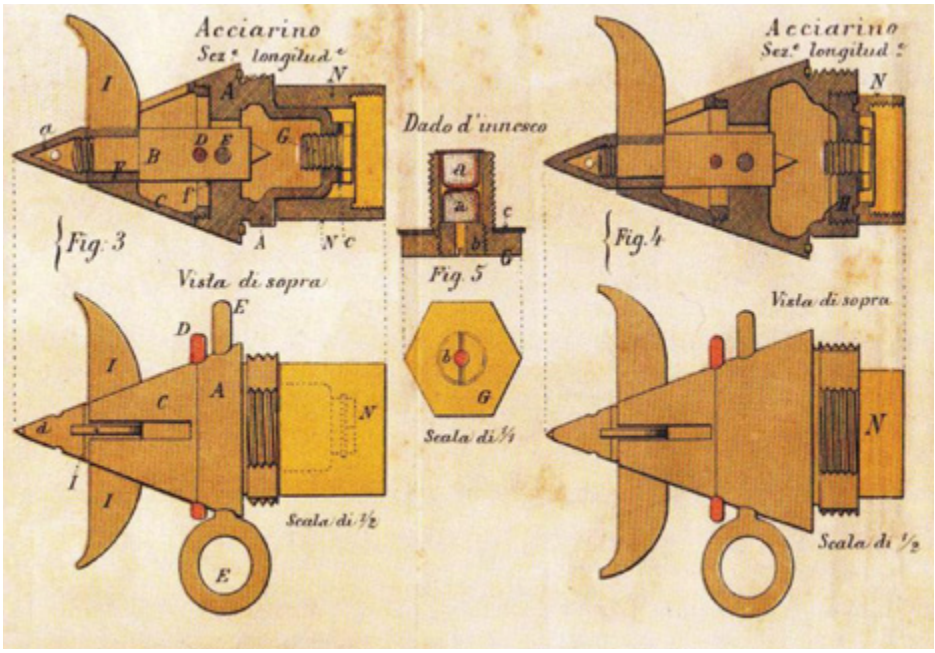
■ **Figure 4.** *Whitehead's First Contact Pistol Mechanism*

2.3. Whitehead's A22 Contact Pistol (1877)

The second torpedo model which was massed produced by Whitehead was the A22 x 14" x 14'6".[6] The pistol design was based on direct impact and held in place by a safety ping (E) which was removed prior to launching. Once removed, only a shear pin (D) protection remained to prevent the striker (B) from impacting the detonation cap (G).

The "interrupted" screw thread as shown was introduced to allow rapid insertion of the pistol – there was a matching "interrupted" inside thread on torpedo nose cone section. The pistol's threaded sections would align with the nose cone's non-threaded sections permitting the pistol to be lowered into the nose and finally twisted into a locked position.

The A22 torpedo was the model reportedly copied by Louis Schwarzkopf to be produced in all phosphor bronze (B20 x 356 x 5.84) and generally referred to as the "Whitehead-Schwarzkopf" torpedo.



■ **Figure 5.** *Whitehead's A22 Contact Pistol*

[6] Petrucci, WASS 133 years of History Vol 1



Figure 6. *Whitehead A22 Contact Pistol highlighting the quick insertion interrupted screw thread*[7]

[7] Images courtesy of Armaments Corporation, USA

3. CONCLUSIONS

The late 1800s was the golden years of torpedo development where many creative torpedo prototypes were produced and marketed to the world. Of these, only a very small handful were practical enough to be adapted by the various navies of the world and the Whitehead torpedo was by far the most predominant one.

The design of the Whitehead torpedo underwent years of continuous modifications and fine tuning with the original stabilizing fins being removed with the introduction of counter-rotating propellers; a pendulum based mechanism for depth control (the "Secret" chamber); the pointy shape head developing into a more rounded blunt nose enabling higher explosive warheads and the later implementation of the gyro for steering.

During the above changes, the design of the torpedo pistol also underwent radical re-design where the original spring pistol mechanism based on a rifle's percussion design was replaced by a simpler contact one once the velocity of the torpedo reached a point where the inertia of the torpedo itself could detonate the explosion. With the introduction of safety fan mechanisms, the torpedo could be launched and only to be "armed" at a safe distance away from the ship.

Numerous pistol designs were implemented to increase the "angle of bump" in order to cause detonation if the torpedo stuck the target at an off centre angle. "Whiskers" could only increase the "angle of bump" up to an effective 30-35 degrees from off centre.

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SAŽETAK

Salvacoste, *izvorni koncept Giovannija Luppisa, plutajuća naprava bez ljudske posade kojom se se upravljalo s kopna, a bila je namijenjena uništenju brodova, dovela je do izuma podvodnog torpeda na vlastiti pogon. Bio je to kvantni skok u tehnologiji pomorskog oružja, koji je zauvijek promijenio pomorsku taktiku i strategiju. Brodovi više nisu morali tegliti eksplozivne naprave da bi ih izbacili na neprijateljske brodove poput Harveyeva torpeda ili zabili eksplozivnu glavu* Spar *torpeda u trup protivničkog broda. Godine 1866. Whitehead je izumio „lokomotivu" na vlastiti pogon ili „ribu torpedo" koja je imala unaprijed određenu putanju na unaprijed određenoj dubini, sve do mete.*

Došavši do mete, uspješna detonacija oslanjala se isključivo na jednu ključnu komponentu, na upaljač ili detonator. Kao što je to slučaj s njegovim dvojnikom u artiljeriji, upaljač je jezgra projektila i upravlja eksplozijom. Bez pouzdanog mehanizma ispaljivanja/detonacije torpedo ne bi uspio u svojoj misiji, čime bi njegovo postojanje palo u zaborav.

Projektiranje upaljača torpeda doživjelo je radikalnu promjenu tako što je izvorni mehanizam upaljača na oprugu, zasnovan na naboju puške, zamijenjen jednostavnijim kontaktnim mehanizmom kada je jednom brzina torpeda dostignula točku na kojoj njegova inercija može izazvati detonaciju. Uvođenjem mehanizma sigurnosnog propelera, torpedo se mogao lansirati i upotrijebiti kao oružje tek na sigurnoj udaljenosti od broda.

Primjenjivali su se brojni nacrti upaljača kako bi se povećao „kut udara" i tako omogućio veći postotak uspjeha detonacije kad torpedo pogodi metu na njezinu rubnom području. Uvođenjem dodatnih poluga ili „mačjih brkova" upaljača, „kut udara" uspjelo se samo povećati do učinkovitih 30 – 35 stupnja izvan središta mete.

Konačno, uvođenjem upaljača inercijskog tipa, koji su projektirali Universal Bell *i poslije* Universal Pendulum, *prevladano je oslanjanje na mehanizam upaljača koji se nalazio na vršku torpeda i započelo je vrijeme modernog torpeda.*

Ovo istraživanje ranog projekta Whiteheadova upaljača omogućava uzbudljiv pogled u rani razvoj mehanizma upaljača, u njegovo mijenjanje kojim su prevladane prepreke, u izazove koji i danas postoje i napredna usavršavanja koja vode većoj pouzdanosti.

Ključne riječi: *Luppis, Whitehead, torpedo, upaljač, nacrt*

MOGUĆNOSTI RAZVOJA INDUSTRIJSKOG TURIZMA GRADA RIJEKE

Possibilities for industrial tourism development in the city of Rijeka

Daniela Gračan, Zrinka Zadel, Antonela Grabar

SAŽETAK

Industrijska baština, popularno nazivana i krajolikom nostalgije*, obuhvaća zgrade, lokalitete i infrastrukturu bivše industrijske namjene, koji su vrijedan resurs za gospodarstvo, lokalno stanovništvo, ali i za turizam. To su zapravo ostaci industrijske djelatnosti koji imaju određeni tržišni potencijal, a prenamijenjeni su (ili mogu biti prenamijenjeni) u lokalitete od povijesne, tehnološke, socijalne, arhitektonske i znanstvene važnosti. Osim materijalnih, mogu sadržavati i nematerijalne elemente te zahtijevaju prilagođen znanstveni pristup poznat kao industrijska arheologija.*

Kao posljedica razvoja turističkih aktivnosti na lokalitetima, zgradama i krajolicima vezanim uz povijesne industrijske procese nastaje turizam industrijske baštine, odnosno industrijski turizam. Razvojem industrijskog turizma postižu se višestruke prednosti poput povećanja prosperiteta uže i šire zajednice, poticanja revitalizacije vrijednih industrijskih spomenika i lokaliteta te postizanja konkurentske prednosti, čime se potiče razvoj selektivnih oblika turizma koji umanjuju negativne učinke sezonalnosti i diverzificiraju osnovni turistički proizvod destinacije. Važnost industrijskog turizma može se iščitati i iz podataka Odbora za promet i turizam Europskog parlamenta. U 2013. godini realizirano je 18 milijuna noćenja i 146 milijuna posjeta industrijskim atrakcijama te ostvarena direktna turistička potrošnja od devet bilijuna €.

Zahvaljujući nekoć uspješnoj riječkoj industriji, grad Rijeka danas raspolaže bogatom industrijskom baštinom, što je osnovni preduvjet razvoja industrijskog turizma. Svoj puni potencijal razvoja grad može postići jedino ako se adekvatno valorizira i revitalizira industrijska baština te stavi u funkciju, pri čemu se turizam industrijske baštine pojavljuje kao glavni pokretač razvoja destinacije.

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U radu će se istražiti mogućnosti i potencijal razvoja industrijskog turizma grada Rijeke. Analizirat će se prednosti i nedostaci razvoja industrijskog turizma, što će se detaljno prikazati preko SWOT matrice.

Ključne riječi: *industrijska baština, industrijska arheologija, turizam, specifični oblici turizma, industrijski turizam, konkurentska prednost*

1. UVOD

Promjene socijalnih, tehnoloških i ekonomskih okolnosti u Europi dovode do velikih proizvodnih inovacija koje kulminiraju u drugoj polovici 18. stoljeća. Te su se promjene događale tolikom brzinom da im je pridan naziv *revolucije*, a naknadno dobivaju pridjev *industrijska* s obzirom na to da predstavljaju pomak u sferi manufakturne proizvodnje i distribucije.

Osim što su prekretnica u evoluciji čovječanstva, odražavaju povijesni fenomen koji zadire u sve aspekte života. Napretkom industrijske tehnologije počinje se provoditi distinkcija rada i dokolice; životni standard i slobodni dohodak rastu, čime se intenziviraju turistička kretanja koja postaju potreba, a ne luksuz.

Početak kraja industrijske revolucije uvjetovan je drugom, tehnološkom revolucijom. Kraj 19. stoljeća obilježen je raspadom industrijskog sektora, a svi pozitivni učinci takva načina proizvodnje zamijenjeni su negativnim konotacijama. Ono što preostaje kao njezin produkt napušteni su pogoni, strojevi i ostala infrastruktura koja danas čini industrijsku baštinu – temeljni resurs industrijskog turizma.

Na današnjem turističkom tržištu ponuda uvelike premašuje potražnju, konkurencija je nelojalna, a zahtjevi turista sve su veći i teže ostvarivi. Da bi opstala na tržištu, destinacija mora težiti stalnim inovacijama u samoj turističkoj ponudi u kojoj se javljaju selektivni oblici turizma kao aktualni turistički trend. Turistu je danas kao iskusnijem, zahtjevnijem i izbirljivijem potrošaču nužno ponuditi jedinstven doživljaj „upakiran" u turistički proizvod, pri čemu se moraju nadopuniti osnovni elementi turističkog proizvoda. Urbani, kulturni i industrijski turizam pojavljuju se kao svojevrstan odgovor kojim će se adekvatno valorizirati i staviti u funkciju postojeći resursi i bogato kulturno-civilizacijsko nasljeđe grada, a sve radi održivog razvoja, produljenja turističke sezone i obogaćivanja trenutačne turističke ponude.[1]

[1] Geić, S. (2002) *Turizam i kulturno-civilizacijsko naslijeđe*, Veleučilište u Splitu, Split

2. INDUSTRIJSKA BAŠTINA – KRAJOLIK NOSTALGIJE

Industrijska baština, u francuskom govornom području nazivana i *Les Lieux de Mémorie*, obuhvaća zgrade, lokalitete, opremu i infrastrukturu bivše industrijske namjene kao vrijedan resurs za gospodarstvo, lokalno stanovništvo i turizam. Osim materijalnih, pod industrijskom baštinom razumijevamo i nematerijalne resurse kao što su tradicija, usmena predaja, znanje, povijesni proizvodni procesi te kultura življenja, koji često zahtijevaju prilagođen znanstveni pristup.[2]

Rastom opće svijesti o važnosti očuvanja i zaštite navedenih resursa, krajem prošlog stoljeća javlja se pojam industrijske arheologije kao interdisciplinarne znanosti koja proučava sve materijalne i nematerijalne elemente baštine: vezane dokumente, artefakte, stambene zgrade te prirodni i industrijski krajolik koji ju okružuje.[3] Osim što temeljito istražuje i proučava postojeću baštinu, usmjerena je na kompletnu analizu industrijskih resursa prije njihove pretvorbe u turistički. Svaka industrijska atrakcija resurs je industrijskog turizma, no svaki industrijski resurs nije i istoimena atrakcija.

Može se reći da industrijska baština predstavlja ostatke industrijske djelatnosti s određenim tržišnim potencijalom, prenamijenjene (ili mogu biti prenamijenjene) u lokalitete od povijesne, tehnološke, socijalne, arhitektonske i znanstvene važnosti. Svoj puni potencijal dostižu jedino ako su prepoznati, adekvatno valorizirani i revitalizirani te stavljeni u funkciju, pri čemu se turizam industrijske baštine pojavljuje kao glavni pokretač.

U prvom izvješću u sklopu Lisabonskog ugovora Europski parlament dolazi do zaključka da revitalizacija industrijske baštine pridonosi destinacijama, ali i potiče uspostavu održivih oblika turizma očuvanjem, transformacijom i renovacijom industrijskih lokacija, što je i primarni cilj ovoga selektivnog turističkog oblika.[4]

Sagledava se i kroz nekoliko aspekata koji svjedoče o njezinoj važnosti:

1. Dokaz je industrijskih aktivnosti koje su za sobom ostavile duboke posljedice na čovječanstvo i kao takve ih treba valorizirati.
2. Posjeduje univerzalne, jedinstvene vrijednosti koje daju dodatnu vrijednost destinaciji u kojoj se nalazi, što je dovoljan motiv za njezinu zaštitu.
3. Osim ekonomske (tehnološke i znanstvene) vrijednosti, posjeduje i onu neekonomsku, socijalnu vrijednost za čovječanstvo. Odraz je života malog,

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[2] Feifan Xie, P. (2015) *Tourism and Cultural change – Industrial Heritage Tourism*, Channel View Publications

[3] The International Committee for the Conservation of the Industrial Heritage (TICCIH), *Industrial heritage*. Dostupno na http://ticcih.org/about/charter/ (pristupljeno 5. svibnja 2016.)

[4] Committee on Transport and Tourism, Europe, the world's No 1 tourist destination – a new political framework for tourism in Europe [2010/2206(INI)]

običnog čovjeka te identiteta cijele jedne generacije. Može dati i znatnu estetsku vrijednost destinaciji.

4. Posjeduje vrijednosti svojstvene samoj lokaciji, okruženju, industrijskom okolišu ili pisanoj dokumentaciji, ali i ljudskim sjećanjima, običajima, tradiciji. Rijetko se može prenijeti, kopirati i imitirati, što je značajan izvor konkurentske prednosti.[5]

Industrijska baština može se promatrati i na temelju:

1. Ekonomskog značaja – potrošnja na lokalitetima (ulaznice, karte, sekundarna turistička potrošnja).
2. Socijalnog značaja – osobna i nacionalna emocionalna povezanost stanovništva.
3. Političkog značaja – simbolika industrijske baštine može se koristiti i u političke svrhe te u svrhu svojevrsne prepoznatljivosti.
4. Znanstveni značaj – mnogi lokaliteti sadržavaju neistražena područja koja mogu pridonijeti daljnjem razvoju znanosti.[6]

Mnogobrojne studije, konvencije, povelje i dokumenti objavljeni u zadnjih nekoliko godina dovoljan su dokaz o porastu zanimanja struke za ovu problematiku. U većini se objavljenih radova industrijski turizam promatra kao dodatni element osnovnog proizvoda koji u sinergiji s nekim od ostalih oblika turizma potpomaže kvalitetu života lokalnog stanovništva putem novih izvora prihoda, otvaranja novih radnih mjesta, izgradnje imidža i brendiranja destinacije.

3. POJAM I ZNAČAJ INDUSTRIJSKOG TURIZMA

Sam pojam industrijskog turizma do danas nije dovoljno obrađen u stručnoj literaturi jer navedena problematika zahtijeva suradnju stručnjaka iz različitih znanstvenih područja te same poznavatelje kulturno-industrijske baštine koji jedino zajedničkim radom i menadžmentom mogu stvoriti jedinstven i autohtoni turistički proizvod.

O snazi i potencijalu koji industrijski turizam ima na razini Europe dovoljno svjedoče podaci iz 2013. o ekonomskom utjecaju turističkih kretanja s 18 milijuna realiziranih putovanja, 146 milijuna posjeta industrijskim atrakcijama i direktnoj turističkoj potrošnji od 9 bilijuna €, ne računajući multiplikativni efekt na samo gospodarstvo.[7]

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[5] The International Committee for the Conservation of the Industrial Heritage (TICCIH), *The Nizhny Tagil Charter for the Industrial Heritage*. Dostupno na http://www.icomos.org/18thapril/2006/nizhny-tagil-charter-e.pdf (pristupljeno 5. svibnja 2016.)

[6] Dallen, J. T., S. Boyd (2003) Heritage Tourism, Prentice Hall, Harlow

[7] Lane, B., Kastenholz, E., Lima, J., Majewsjki, J. (2013) European parliament structural and cohesion policies, *Industrial heritage and agri/rural tourism in Europe*, Brussels, European Union

Postoji i nekoliko studija kao što je ona Udruge *Heritage Lottery Fund* i *Visit Britain online* vodiča kojom se došlo do saznanja kako je vrijednost turističke potrošnje vezane uz industrijsku baštinu 2010. iznosila oko 24 bilijuna €, a generirala je više od 250.000 stalnih radnih mjesta. Iako interpretaciji navedenih podataka treba pristupiti s oprezom, možemo reći kako ova vrsta turizma donosi velike koristi gospodarstvu zemlje domaćina, čime se opovrgavaju tvrdnje nekih od stručnjaka kako turizam industrijske baštine donosi isključivo neekonomske koristi.[8]

Navedeno potvrđuju i studije utjecaja *Festiniong* i *Welsh Highland* željeznice u sjevernom Walesu, inače najstarije uskotračne željeznice na svijetu. Njihov je prihod 2008. iznosio oko šest milijuna €, čime se u lokalnu ekonomiju slilo dodatnih pet milijuna preko neizravne i inducirane potrošnje. Te je godine željeznicu posjetilo ukupno 128.000 putnika, od kojih su 95 posto bili turisti. Pretpostavlja se da je željeznica bila primaran motiv dolazaka za samo 9,38 posto turista (12.000), čime se nameće zaključak kako je industrijska baština u destinacijskom proizvodu sekundarna ili tercijarna atrakcija koja se mora vezati uz ostale oblike turizma jer nema dovoljno snažan privlačni potencijal da bi se na tržište plasirala kao jedinstven, nezavisni turistički proizvod.[9]

4. ANALIZA TRŽIŠTA

U već spominjanoj studiji Europske unije, turistička potražnja industrijskog turizma kvantitativno je analizirana. Na temelju fragmenata turističke potrošnje iz uobičajenih novčanih tokova došlo se do procjene da ovaj tip turizma godišnje generira 18 milijuna noćenja i 146 milijuna izleta, čime se potvrđuje postojanje potražnje za industrijskim turizmom.[10]

Da bi turističku potražnju kvalitativno definirali, pristupamo njezinoj daljnjoj segmentaciji i navodimo profil potencijalnog posjetitelja industrijske baštine:

- Turisti čiji je primarni motiv odmor (*leisure tourists*) – iskusni turisti koji traže jedinstven doživljaj na putovanju.
- Studenti – industrijski lokaliteti pružaju mladim ljudima priliku za educiranje o povijesti, procesima proizvodnje i kulturi.
- Poslovni turisti – zaposlenici kompanija različitih djelatnosti koji u industrijskim lokalitetima pronalaze inspiraciju za nove proizvode i poboljšanje postojećih procesa proizvodnje ili se pak educiraju o poslovanju nekadašnjih tvrtki i pogona.

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[8] *Ibid.*

[9] Williams, Megan Louise (2008) *The Economic Impact of the Ffestiniog and Welsh Highland Railways on Gwynedd*, Doktorska disertacija, Bangor University

[10] Lane, B. i dr., *op. cit.*

- Novinari i istraživači – industrijski je turizam aktualna tema koja nudi bezbroj mogućnosti za daljnju znanstvenu obradu.[11]

Kada govorimo o cjelokupnoj demografskoj i geografskoj segmentaciji potražnje možemo reći da su ciljna skupina industrijskog turizma obrazovani seniori (50 i više godina) i mlađa populacija (15 – 29 godina), a dolaze iz Velike Britanije, SAD-a, Kine i Japana. Te se zemlje smatraju razvijenima u smislu organiziranih posjeta industrijskim pogonima te se stoga stvorila pretpostavka da će se njihovi rezidenti tim obrascem ponašanja koristiti i pri putovanju.

Industrijske lokalitete posjećivat će i iskusniji turisti sa „zrelijih" emitivnih tržišta koji traže nova iskustva za vrijeme godišnjeg odmora i to iz Nizozemske, Njemačke i Danske, što je prilika za urbane gradove koji još uvijek nisu na popisu najposjećenijih destinacija, kao što je i grad Rijeka.[12]

Unazad pet godina u Rijeci je prisutan kontinuirani rast broja dolazaka i noćenja. U 2015. broj ležajeva iznosi 2459, što je porast od 8,09 posto u odnosu na prethodnu godinu. Temeljni turistički proizvodi grada usmjereni su na kulturni, urbani, vjerski i MICE turizam.

U razdoblju od 2011. do 2015. broj dolazaka prosječno se povećavao po stopi od 10,9 posto, što je dovelo do povećanja broja noćenja u istom razdoblju po prosječnoj stopi od 12,38 posto. Turisti u Gradu Rijeci u zadnjih pet godina prosječno borave dva dana.

Najveći broj dolazaka tijekom 2015. ostvarili su državljani Italije, Njemačke, Španjolske, Francuske, Austrije, SAD-a, Mađarske, Japana, Velike Britanije i Poljske. Slična je situacija i s ostvarenim noćenjima: najveći broj ostvarili su turisti iz Italije, Njemačke, SAD-a, Francuske, Španjolske, Poljske, Austrije, Velike Britanije, Mađarske i Slovenije. Što se dobi turista tiče, od ukupno ostvarenog broja dolazaka i noćenja većinu čine osobe od 19 do 30 godina, a slijede ih osobe od 31 do 40 godina te od 41 do 50 godina.[13]

Ako se želi analizirati motiv dolaska u destinaciju, potrebno je osvrnuti se na istraživanje koje je proveo Fakultet za menadžment u turizmu i ugostiteljstvu iz Opatije. Došlo se do zaključka da je glavni motiv dolaska turista u destinacije na Kvarneru odmor i relaksacija (47,71 posto) te zabava i novi doživljaji (18,05 posto). Podaci pokazuju i velik broj onih koji su destinaciju posjetili dva ili više puta (26 posto).

Iako se proizvodi kulturnog i industrijskog turizma ne mogu ubrojiti među važnije samostalne motive dolaska, nesumnjivo su važan prateći sadržaj turističkog boravka čiji je značaj u porastu. Aktivnosti turista na Kvarneru između

[11] Otgaar, A., Van der Berg, L. i dr. (2010) Industrial tourism, Opportunities for City and Enterprise, Erasmus University Rotterdam, Netherlands

[12] *Ibid.*

[13] TZ Grada Rijeke. Dostupno na: http://press.visitrijeka.hr (pristupljeno 8. svibnja 2016.)

ostalog podrazumijevaju razgled znamenitosti (59,5 posto), posjet muzejima i izložbama (41,2 posto) te odlazak na organizirane izlete i ture (53,8 posto).[14]

Na rastuću ulogu i važnost industrijskih dobara upućuje i lista industrijske baštine UNESCO-a. Za Europu se može reći da posjeduje većinski monopol u tom segmentu: na prostoru kontinenta locirano je više od 50 posto lokaliteta s popisa (30 od postojećih 45)[15] te više od 200 potencijalnih lokaliteta koji posjeduju određeni tržišnu vrijednost.[16]

5. INDUSTRIJSKA BAŠTINA RIJEKE

Iako se ne nalazi na popisu gradova sa značajnijom industrijskom baštinom, grad Rijeka posjeduje i velik broj potencijalnih lokaliteta koji imaju sve predispozicije za buduću revalorizaciju. Na užem i širem području grada registrirano je više od 50 lokaliteta bivše industrijske namijene.[17]



Slika 1. *Karta industrijske baštine grada*
Izvor: Riječka industrija. Dostupno na www.rijekaheritage.org (pristupljeno 6. svibnja 2016.)

[14] Institut za turizam. Proizvodi kulturnog turizma. Dostupno na: www.kvarner.hr (pristupljeno 9. svibnja 2016.)

[15] UNESCO. Dostupno na: http://whc.unesco.org. (pristupljeno 23. ožujka 2016.)

[16] Falser, M. (2001) Is industrial Heritage under-represented on the World Heritage List?, Studija slučaja, UNESCO World Heritage Centre, Austrija

[17] Riječka industrija, www.rijekaheritage.org (pristupljeno 6. svibnja 2016.)

Tablica 1. *Popis industrijske baštine grada Rijeke*

BAŠTINA		VALORIZACIJA
Tvornica duhana		pod zaštitom konzervatorskog zavoda; u tijeku restauracija
Rafinerija nafte	stambena zgrada pogonska zgrada upravna zgrada	administrativna zgrada jedina u funkciji; sačuvani pogonski strojevi
Zgrada za preradu parafina		administrativna zgrada jedina u funkciji; sačuvani pogonski strojevi
Rafinerija šećera uprava		pod zaštitom konzervatorskog zavoda; u tijeku restauracija
Tvornica igraćih karata		sačuvana; stambeni prostori
Tvornica konopa		nezaštićena, u izrazito lošem stanju; prostor parkirališta
Ljuštionice riže	stambena zgrada	nezaštićena; stambena zgrada
	pogonska zgrada	sačuvana jedino arhitektonska forma; upravna zgrada INA-e
Tvornica papira	energana	zaštićena, ali devastirana
	pogon i skladište	arhitektonski spomenik, ali devastiran i napušten
	upravna zgrada	djelomično narušena, no u dobrom stanju; prostor zubotehničkog laboratorija
Stambena zgrada Tvornice sapuna		nezaštićena; stambena zgrada
Klaonica		spomenička baština, sačuvana prvotna namjena (potrebe mesne industrije)
Tvornica drva		nema veću povijesnu važnost, prostor Tvornice *Istravino*
Talionica olova (Plumbum – Vulkan)		sačuvan mali dio kompleksa; privatne djelatnosti (hostel, teretana, prostorije vjerske zajednice)
Lazaret		sačuvan, ali bez funkcije
Tvornica alkohola, kovina i kemijska industrija		nezaštićena, no sačuvana u promijenjenom obliku
Palača *Littorale*, Tvornica likera, limenih konzervi i tiskara		restaurirana i sačuvana, ali bez funkcije
Kemijska industrija		većim dijelom sačuvan; preinake za potrebe rada brodogradilišta
3. maj		nezaštićene, izložene adaptacijama za potrebe brodogradilišta
Tvornica *Torpedo*	pogonske zgrade	jednim dijelom konzervirane; poslovni prostori
	lansirna rampa	zaštićeni, no u iznimno lošem stanju

BAŠTINA		VALORIZACIJA
Tvornice sapuna	Heindlhofer	sačuvano prizemlje
	Levi & Bianchi	konzervirana, ali u lošem stanju; prostorije ljevaonice metala
Pivovara		sačuvana; prenamjena u sportsku dvoranu i prostorije udruga
Mlinovi	Srećka Turine	sačuvani samo dijelovi građevine koji su neprepoznatljivi
	u Žaklju	nezaštićen, u lošem stanju
	Matešićev	nezaštićen, u lošem stanju
Crpna stanica i izvor		konzervirana u prvotnom obliku, sačuvane stare pumpe
Kožara	Bakarčić-Simonić	sačuvana u izvornom obliku; prostorije trgovine *Plodine*
	Ružić	revitalizirana (Državni arhiv)
Spalionica smeća		konzervirana; prenamjena u parkirališna mjesta
Termoelektrana	upravna zgrada	kulturno dobro; zgrada konzervirana, sačuvana prvotna namjena (HEP)
Ljevaonica metala	Cussar	konzervirana i zaštićena; u vrlo dobrom stanju; stambeni i poslovni prostori
	Matteo Skull	djelomično revitaliziran (Državni arhiv), ostatak u lošem stanju iako zaštićen
Tvornica tjestenine		zaštićeni spomenici
Tramvajska remiza		devastirana unutrašnjost, vidljive naznake tračnica; radionica *Autotroleja*
Lučke dizalice		simboličko značenje; za potrebe luke
Željeznički kolodvor		djelomično zapušten
Zakretni željeznički most		zaštićeno kulturno dobro
Tvornica kotlova, strojeva, parobroda		sačuvani jedino arhivski nacrti
Skladišta	željezničko IIIb	u dobrom stanju, ali napušteno
	lučko 41	spomenička baština
	carinska	spomenička baština; u lošem stanju pod konzervatorskom zaštitom, no napuštena
	kompleks „metropolis“	
	lučko XIV	nedovoljno istaknuta važnost; za potrebe riječke luke
	lučko XII i XV	smatraju se kulturnim dobrom; za potrebe riječke luke

Izvor: Riječka industrija. Obrada autora prema www.rijekaheritage.org (pristupljeno 12. svibnja 2016.)

U vrijeme začetka industrijske revolucije u Rijeci je egzistiralo 98 mlinova dok je čitava Slavonija posjedovala tek 489 mlinova. Na području Rijeke tada su djelovale četiri tvornice tjestenine, a Zagreb je imao samo dvije. Cijela Hrvatska imala je 26 pivovara, od kojih su dvije bile riječke. Najveća duhanska tvornica koja je imala monopol na tadašnjem tržištu poslovala je u Rijeci. Tu se nalazila i tvornica papira koja je izvozila kvalitetan cigaretni, pisaći i tiskarski papir u cijeli svijet. Radile su i dvije tiskare, naftna rafinerija, tvornica konopa, torpeda, šećera, igraćih karata. Ondašnja industrija Rijeke posjedovala je 50 posto industrije cjelokupne Republike Hrvatske.[18]

Propadanje velebne riječke industrije započinje početkom 20. stoljeća, a porazna je činjenica da od mnogobrojnih tvrtki koje su u to vrijeme poslovale više nije aktivna niti jedna. Ono što je preostalo nakon njihova gašenja derutni su pogoni, zgrade i oprema koje čuvaju duh nekih minulih vremena i tragove slavne povijesti, a samim time predstavljaju bogatu industrijsku baštinu grada, ali i čitave zemlje.



Slika 2. *Grad Rijeka, sredinom 20. st.*
Izvor: TZ Grada Rijeke. Dostupno na www.visitrijeka.hr (pristupljeno 6. svibnja 2016.)

Danas se najvažnijim spomenicima industrijske baštine smatraju bivši industrijski kompleks *Rikard Benčić* (Šećerana), kompleks Tvornice papira (*Hartera*), Tvornica *Torpedo* te lučka skladišta za koje već postoje mnogobrojni projekti u fazi pripreme. Iako su neki od lokaliteta već u funkciji, većinom su napušteni i u lošem stanju bez obzira na konzervatorsku zaštitu i titulu kulturnog dobra. Niti jedan lokalitet nema istaknutu turističku funkciju, osim bivše talionice olova (hostel). Posebno je zabrinjavajuće stanje lansirne rampe i skladišta *Torpeda* koji su izloženi propadanju iako predstavljaju prvu tvornicu takva tipa u svijetu i samim time čine kulturni spomenik neprocjenjive vrijednosti.

[18] Žic, I. (2003) *Riječki orao, venecijanski lav i rimska vučica*, Adamić, Rijeka









Slike 3–6. *Prikaz industrijska baštine Rijeke danas (Šećerana, Hartera, lučka skladišta i Torpedo) Izvor: Riječka industrija. Dostupno na www.rijekaheritage.org (pristupljeno 9. svibnja 2016.); Lokalpatrioti Rijeka. Dostupno na: http://www.lokalpatrioti-rijeka.com/ (pristupljeno 9. svibnja 2016.)*

6. PRENAMJENA INDUSTRIJSKE BAŠTINE

Najbolji je način zaštite navedenih lokaliteta prenamjena, odnosno revitalizacija postojeće infrastrukture koja će podrazumijevati promjenu ili proširenje funkcije objekta uz obvezatnu valorizaciju baštinske i povijesne vrijednosti.[19] Osim prije isticanih koristi, prenamjenom ovakvih objekata postiže se dodatna estetska vrijednost destinacije zanimljivim spojem urbane i povijesne arhitekture, ali i povećava osjećaj ponosa kod lokalnog stanovništva.

Diljem svijeta puno je primjera dobre prakse koje treba detaljnije analizirati, modificirati i primijeniti na postojećoj resursnoj osnovici.

Jedan od takvih primjera zasigurno je *Torpedo Factory Art Center* u Alexandriji, SAD. Osnovan u staroj Tvornici streljiva, sadrži najveći broj umjetničkih studija u SAD-u (82), sedam galerija, dvije radionice, muzej, suvenirnicu i ugostiteljske objekte koji se bave organizacijom raznih događanja u jedinstvenom ambijentu. Mjesto je održavanja mnogobrojnih kulturnih manifestacija, a na godišnjoj razini privuče oko 500.000 posjetitelja.



Slike 7. i 8. *Torpedo Factory Art Center (Alexandria, SAD)*
Izvor: www.oldtownpost.com, www.obertjinksphotography.com (pristupljeno 9. svibnja 2016.)

Lučka skladišta također su nepresušan izvor ideja za buduću prenamjenu. Izvrstan su primjer skladišta duhana u Liverpoolu gdje se trenutačno provodi projekt prenamjene kompleksa u stambene, izložbene i hotelske prostore. Tako bi ubrzo u zgradama skladišta trebali niknuti poslovni hotel i kongresni centar, uredski prostori i luksuzni stambeni apartmani.

[19] Zadel, Z. (2011) *Uloga kulturnog turizma u jačanju konkurentske prednosti turističke destinacije*. Doktorska disertacija. Sveučilište u Rijeci, FMTU, Opatija



■ **Slika 9.** *Stanley Tobacco Warehouse danas i idejno rješenje (Liverpool, Velika Britanija)*
Izvor: www.gov.uk, www.liverpoolecho.com.uk (pristupljeno 9. svibnja 2016.)

U svijetu je zasigurno najpopularnija pretvorba bivših industrijskih lokaliteta u muzeje, što svjedoči i primjer muzeja *Tate Modern* u Londonu, koji se nalazi u prostorijama bivše elektrane. Misija je bila pretvoriti impresivne prostorije u kojima su se nalazili generatori u društveni prostor u kojemu će se održavati izložbe moderne umjetnosti, priredbe i konferencije. Od 2000., kada je otvorio svoja vrata, više od šezdeset milijuna posjetitelja prošlo je kroz navedenu prostoriju koja je do sada ugostila mnoga priznata umjetnička djela i postave.



■ **Slika 10.** *Tate Modern muzej*
Izvor: www.tate.org.uk (pristupljeno 14. svibnja 2016.)

U muzeju se nalaze i 84 galerije koje spadaju među top tri turističke atrakcije Velike Britanije, a o važnosti koju muzej ima za lokalnu ekonomiju dovoljno svjedoči to što zapošljava više od 4000 osoba.[20]

[20] Thapra, Industrial Heriatge as a Tool for Social and Economic Change, http://www.thapra.lib.su.ac.th/objects/thesis/fulltext/thapra/Julia-Jane_Davies/Chapter6.pdf (pristupljeno: 14. svibnja 2016.)

7. SWOT MATRICA

Trenutačno stanje i buduće viđenje navedenoga destinacijskog proizvoda prikazano je pomoću SWOT matrice. U ovom radu matrica je usmjerena na potencijal i mogućnosti razvoja industrijskog turizma u gradu Rijeci u kojemu je kao glavni cilj promatran razvoj budućega turističkog proizvoda istoimenog turizma.

SNAGE

- povoljan geoprometni položaj
- bogata prirodna i kulturna baština (resursna osnovica)
- slavna industrijska povijest
- velik broj manifestacija i događanja
- brojne udruge iz djelokruga kulture
- Udruga Pro Torpedo
- Strategije razvoja i prateći dokumenti
- mnogobrojni kulturni projekti koji čekaju realizaciju
- izgradnja imidža kulturno-urbanog grada
- blizina obalnih etabliranih turističkih destinacija
- industrijski resursi jake privlačne snage
- Međunarodna konferencija o industrijskoj baštini

SLABOSTI

- loša prometna infrastruktura (zrakoplovna i morska)
- nezadovoljavajuća postojeća kulturna i turistička infrastruktura
- ograničena financijska sredstva
- nedovoljno izgrađen brend i imidž destinacije
- neprepoznatljiv i nejasan turistički proizvod
- destinacijski menadžment
- neadekvatno valorizirana kulturna baština
- nestručan kadar i nedovoljan broj djelatnika
- *outgoing* agencijsko poslovanje
- nedovoljno razrađen plan realizacije i upravljanja industrijskom baštinom
- loša promocija industrijske baštine i povezanih aktivnosti
- propadanje/neočuvanje industrijske baštine
- izostanak međusektorske koordinacije

PRILIKE

- nove tržišne niše i aktualni turistički trendovi
- mogućnost cjelogodišnjeg poslovanja
- međusektorska suradnja i partnerstvo
- low-cost zrakoplovne linije
- Europska prijestolnica kulture 2020
- EU fondovi
- podrška međunarodnih institucija kulturnog i industrijskog turizma
- razvoj malog i srednjeg poduzetništva
- razvoj novog, jedinstvenog turističkog proizvoda
- kulturno-industrijske i gradske ture

PRIJETNJE

- nedovoljan smještajni kapacitet
- nedovoljan broj udruženje/poduzeća u sferi kulture i turizma
- neusklađenost ponude s aktualnim turističkim trendovima
- loše stanje industrijske baštine
- neinovativni turistički proizvod
- pravne i vlasničke dubioze
- loša komunikacija među dionicima

Slika 11. *SWOT matrica*
Izvor: obrada autor

Od davnina poznata kao kulturno-industrijski grad, Rijeka ima izvrsne predispozicije za daljnji razvoj s obzirom na spomenuti imidž, geografski položaj i brojne turističke resurse koji spadaju u segment kulturno-industrijske baštine. Snaga je grada upravo podizanje svijesti u ovom segmentu, a očituje se u postojanju sve većeg broja udruga, inicijativa, projekata i konferencija. Velik iskorak učinila je upravo Udruga *Pro Torpedo* koja već sedmu godinu zaredom organizira Međunarodnu konferenciju o istoimenoj temi i problematici.[21]

Od vezanih strateških dokumenata potrebno je istaknuti aktualan Strateški plan razvoja turizma Kvarnera sa strateškim i operativnim marketing planom do 2020., Strategiju razvoja kulturnog turizma grada (2015. – 2020.), Prostorni plan uređenja (2007.) i Strategiju kulturnog razvitka (2013. – 2020.), koji u svojim ciljevima i smjernicama sadrže analize, prijedloge i projekte za budući razvitak kulturno-industrijskog imidža grada. Tome pridonose kulturne manifestacije koje se održavaju na godišnjoj razini, a privlače velik broj posjetitelja i tako formiraju dio kulturno-industrijskog proizvoda grada.[22] U sve strateške planove potrebno je uvesti dodatne mjere kojima bi se potaknuo razvoj kreativnih industrija, adaptacija objekata industrijske baštine, bolja organizacija i aktivnije uključenje svih kulturnih organizacija i grada, ali i mjere zaštitite s ciljem stvaranja jedinstvenog i održivog industrijskog proizvoda.

Na temelju predstojeće titule prijestolnice kulture, Rijeka se može dodatno afirmirati i brendirati kao središte kulturno-urbanog turizma Republike Hrvatske, ali i kao jedan od svjetskih gradova. Prilika su aktualni tržišni trendovi koji uključuju kraća vikend-putovanja (*city break*) i doživljajnu komponentu odmora, pri čemu se kao svojevrstan odgovor javlja razvoj kulturno-industrijskih tura. U to se može uključiti mnogobrojne kulturne i industrijske spomenike, ali i ostale atrakcije te na taj način oblikovati jedinstven turistički proizvod kojim će se postići tržišna diferencijacija i uspostavljanje kulturnog identiteta. Kada se utvrdi postojanje kvalitetnoga turističkog proizvoda, lakše je dobiti podršku međunarodnih institucija, ali i Europskih fondova koji osim kapitala mogu ponuditi i pomoć stručnjaka te vezanih institucija. Između ostalog, ovakvi turistički proizvodi mogu produljiti trajanje turističke sezone (smanjiti negativan učinak sezonalnosti), privući turiste i posjetitelje iz okolnih destinacija, ali i povećati prosječno vrijeme boravka u samoj destinaciji koje je još uvijek vrlo kratko.

Navedeni tržišni imidž i „marka" Rijeci mogu donijeti mnogostruke koristi. Osim što su sjedišta velikih kompanija i organizacija, u prestižnim svjetskim gradovima raste potražnja za nekretninama, potiče se razvoj poduzetništva, otvaraju se radnje i pogoni te s time povezana radna mjesta, što naposljetku pridonosi razvoju opće ekonomije i gospodarstva. Ono što je također važno, a

[21] Protorpedo. Dostupno na: www.protorpedo-rijeka.hr (pristupljeno14. svibnja 2016.)

[22] www.rijeka.hr/manifestacijeKultura (pristupljeno 14. svibnja 2016.)

bitna je odrednica industrijskog turizma, poticanje je obnove starih građevina i ulica te revalorizacija postojeće baštine, kojima Rijeka raspolaže. Daljnjim razvojem prometne infrastrukture (posebice zrakoplovne) otvara se mogućnost za nova tržišta i daljnji turistički razvoj.

Iako ima mnogostruke prednosti, takav smjer razvoja može donijeti i određene negativnosti. U nekim razdobljima gradovi mogu biti prenatrpani turistima, čime se prelazi opteretni kapacitet destinacije i potiče saturacija, što nikako nije poželjan ishod, poglavito zbog osjetljivog okruženja neprocjenjive ekonomske i emocionalne vrijednosti. Kompetitivan menadžment destinacije, pravilno upravljanje i pozicioniranje ključ su odgovornoga turističkog razvoja unutar granica održivosti.

Trenutačni je problem grada Rijeke nejasno definiran i suviše diverzificiran turistički proizvod koji je teško plasirati u određeni tržišni segment. Velik je nedostatak i nedovoljan smještajni kapacitet koji ne može primiti veće grupe gostiju. Ubuduće je nužno segmentirati tržište, usmjeriti se u određenu tržišnu nišu te u tom smjeru nastaviti razvijati postojeću ponudu i resursnu osnovicu. Tako se može potaknuti obnova i revitalizacija postojeće „jake" industrijske baštine, koja je većim dijelom napuštena i derutna te nema nikakvu funkciju iako posjeduje golem razvojni potencijal. Sudeći po mnogobrojnim svjetskim primjerima, industrijski turizam, ako je pravilno ustrojen, može biti glavni pokretač razvoja i turizma i lokalne ekonomije i gospodarstva.

Jedna od većih prepreka u gradu Rijeci zasigurno je i nedostatak koordinacije i adekvatnog menadžmenta kojim bi se uvele razvojne mjere konkretno za urbani turizam, kreativne industrije i kulturne manifestacije, čime bi se naposljetku razvila brojnija „kulturna" publika i integralni proizvod. Povezivanjem Grada, Turističke zajednice i domaćega stanovništva, ali i ostalih dionika koji su izravno ili neizravno povezani s industrijskom baštinom na višoj razini, prevladala bi se birokracija i postojeće dubioze i pokrenuli projekti koji za sada stagniraju i gorući su problem. Daljnjim poticanjem nastavnih programa iz područja kulturne baštine, industrijske arheologije, kreativnih industrija i marketinga potaknuo bi se razvoj kompetitivnog kadra, čime bi se pojačali svi segmenti kulture i na taj način Rijeci donijeli titulu „kulturnoga predvodnika regije".

8. ZAKLJUČAK

Osim neekonomske funkcije koja se ogleda u zaštiti i prenamjeni industrijskih dobara, industrijski turizam donosi značajne ekonomske koristi za turizam i gospodarstvo zemlje, što potvrđuju i studije vezane turističke potrošnje.

Iako na godišnjoj razini potakne realizaciju 18 milijuna noćenja i 146 milijuna izleta, industrijsku baštinu u destinacijskom proizvodu promatramo kao sekundarnu ili tercijarnu atrakciju koju je potrebno vezati uz ostale oblike turizma zbog toga što ne posjeduje dovoljno snažan privlačni potencijal da bi se

na tržište plasirala kao jedinstven proizvod ili primarni motiv dolaska. Za Rijeku je ova činjenica obećavajuća s obzirom na trenutačnu turističku ponudu koja je poglavito usmjerena na MICE, vjerski te dijelom urbani turizam.

Demografskom i geografskom segmentacijom turističke potražnje naveden je profil potencijalnoga posjetitelja industrijske baštine. Ciljnu skupinu ove vrste turizma čine mlađa populacija i obrazovani seniori, a većinom su to iskusni turisti u potrazi za jedinstvenim doživljajem, studenti, poslovni turisti te novinari i istraživači iz Velike Britanije, SAD-a, Kine, Japana, Nizozemske, Njemačke i Danske. Iz podataka TZ Rijeke može se iščitati da su tijekom 2015. najveći broj dolazaka ostvarili državljani Njemačke, Japana, Velike Britanije i SAD-a, većinom u dobi od devetnaest do pedeset godina. S obzirom na to da u Rijeku dolazi manji broj seniora, postojeću ponudu treba potpuno usmjeriti na ciljni tržišni segment ili je adekvatno diverzificirati: prosječni dani boravka u gradu Rijeci unazad pet godina ostaju jednaki, što upućuje na to da je Rijeka tranzitni grad, ali i da joj nedostaje turističkih sadržaja i aktivnosti.

Grad Rijeka svoj bi turistički proizvod zasigurno trebao razvijati u smjeru gradskog urbanog turizma, pri čemu bi se industrijski lokaliteti uvrstili kao dodatni segment ponude. Iako ima više od pedeset atraktivnih industrijskih lokaliteta, kao najvažniji su istaknuti kompleks *Rikard Benčić*, *Hartera,* Tvornica *Torpedo* te lučka skladišta. Prijeko je potrebno ugledati se na svjetske primjere industrijskih atrakcija kako bismo postali svjesniji neprocjenjiva kulturnog bogatstva koji posjedujemo.

Na temelju izloženih činjenica nameće se zaključak da je turistička revalorizacija industrijske baštine najefektivniji oblik prenamjene jer osim što pridonosi njezinoj konzervaciji (neekonomska korist), pridonosi i otvaranju novih radnih mjesta, gradnji povezane infrastrukture, povećanju prihoda od turizma i samim time razvoju lokalnog, ali i nacionalnoga gospodarstva. Aktualna kandidatura za Europsku prijestolnicu kulture te Europski fondovi značajna su prilika za pokretanje navedenih inicijativa te daljnju afirmaciju Rijeke kao svjetski poznate urbano-kulturne metropole.

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SUMMARY

Industrial heritage, popularly known as the 'landscape of nostalgia' refers to buildings and infrastructure of the former industrial purpose that represents a valuable resource for the economy, local population and also for tourism. These are actually the remains of industrial activities that have a specific market potential and are converted (or can be converted) to sites of historical, technological, social, architectural and scientific importance. Besides the tangible, they may include intangible elements that require a custom scientific approach known under concept of industrial archeology.

Industrial heritage tourism or industrial tourism occurs as a result of the tourist activities at the sites, buildings and landscapes associated with the historical industrial processes. The development of industrial tourism can offer multiple benefits such as: increased prosperity of immediate and wider community, revitalization of valuable industrial monuments or sites and competitive advantage which promote the development of selective forms of tourism that can reduce the negative effects of seasonality and diversify the basic tourist product of the destination. The importance of industrial tourism can be read from the data of the European Parliament's Committee on Transport and Tourism. Industrial tourism generated 18 million overnight tourist trips plus 146 million day visits and a spending of almost €9 billion in 2013.

Thanks to once successful industry, Rijeka has a rich industrial heritage, which is a basic prerequisite for the industrial tourism development. Their full potential, the city of Rijeka can be achieved only with adequately evaluated and revitalized industrial heritage where the industrial heritage tourism emerges as the main engine to the development of the destination.

This paper will explore the possibilities and potential of industrial tourism development in the city of Rijeka. The advantages and disadvantages of the industrial tourism development will be analyzed and displayed through detailed SWOT matrix.

Keywords: *industrial heritage, industrial archeology, tourism, selective forms of tourism, industrial tourism, competitive advantage*

O BALISTICI U RIJECI, POTOM U ZAGREBU DO 1956.

On ballistics in Rijeka, then also in Zagreb, until 1956

Branko Hanžek*, Dubravko Horvat**

SAŽETAK

Kao znanstvene sredine, gradovi Rijeka i Zagreb imali su, svaki na svoj način, važne uloge u događajima povezanim s razvojem balistike (u vodi i u zraku). U Rijeci je povijest balistike pisana kao proces događanja u ustanovama i tvrtkama povezanim s vojskom, i ta događanja imaju primat u Hrvatskoj i u svijetu. Balistiku su razvijali Peter Salcher i Ivan Blaž Lupis-Vukić te Robert i John Whitehead – što je dobro poznato i iz prijašnjih konferencija. Razvoj balistike u Zagrebu tekao je kroz sveučilišnu nastavu odgovarajućih kolegija poput Mehanike fluida i Mehanike – dinamike i kinematike krutog tijela (zvrkovi). Na taj je način došlo do promjene u načinu razmišljanja, što je dovelo do napretka znanosti o balistici.

Temama bliskim balistici bavili su se Vinko Dvořák, Stanko Hondl, Vladimir Srećko Vrkljan, Dušan Pejnović, Ivan Plotnikov, Milivoj Prejac, Vatroslav Lopašić i Davorin Bazjanac – što je manje poznato. U sveučilišnoj nastavi počinju se rabiti zanimljivi obrazovni filmovi, što će biti predstavljeno i na konferenciji. Pritom ćemo se ograničiti na razdoblje do 1956. kada je od Tehničkog fakulteta u Zagrebu nastalo nekoliko samostalnih fakulteta tehničke naravi.

Ključne riječi: *povijest balistike, fizikalni i tehnički aspekti gibanja projektila*

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1. UVOD

Uloge P. Salchera, E. Macha, I. B. Lupisa-Vukića u proučavanju balističkih gibanja prilično su poznate. Zna se da je P. Salcher (1848. – 1928.), u suradnji s E. Machom (1838. – 1916.) i Sandorom Rieglerom (1855. – ?), načinio 1886. snimke leta puščanog zrna nadzvučnom brzinom kretanja u Rijeci. Istraživanja s istom tematikom Salcher je nastavio i 1887. u suradnji s Johnom Whiteheadom (1854. – 1902.). O suradnji Macha i Salchera održan je i međunarodni skup u Rijeci 2004., a radovi sa skupa objavljeni su 2011. godine. [1] Poznato je i da je u Rijeci 1861. kapetan Ivan Blaž Lupis-Vukić (1813. – 1875.) izumio torpedo. Torpedo je bio zapravo pomorski automatski upravljiv projektil s vlastitim pogonom (motor na komprimirani zrak) i razornim nabojem. Lupis je sklopio ugovor o suradnji s Robertom Whiteheadom (1823. – 1905.), ocem spomenutog Johna. Robert je 1874. osnovao u Rijeci prvu tvornicu torpeda na svijeta, a unaprijedio je torpedo konstruiranjem uređaja za automatsko održavanje smjera (žiroskop). [2] Njihov život i djelo opisani su u publikacijama E. Dubrovića [3] i I. Lukežića [4, 5].

Od znanstvenika u Zagrebu potekle su rasprave koje su više-manje povezane s balistikom. Tako je V. Dvořák 1900. napisao članak o pokusima s preuređenim zvrkom, S. Hondl je 1903. na Mudroslovnom fakultetu Sveučilišta u Zagrebu kao privatni docent predavao hidrodinamiku. V. S. Vrkljan je 19. siječnja 1937. predavao na Pučkom sveučilištu u Zagrebu o letu topovskih taneta, koristeći fizikalna razmatranja kosog hitca u zrakopraznom prostoru, uz utjecaj zakrivljenosti Zemlje, rotacije Zemlje i otpora zraka. D. Pejnović je izvodio pokuse u kojima je određivao brzinu zvuka i ultrazvuka u zraku i u vodi, kao i ovisnost te brzine o raznim fizikalnim veličinama. M. Prejac je predavao teoretsku mehaniku od 1919. do 1945. i napisao skriptu koja je doživjela dva izdanja. Profesor I. Plotnikov je 1930. objavio skriptu *Tehnička fizika* u kojoj je opisao nastanak vrtloga oblika prstenastog koluta. Profesor V. Lopašić svoje je pokuse sa zvrkovima izvodio od 1950. do 1956. i opisao ih u udžbeniku *Predavanja iz fizike* 1956. godine. Profesor Davorin Bazjanac već je 1954. na Tehničkom fakultetu u Zagrebu predavao kolegije: Tehnička mehanika, Dinamika raketnog leta, Osnove teorije giroskopa i Primijenjena teorija giroskopa. Radi potpunijeg upoznavanja sa znanstvenicima iz Zagreba koji su se bavili tom problematikom, u radu su detaljnije opisani njihovi životi i djela.

2. ZNANSTVENICI KOJI SU RADILI NA MUDROSLOVNOM FAKULTETU SVEUČILIŠTA U ZAGREBU

Vincenc (poslije zvan Vinko) **Dvořák** rođen je 21. siječnja 1848. u malome mjestu Dušejov blizu grada Jihlave u Češkoj. Nakon što je 1866. upisao Filozofski fakultet Sveučilišta *Karl-Ferdinand* u Pragu, absolutorij na njemu stekao je 1871. Iste je godine postao asistentom znamenitoga fizičara Ernsta Macha, čiji je bio učenik tijekom studija. Doktorirao je 1873. iz filozofije, s označenom fizikom kao strukom. Od 1874. privatni je docent. U Zagreb je stigao najkasnije 29. listopada 1875. kako bi predavao sveučilišnu fiziku. Nakon što je Dvořák upravo 29. listopada 1875. prisegnuo za profesora fizike zagrebačkog Sveučilišta, ustrojava svojim nastupom od 1. studenoga 1875. katedru za fiziku. Osnivanjema katedre za fiziku označava početak moderne sveučilišne nastave ne samo kao predavač već s nakanom izvođenja demonstracijskih pokusa i praktičkih vježbi. Za to mu je trebao fizički kabinet pa je već 7. studenoga 1875. na sjednici profesorskog zbora Mudroslovnog fakulteta istupio s tim prijedlogom i s naputkom vezanim uz namještenje podvornika za taj kabinet. Tako ujedno postaje i osnivač fizikalnog kabineta iz kojega se poslije razvio Fizički zavod. Bio je i dvaput (1881./1882. i 1891./1892.) dekan Mudroslovnog fakulteta te 1893./1894. dvadeseti rektor Svučilišta u Zagrebu. Dvořákov eksperiment u kojem je pokazao strujanje zraka u Kundtovoj cijevi te učinak prozvan po njemu, i danas su postignuća navođena u mnogim sveučilišnim udžbenicima. Jedan Dvořákov akustički uređaj sastojao se od tri aluminijske pločice s puno čunjastih rupica, a služio je (i danas služi) za mjerenje razine zvučne jakosti, tzv. zvukomjer (zvučni radiometar). Tada je to u svijetu bio najbolje izrađen zvučni radiometar, a Dvořák ga je prvi počeo



Slika 1. *Vinko Dvořák*

izrađivati i mjeriti njime, što priznaje i nobelovac H. S. W. Rayleigh. Tim se radiometrom mogla mjeriti razina zvučne jakosti tonova iste frekvencije. I to apsolutno mjeriti, dok današnji zvučni radiometri mjere samo relativne razine zvučne jakosti pa je, prema nekim hrvatskim elektroakustičarima, taj stari uređaj u prednosti pred suvremenijim! Vinko Dvořák objavio je 1900. članak o pokusima sa zvrkom. Odnosilo se to na jednostavne, tzv. dječje zvrkove Schmidtove konstrukcije. Kod te se konstrukcije osovina zvrka može prihvatiti rukom i zvrk se može staviti u pokret rotacije prislanjanjem tijela na rotirajuću ploču. Jedan (ispupčeni) kraj osovine vrtećega zvrka može se slobodno kretati po podlozi koja ga podupire i on tada pleše na podlozi. Dvořák je Schmitovim zvrkom pokazao pojavu *nutacije* i to tako da je na drugi (udubljeni) kraj osovine stavio prilično dugačak tanki štapić čiji je drugi kraj povezao s čvrsto učvršćenom kukicom. Nakon što je prigodno uredio Schmidtov zvrk, dobio je tzv. *poligonalno njihalo,* pri čemu se ne pojavljuje čisto precesijsko gibanje dok je brzina rotacije premala. Zvrk će samo s vrlo dugačkim štapićem biti upotrijebljen kao poligonalno njihalo. Ispupčeni (slobodni) kraj osovine opisivat će pojavu nutacije koja je na taj način lijepo prikazana valovitom krivuljom. Dvořák opisuje i novi pokus sa zvrkom koji ima duži kraj i koristi se kao konično njihalo; ako zvrk rotira, os rotacije može se rukom staviti u preces i ono gibanje pa se može dogoditi da težina zvrka bude gotovo potpuno dokinuta. Tada se uhvati tanki štapić i os se prilično brzo dovede u precesijsko gibanje u suprotnom smjeru, pa se slobodno pusti. Zvrk ostaje u preokrenutome precesijskom gibanju, a razlika u frekvenciji okretanja može se tumačiti kao da je težina zvrka porasla. Dvořák na kraju kaže da je za izvođenje toga novog pokusa potrebno puno vještine i vježbanja. Nakon umirovljenja 1912. nositelj je Komturskog križa Ordena Franje Josipa I. Bio je i redoviti član HAZU-a (tada JAZU) i dopisni član Češke akademije znanosti i umjetnosti. Umro je u Zagrebu 6. svibnja 1922. godine. [6, 7] Napisao je 65 znanstvenih i stručnih članaka koji zapravo sačinjavaju 60 radova i koji su doživjeli 80 izdanja.

Stanko Hondl rođen je u Zagrebu 22. listopada 1873. godine. Tu je na zagrebačkom Sveučilištu doktorskom promocijom 5. svibnja 1898. završio svoje školovanje. Nakon doktorske promocije Hondl je šk. g. 1899./1900. svoj dopust u znanstvene svrhe proveo u sveučilištima u Berlinu i Göttingenu. Habilitirao je 1903. na Mudroslovnom fakultetu Sveučilišta u Zagrebu nakon što je 23. prosinca 1902. dobio *veniam legendi* (dozvolu za održavanje predavanja) na osnovi habilitacijskog postupka i postao privatni docent hidrodinamike te nauke o potencijalima i nauke o elasticitetu na zagrebačkom Sveučilištu. Izvanrednim profesorom fizike na istom fakultetu imenovan je 1911. naslijedivši na tome mjestu prvoga profesora fizike Vinka Dvořáka. Rješenjem cara Franje Josipa I. od 29. ožujka 1915. Stanko Hondl imenovan je javnim redovnim profesorom za fiziku na Sveučilištu u Zagrebu. Godine 1933. postao je potpredsjednik, a dr. Albert Bazala predsjednik Jugoslavenske akademije znanosti i umjetnosti (JAZU)



Slika 2. *Stanko Hondl*

za godine 1933./1934. –1935./1936. U Ljetopisu JAZU, sv. 49., navedeno je da su iste osobe izabrane za iste funkcije, ali za godine 1936./1937. – 1938./1939., a Ljetopis, sv. 52., svjedoči da su iste osobe bile u istim ulogama godine 1939./1940. Ljetopis, sv. 53., navodi da je uz predsjednika JAZU-a A. Bazalu izabran kao potpredsjednik dr. Tomo Matić za godine 1940./1941. – 1942./1943. Hondl je bio rektor Sveučilišta 1935./1936. i 1936./1937. Silno je uzdignuo nastavu sveučilišne fizike kada je 1937., njegovim zalaganjem, dovršena zgrada fizike (Fizikalni zavod) na Marulićevu trgu 19 u Zagrebu. Za potrebe nastave nabavio je i tri edukacijska filma, od kojih je jedan (*Ballistische Untersuchungen* iz 1936.) prikazan na ovom kongresu. Dipl. Phil. Karlo Kempni obranio je 1940. disertaciju pod naslovam *Hidrodinamički efekti pri rotaciji krutih valjaka u tekućini.* Mentor mu je bio prof. dr. Stanko Hondl. Profesor Hondl bio je dva puta umirovljen, 1945. i 1946. godine. Umro je 9. travnja 1971. u Zagrebu, u dubokoj starosti, u 98. godini.

Objavio je 147 radova (124 članka i 23 prikaza), 99 članaka i natuknica u Hrvatskoj enciklopediji (od 1941. do 1945.), 17 uredničkih članaka, napisao je knjigu (udžbenik), prema njegovim predavanjima izrađena je i objavljena skripta i preveo je jednu knjigu. [8, 9]

Vladimir Srećko Vrkljan rođen je u Sv. Petru Orehovcu pokraj Križevaca 26. kolovoza 1894. Realnu gimnaziju položio je u Zagrebu 1912., a ispit zrelosti u Karlovcu 1913. Završio je Mudroslovni fakultet u Zagrebu 1917. (izdan mu je apsolutorij 18. srpnja, br. 367). Dana 30. srpnja 1920. dodijeljen je kao „pomoćna sila“ Seminaru teoretske fizike Mudroslovnog fakulteta. Na čast doktora filozofije promaknut je 31. listopada 1924. na temelju samostalno izrađene znanstvene rasprave *Razvoj kvantne teorije crtanih optičkih spektara* i položenih usmenih ispita iz fizike (glavna) i matematike (sporedna struka) i



Slika 3. *Vladimir Vrkljan*

filozofije. Ukazom kralja od 5. kolovoza. 1929. postavljen za docenta iz Primijenjene matematike (mehanika, teorijska fizika, nebeska mehanika) na Filozofskom fakultetu u Zagrebu, a novim ukazom od 16. rujna 1933. za izvanrednog profesora Primijenjene matematike na istom fakultetu. Od zimskog poljeća (semestra) 1934./1935. do 1936./1937., zajedno s red. prof. dr. Ladislavom Stjepanekom, predaje dva sata na tjedan Vježbe iz racionalne mehanike i teorijske fizike. Održao je i predavanje na Pučkom sveučilištu u Zagrebu pod nazivom *Što fizika znade o lijetu taneta* 1937. godine. Ukazom od 30. srpnja 1940. postavljen je za redovitog profesora Primijenjene matematike na Filozofskom fakultetu u Zagrebu. Od 1943. do 8. lipnja 1946. (kada je već osnovan Prirodoslovno-matematički fakultet – PMF) vodi Seminar za teoretsku fiziku i primijenjenu matematiku Mudroslovnog fakulteta u Zagrebu. Nakon toga je umirovljen. Godine 1950. izabran je za dopisnoga člana JAZU-a izvan radnog sastava. Zapažen je kao fizičar koji se među prvima u Hrvatskoj bavio kvantnom fizikom i teorijom relativnosti te njihovom sintezom zvanom relativistička kvantna mehanika.

Vladimir Srećko Vrkljan umro u Zagrebu 1. ožujka 1974. godine. Objavio je 123 znanstvena i stručna rada i napisao skriptu *Racionalna mehanika* koju je 1935. objavio Klub studenata matematike i fizike [10, 11] U skripti se, među ostalim, govori o problematici kosog hitca.

Dušan Pejnović rođen je 4. siječnja 1883. u Sisku. Godine 1903., 1. srpnja, položio je ispit zrelosti na realnoj gimnaziji u Zagrebu (svjedodžba br. 20), a 1907. apsolvirao na zagrebačkome Mudroslovnom fakultetu. Od 1907. službuje u Fizikalnom institutu Mudroslovnog fakulteta Sveučilišta u Zagrebu. Dana 5. svibnja 1928. postavljen je ukazom br. 7386 za docenta fizike i prema tadašnjem

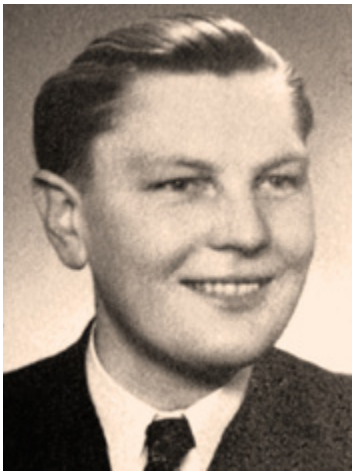


Slika 4. *Dušan Pejnović*

zakonu mogao je predavati na Sveučilištu. Na temelju dekreta br. 58687–II–1940. Pejnović 17. srpnja 1940. postaje izvanredni sveučilišni profesor eksperimentalne fizike na Filozofskom fakultetu. Dekret je potpisao tadašnji ban Banovine Hrvatske Ivan Šubašić. Od osnutka Prirodoslovno-matematičkog fakulteta 1946. do 30. svibnja 1951. bio je redovni profesor fizike. Mnogo je pridonio osuvremenjivanju nastave fizike. Umro je 19. veljače 1958. u Zagrebu za svojim radnim stolom. [12] Objavio je 162 publikacije (116 znanstvenih i stručnih članaka, 14 natuknica u Hrvatskoj enciklopediji i 32 zadatka).

3. ZNANSTVENICI KOJI SU RADILI NA TEHNIČKOM FAKULTETU SVEUČILIŠTA U ZAGREBU

Prvi hrvatski sveučilišni tehnički fizičar bio je **Milivoj Prejac**. Rođen je 17. kolovoza 1884. u Desiniću, kotar Pregrada. Ispit zrelosti položio je u Donjogradskoj gimnaziji u Zagrebu 2. srpnja 1902. Svjedodžba je izdana toga dana pod brojem 39, a svrha joj je bila polazak na sveučilište. Od 1902./1903. do 1905./1906. (8 semestara) bio je slušač Kraljevskog sveučilišta u Zagrebu i vježbao u Fizikalnom zavodu (3 semestra), u Kemijskom laboratoriju (1 semestar), u Matematičkom seminaru (6 semestara) i u Pedagoškom seminaru (2 semestra). Godine 1906./1907. upisao se kao redovni slušač nekih kolegija na Filozofskom fakultetu u Beču. Dana 16. lipnja 1913. promaknut je u doktora filozofije. Pisanu disertaciju *Teorija elektrona* odobrili su prof. dr. Dvořák i prof. dr. Vladimir Varićak. Pred komisijom koju su činili ta dva profesora, Milivoj Prejac položio je 27. travnja 1911., u prvom pokušaju, s odličnim uspjehom usmeni strogi ispit iz fizike kao glavne te matematike kao popunjujuće struke. Položivši 13. lipnja 1913. usmeni strogi ispit iz filozofije, mogao je pristupiti promociji doktora znanosti i



Slika 5. *Milivoj Prejac*

dobiti diplomu doktora znanosti. Ukazom kralja br. 28690 od 23. srpnja 1919. imenovan je za javnog izvanrednog profesora teoretske mehanike u Tehničkoj visokoj školi. Dana 21. studenoga 1922., ukazom broj 49172, imenovan je za javnoga redovitog profesora Tehničke visoke škole u Zagrebu, a nakon toga ukazom od 5. lipnja 1926. broj 67328 preimenovan je u javnoga redovnoga profesora na Tehničkom fakultetu Sveučilišta Kraljevine SHS u Zagrebu. Prejac je pedagoški djelovao kao sveučilišni profesor od 1919. do 1945. kada je 27. prosinca umirovljen. Umro je u Zagrebu 11. svibnja 1972. Napisao je tri znanstvena rada i izdao skriptu *Mehanika* koja je doživjela dva izdanja. [13]

Ivan Plotnikov rođen je 4. prosinca 1878. u Tambovu u Rusiji. Absolutorij Fizikalno-matematičkog fakulteta moskovskoga Sveučilišta stekao je 1901. Po-



Slika 6. *Ivan Plotnikov*

stigao je doktorat filozofije na leipziškom sveučilištu 1905. i postao asistent prof. Ostwalda (Nobelova nagrada za kemiju 1909.). Plotnikov je postigao i doktorat iz kemije na odeskom Sveučilištu 1915. Dolazi u Zagreb 1920. gdje postaje ugovorni redovni profesor fizike i fizikalne kemije na Tehničkoj visokoj školi. Nakon što je stekao državljanstvo, izabran je 1926. za redovitog profesora Zavoda za fiziku i fizikalnu kemiju Tehničkog fakulteta. Umirovljen je 1943. u istom zvanju i kao nadstojnik istoga zavoda. Umro je 31. svibnja 1955. u Zagrebu. Objavio je 14 knjiga i udžbenika, 109 znanstvenih članaka, 56 stručnih članaka i dobio jedan patent. [14]

Vatroslav Lopašić rođen je 9. prosinca 1911. u Pakracu. Realnu gimnaziju (klasični smjer) završio je u Zagrebu gdje je i maturirao 1930. Te je godine upisao Filozofski fakultet zagrebačkog Sveučilišta, a 1934. je diplomirao I. grupu znanosti (Grupa za teorijsku matematiku). Doktorirao je iz eksperimentalne fizike 1938. na Sveučilištu u Zagrebu. Na Filozofskom fakultetu radio je od 30. studenoga 1934. do 14. lipnja 1946., na Prirodoslovno-matematičkom fakultetu do 31. prosinca 1946., na Višoj pedagoškoj školi od 15. lipnja 1947. do 8. ožujka 1950., na Tehničkom fakultetu od 9. ožujka 1950. do 30. lipnja 1956. i na Elektrotehničkom fakultetu od 1. srpnja 1956. do 30. rujna 1982. Mala disproporcija u plaćanju između odlaska s Više pedogoške škole i dolaska na Tehnički fakultet može se objasniti prateći dopisivanje tih dviju ustanova. Naime, kad je počeo raditi na Tehničkom fakultetu plaću je primao na Višoj pedagoškoj školi dok nije potpuno (i poslom i isplatom), u travnju 1950., prešao na Tehnički fakultet. U svojim je glasovitim *Predavanjima iz fizike* opisao izvedeni pokus s tri Schmitova zvrka. Na jedan teški Schmitov zvrk stavi se drugi identičan, ali tako da se oba zvrka vrte u istom smislu i približno istom brzinom. Ako bi se vrtjeli u protivnom smislu, gornji bi se zvrk prevrnuo i pao. Na dva zvrka koji balansiraju



Slika 7. *Vatroslav Lopašić*

jedan na drugom može se staviti i treći, lakši, koji se vrti u istom smislu, kao i prva dva ispod njega. Ta vrtnja na dobroj podlozi od čelika traje i do četvrt sata. U početku rada na Filozofskom fakultetu bio je asistent dnevničar radeći na predavanjima prof. Hondla i Laboratorijskim vježbama koje je vodio doc. dr. D. Pejnović. Tako je radio do 9. listopada 1936. Od 10. listopada 1936. do 11. travnja 1939. bio je asistent pripravnik.

Prof. dr. Vatroslav Lopašić umro je u Zagrebu 17. prosinca 2003. Objavio je 18 znanstvenih i stručnih članaka, tri natuknice u Hrvatskoj enciklopediji, četiri zadatka u Matematičko-fizičkom listu, dva zadatka u Glasniku matematičko-fizičkom i astronomskom, devet izdanja sveučilišnih udžbenika iz fizike. [15]

Davorin Bazjanac rođen je 22. rujna 1902. i već sutradan kršten je u rimokatoličkoj župi sv. Ilije Proroka u Velikoj Kopanici pod imenom Martin Antun. Kada mu je bilo trinaest godina umro mu je otac, a 1918. i majka. O njegovoj sestri i njemu skrbio je prof. Stanković koji je radio u maloj gimnaziji u Slavonskom Brodu. Budući da D. Bazjanac nije bio materijalno osiguran za daljnje školovanje, 1918. upisao se u kadetsku školu u Karlovcu, a ispit zrelosti položio je 1921. Nakon dvogodišnjeg studija, 1923. na Vojnoj akademiji u Beogradu dobiva čin artiljerijskog potporučnika. Slijedi dvogodišnji studij na Mašinskom odseku Tehničkog fakulteta u Beogradu i dvogodišnji studij na *Ecol d´Application d´Artillerie* u Fontainebleau u Francuskoj. Vraća se 1927. u Kraljevinu SHS i biva upućen na službu u Vojno-tehnički zavod u Kragujevcu gdje je radio pet godina baveći se podizanjem nove tvornice pješačkog streljiva, rukovodeći izradom alata i balističkim ispitivanjem streljiva. U tom razdoblju više je puta bio u Čehoslovačkoj upoznavajući tehnologiju proizvodnje oružja i oruđa. Godine 1932. odlazi na studij u Zürich i to na glasovitu *Eidgenössische technische Hochschule* (ETH) koja je do danas dala 21 nobelovca. Godine 1935. dobiva diplomu



Slika 8. *Davorin Bazjanac*

strojarskog inženjera na ETH-u. U Beograd se vratio 1936. i do 1938. radio je u Ministarstvu vojske (podizanje novih tvornica ratne industrije). U međuvremenu, 1937., položio je majorski ispit s temom autofretaže topovskih cijevi. Godine 1938. opet odlazi u Zürich da bi odredio tekst svoje disertacije i polagao usmeni doktorski ispit. Od godine 1939. do 1941. radio je na proizvodnji streljiva u Kragujevcu. Rat ga je zatekao na službenoj dužnosti blizu Beča te je sredinom 1941. zajedno s diplomatskim osobljem otpremljen u Beograd. Bio je bez posla do kraja 1941. kada je došao u Zagreb gdje je pridijeljen zapovjedništvu zračnih snaga kao šef oružanog odjela. U Zagrebu mu je omogućeno da radi kao znanstvenik. Bio je pošteđen ratnih zbivanja na fronti i službovanja u vojarnama. Čak mu je omogućeno da ode u Švicarsku gdje je konačno utvrdio tekst svoje disertacije (mentor: prof. dr. J. Ackeret, komentor: prof. dr. H. Ziegler) pod naslovom *Untersuchungen mit Hilfe der elektrischen Analogie über den Einfluss der Luftstrahlbegrenzung in Windkanälen auf Tragflügelmessungen* (Istraživanje utjecaja oblika presjeka zračne struje u zračnim tunelima na mjerenja na aeroprofilima) i položio doktorski ispit te je 7. prosinca 1943. promaknut u doktora tehničkih znanosti. Nakon Drugoga svjetskog rata upućen je na rad u Srednju tehničku školu u Zagrebu da bi 15. veljače 1946. bio izabran za honorarnog nastavnika mehanike na Tehničkom fakultetu Sveučilišta u Zagrebu. Predavao je slušačima strojarskog, elektrotehničkog i brodarskog odsjeka. Dana 30. lipnja 1948. postavljen je za izvanrednog profesora mehanike, a za redovnog profesora mehanike i nauke o čvrstoći izabran je 1954. na Tehničkom fakultetu u Zagrebu. Sve do odlaska u mirovinu 31. kolovoza 1973. predavao je na više tehničkih studija.

Tako eminentna osoba koja je iza sebe ostavila mnoštvo zadovoljnih studenata i suradnika napustila nas je 1988. godine. U noći između 20. i 21. rujna umro je profesor Davorin Bazjanac u Zagrebu. U njegovu opusu nalazi se objavljenih 207 bibliografskih jedinica (članaka, skripti, udžbenika). [16, 17]

4. ZAKLJUČAK

Povijest balistike u Rijeci dobro je poznata i zna se da događanja u Rijeci povezana s time imaju primat u Hrvatskoj i svijetu. Povijest balistike u Zagrebu tekla je kroz sveučilišnu nastavu odgovarajućih kolegija poput mehanike fluida i mehanike – dinamike i kinematike krutog tijela (zvrkovi). Manje je poznato da su se temama bliskim balistici bavili znanstvenici u Zagrebu Vinko Dvořák, Stanko Hondl, Vladimir Srećko Vrkljan, Dušan Pejnović, Ivan Plotnikov, Milivoj Prejac, Vatroslav Lopašić i Davorin Bazjanac. Radi što bolje upućenosti u tematiku poželjeno je bilo uklapanje postignuća imenovanih u kontekst njihovih životnih puteva i ostvarenih djela. Stoga su za te zagrebačke znanstvenike predočeni njihovi opsežniji životopisi.

Napomena

U sklopu izlaganja prezentirana je digitalna inačica originalnog filma *Ballistische Untersuchungen* koji je snimljen 1936. godine.

Zahvala

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SUMMARY

Rijeka and Zagreb, as two scientific centres, have played an important role in the events connected with the development of ballistics (in water and air). The history of ballistics in Rijeka mostly took place in firms connected with the military as the military events have priority in Croatia, as well as in the world. Ballistics was developed by Salcher, Whitehead and Luppis, which is well known from former conferences. The development of ballistics in Zagreb is closely connected with university teaching, within courses such as fluid mechanics and mechanics, especially dynamics and kinematics of solids (gyroscopes). Thus a change occurred in formulating the way to deal with ballistics, which resulted in an advancement of the science of ballistics. Topics closely related to ballistics were researched by Dvořák, Hondl, Vrkljan, Pejnović, Plotnikov, Prejac, Lopašić, Bazjanac, which is rather less known. Interesting educations movies began to be used, as will be presented at the conference. We will mainly be concerned with the time period until the year 1956 when the Technical Faculty of the Zagreb University divided into independent faculties of different technical disciplines. Some of the topics from the research and public presentations of the above mentioned scientists will be presented through mathematical solutions of specific problems. The Coriolis force effect will also be discussed and the question of its possible impact on the torpedo motion posed.

Keywords: *history of ballistics, physical and technical aspects of projectile motion*

ŽIROSKOP I NJEGOVA ULOGA U ZNANOSTI I TEHNICI

Gyroscope and its importance in technology and in science in general

Branko Hanžek*, Dubravko Horvat**

SAŽETAK

Gibanje žiroskopa jedan je od najzamršenijih problema klasične mehanike krutog tijela. Poznato je da je žiroskop bitna komponenta uređaja za stabiliziranje gibanja brodova, zrakoplova, ali i projektila u vodi i u zraku. Nedavno je žiroskop ugrađen i u žiroskopske satelite koji opasuju Zemlju i služe za komunikaciju, navigaciju i znanstvena mjerenja. Ovdje ćemo prikazati jednostavnu teoriju žiroskopskoga gibanja i gibanja projektila te probleme koji se pri njihovu gibanju javljaju, a povezani su s gibanjem torpeda kroz viskozno sredstvo i njegovom stabilizacijom. Pri opisu teorije žiroskopa i njegove primjene referirat ćemo se na doprinose hrvatskih znanstvenika i inženjera (Dvořák, Lopašić, Bazjanac, Pajić) koji su u svoje vrijeme posvećivali dio svojih znanstvenih i stručnih istraživanja problemu žiroskopskoga gibanja i njegovoj primjeni.

Ključne riječi: *zvrk, povijest istraživanja o zvrku u Hrvatskoj, precesija zvrka, primjena zvrka u balistici*

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1. UVOD

U kontekstu gibanja torpeda javljaju se dva problema: otpor sredstva – vode zbog njezine viskoznosti te stabilizacija putanje. To je dio općeg problema gibanja projektila kojim se bavi vanjska balistika [1], dio izučavanja gibanja projektila nakon ispaljivanja iz cijevi oružja ili oruđa. Ovdje ćemo prikazati pristup tim problemima s fizikalnoga stajališta. Rješenje gibanja (krutog) tijela koje rotira oko slobodne osi, rješenje je gibanja žiroskopa. Naime, žiroskop [2, 3] je uređaj čiji je bitni dio upravo rotirajuće (kruto) tijelo s velikom kutnom količinom gibanja nastalom tako da se uz velik moment tromosti tijelo zarotira na velik broj okretaja u sekundi, dakle na veliku kutnu brzinu (Dodatak D1). Očuvanje kutne količine gibanja tada se rabi za određivanje stalnog smjera pomoću posebne konstrukcije nosača rotirajućeg tijela zvane kardanski sklop. Na taj se način postiže nepromjenjiv smjer kutne količine gibanja, a time i tijela (projektila, torpeda). Problem gibanja tijela kroz sredstvo u kojem se javlja otpor može se tretira na egzaktni način, rješavajući odgovarajuće diferencijalne jednadžbe (Dodatak D2). Bit će prikazane i neke pojave nastajanja vrtloga tijekom gibanja tijela u viskoznoj tekućini, pri čemu se javlja Magnusov efekt.

2. ROTACIJA KRUTOG TIJELA OKO SLOBODNE OSI. ZVRK

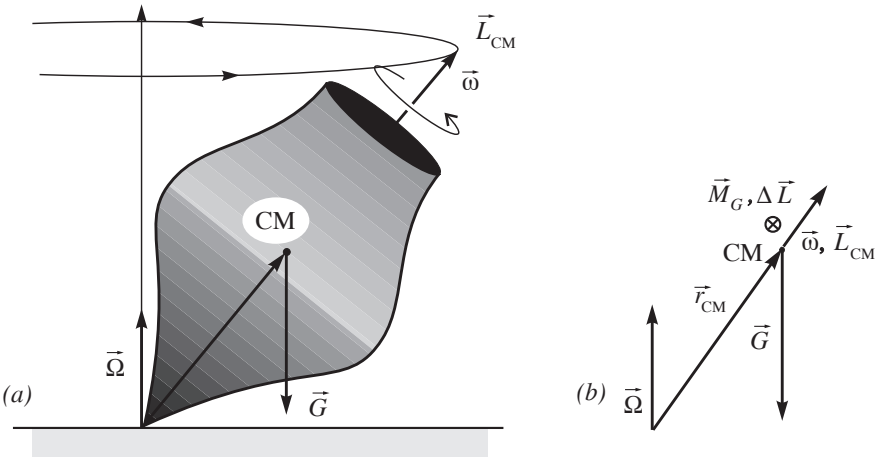
Kruto tijelo može se u prostoru gibati translatorno, može rotirati i, konačno, može izvoditi gibanje koje je superpozicija prvih dvaju gibanja. Najopćenitiji je opis takva gibanja zamršen, no nas ovdje zanima vrtnja krutog tijela [4, 5]. Neka je tijelo, općenito nepravilna oblika, probodeno nekom osi i neka je ta os učvršćena u dvije točke. Tada govorimo o rotaciji krutog tijela oko čvrste osi. Uobičajeno je tu os postaviti duž osi Kartezijeva koordinatnog sustava. Tada vrtnju krutog tijela možemo opisati pomoću vektora kutne brzine rotacije $\boldsymbol{\omega}$, a on ima samo z-komponentu ω_z. Tijelo rotira zbog djelovanja vanjskog momenta sile **M**, a kutna akceleracija tijela $\boldsymbol{\alpha}$ proporcionalna je momentu sile i obrnuto proporcionalna veličini koja mjeri tromost tijela s obzirom na rotaciju, a to je moment tromosti **I**. Posebno je zanimljivo i za nas ovdje važno razmotriti pravilno – aksijalno simetrično tijelo koje rotira. Tada je moguće napisati jednadžbu gibanja tijela, 2. Newtonov zakon za rotaciju u ovakvu obliku:

$$\mathbf{M} = I_z \boldsymbol{\alpha} \quad \text{ili} \quad M = I_z \alpha_z. \tag{2-1}$$

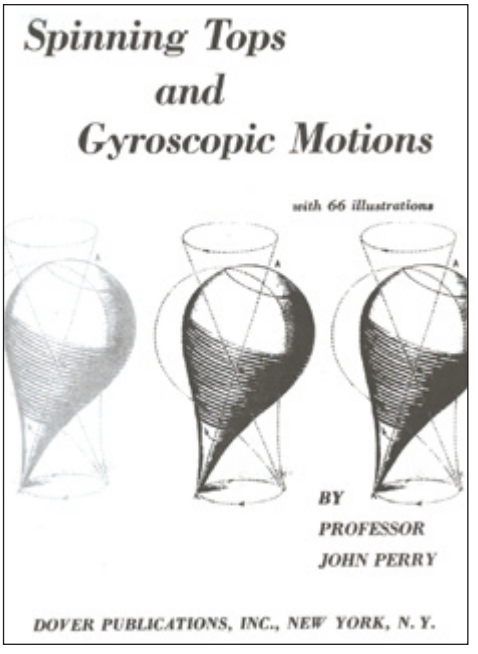
Račun momenta tromosti provodi se vodeći računa o rasporedu mase tijela [5] jer moment tromosti ne mjeri samo masu već i geometriju rasporeda masa. Upravo je zvrk jedno takvo pravilno tijelo koje je zarotirano na određenu kutnu brzinu i ostavljeno da se vrti. Medutim, valja odmah uočiti da je riječ o vrtnji oko osi koja je formalno pričvršćena samo u jednoj točki (u kojoj zvrk dodiruje podlogu).

Kao posljedica osi učvršćene u jednoj točki dolazi do djelovanja vanjskog momenta zbog težine tijela, a rezultat je precesija zvrka. Precesija je pojava vrtnje osi (i *CM*) zbog promjene kutne količine gibanja $\mathbf{L} = I\omega$ u vremenu. To možemo napisati ovako:

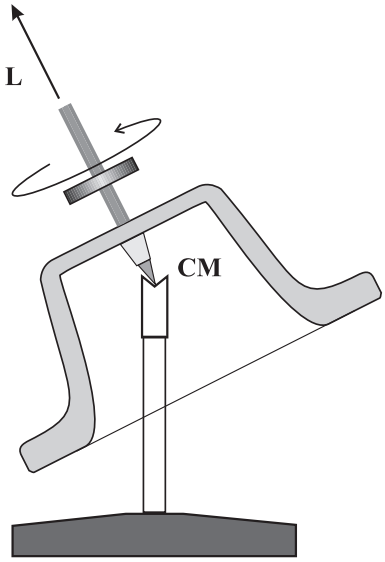
$$\frac{d}{dt}\mathbf{L} = I\,\boldsymbol{\alpha} \quad \text{ili} \quad \mathbf{M} = \frac{d}{dt}\mathbf{L} \tag{2-2}$$



Slika 1. *Zvrk pri brzoj rotaciji*



Slika 2. *Naslovnica knjige* Spinning Tops and Gyroscopic Motions *J. Perryja*



■ **Slika 3.** *Zvrk poduprt u* CM *pa u* **L** *pokazuje stalno u istom smjeru.*

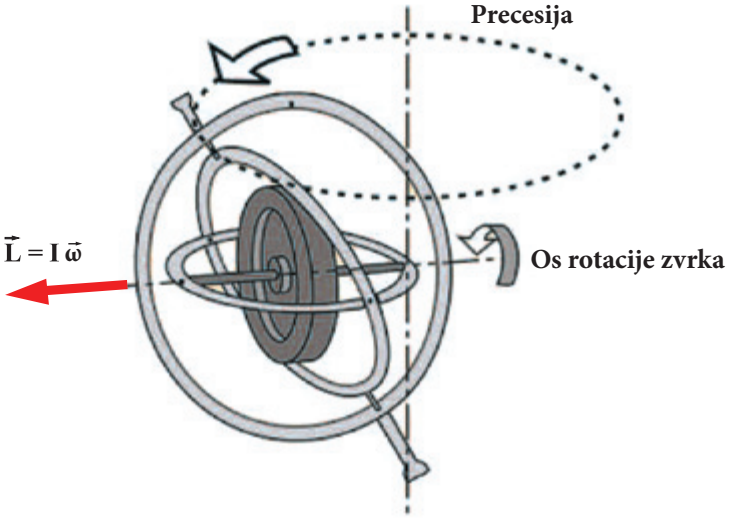
Prema tome, kada nema vanjskog momenta sile, tada je očuvana kutna količina gibanja **L**.

$$\frac{d}{dt}\mathbf{L} = 0\,, \quad \text{gdje je} \quad \mathbf{L} = I\,\omega. \tag{2-3}$$

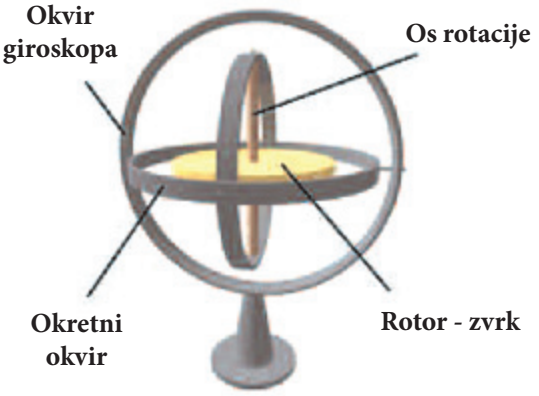
Do tog zakona očuvanja dolazi i pri gibanju tijela pod djelovanjem centralne sile pa je, primjerice, pri gibanju planeta oko Sunca kutna količina gibanja očuvana, što se zatim manifestira kao jedan od Keplerovih zakona – zakon o površinama koje prebrisuju radijus vektori planeta.

Moguće je konstruirati zvrk – rotirajuće kruto tijelo koje se može poduprijeti u težištu (vidjeti sliku).

Činjenica da je kutna količina gibanja očuvana ako na rotirajuće tijelo ne djeluje (vanjski) moment sile, potaknula je fizičare da konstruiraju sklop koji se sastoji od zvrka vrlo velike kutne količine gibanja, postignute prije svega velikim kutnim brzinama, koji ima os tako postavljenu da se može gibati relativno prema okviru koji je drži te kutna količina gibanja **L** tako može zauvijek pokazivati u istom, početnom smjeru. Taj se sklop zove kardanski sklop i prikazan je na dvjema slikama.

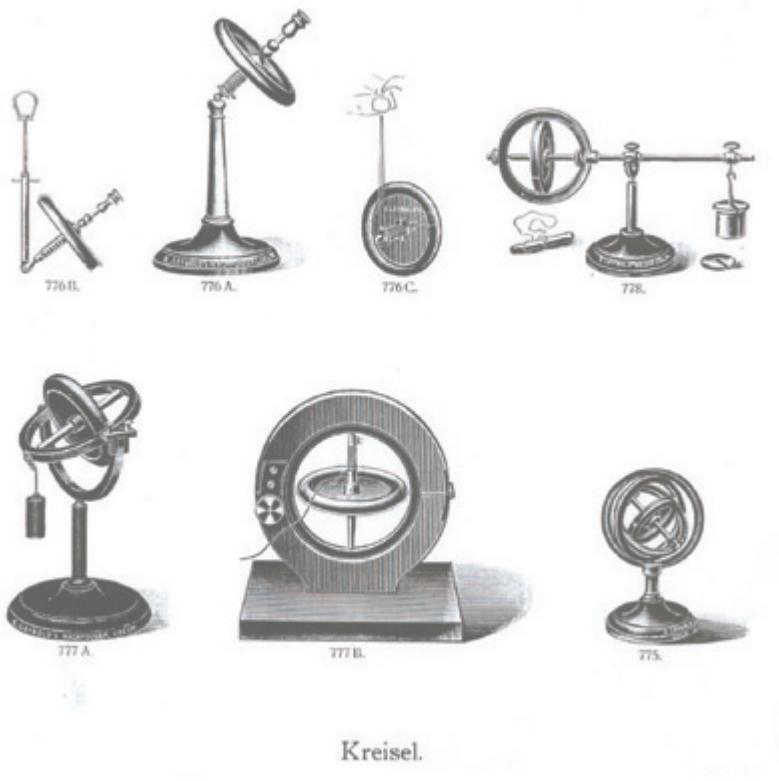


■ **Slika 4.** *Žiroskop s kardanskim sklopom*

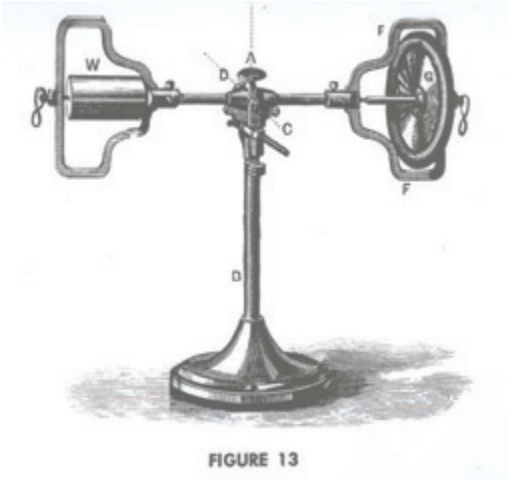


■ **Slika 5.** *Žiroskop s kardanskim sklopom*

Primjeri zanimljivih žiroskopa iz davnog kataloga tvrtke *Leybold* prikazani su na sljedećim slikama.



■ **Slika 6.** *Leyboldovi žiroskopi iz starog kataloga*



■ **Slika 7.** *Zvrk pri (brzoj) rotaciji – stari Leyboldov katalog*

Žiroskop koji pokazuje u jednom te istom smjeru rabi se za stabilizaciju brodova, za održavanje smjera torpeda i za orijentaciju aviona te za stabilizaciju geostacionarnih satelita.

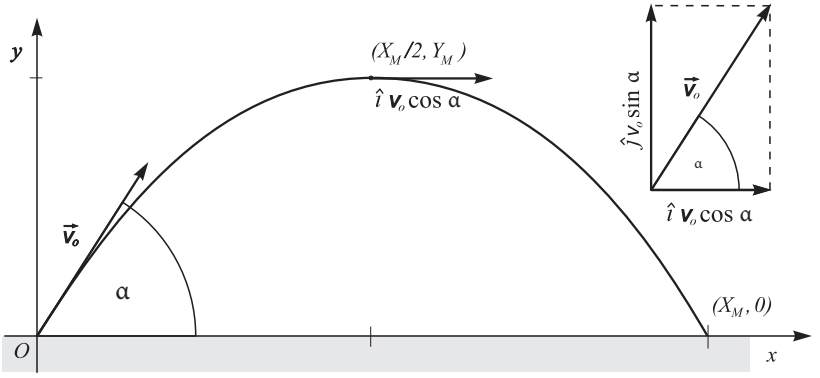
3. GIBANJE TIJELA SA SILOM OTPORA SREDSTVA

Gibanje projektila odvija se u sredstvu koje pruža otpor gibanju. Analiza gibanja pokazuje da je silu otpora najbolje prikazati ovisnu o brzini, pri čemu je ta ovisnost pri malim brzinama dana kroz linearnu funkciju brzine, a pri većim kroz kvadratičnu ovisnost [5, 6, 7]

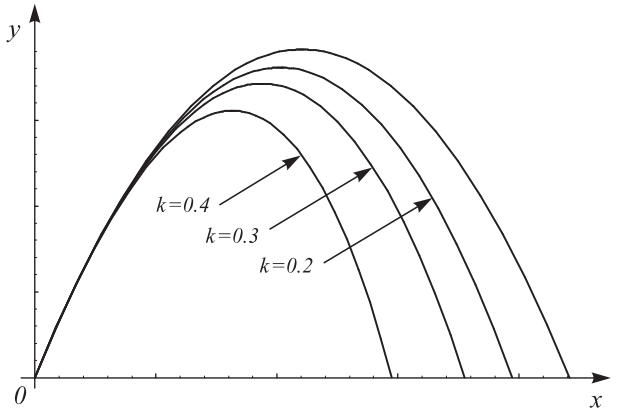
$$\mathbf{F}_{otp} = -k_1|\mathbf{v}|\hat{\mathbf{v}} \quad \text{ili} \quad \mathbf{F}_{otp} = -k_2|\mathbf{v}|^2\hat{\mathbf{v}}. \tag{3-4}$$

Problem gibanja sitnog tijela pri kosom hicu elementarni je problem rješavanja 2. Newtonova zakona [5]. Rješenjem diferencijalne jednadžbe (Dodatak D2) dolazi se do putanje tijela – parabole.

Sam oblik putanje bio je u staroj literaturi prikazan na različite načine, kao što je prikazano na slikama.

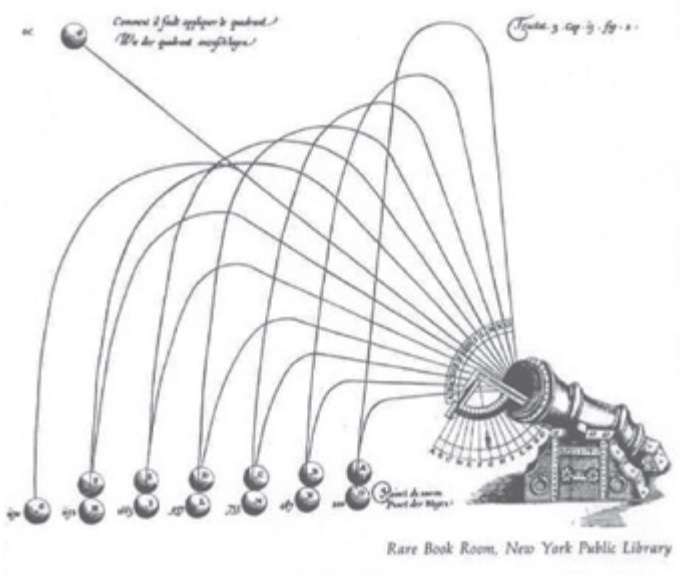


■ **Slika 8.** *Putanja projektila je parabola, bez uključenja otpora sredstva*

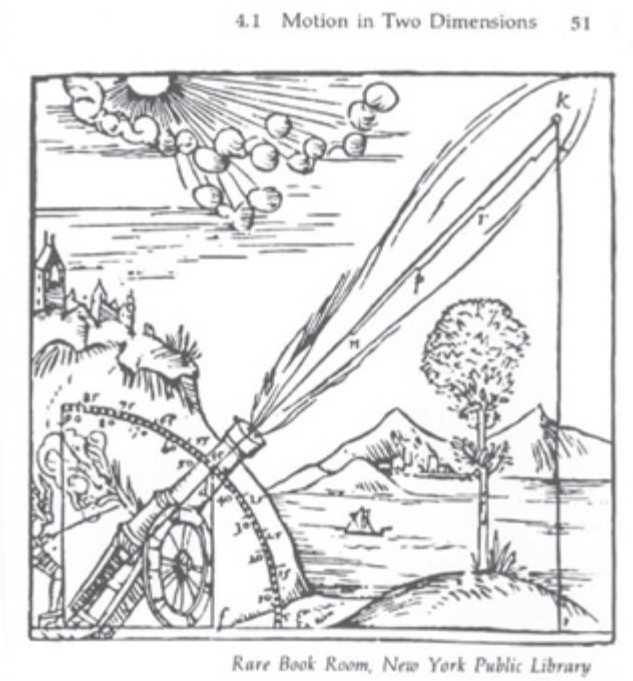


■ **Slika 9.** *Balističke krivulje za različite vrijednosti* k

Zbog prije opisane sile otpora sredstva, rješenje je diferencijalne jednadžbe za taj slučaj (Dodatak D2) deformirana parabola – balistička krivulja [5], prema slici.

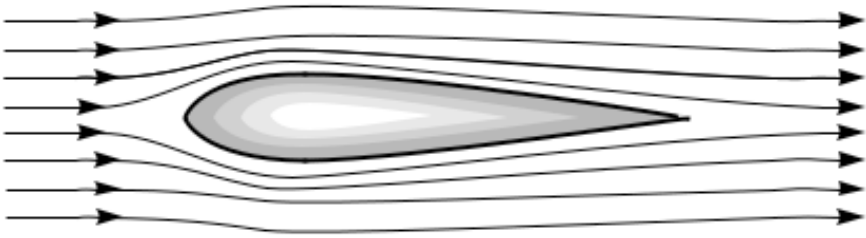


Slika 10. *Kako su prije zamišljali putanje projektila.*

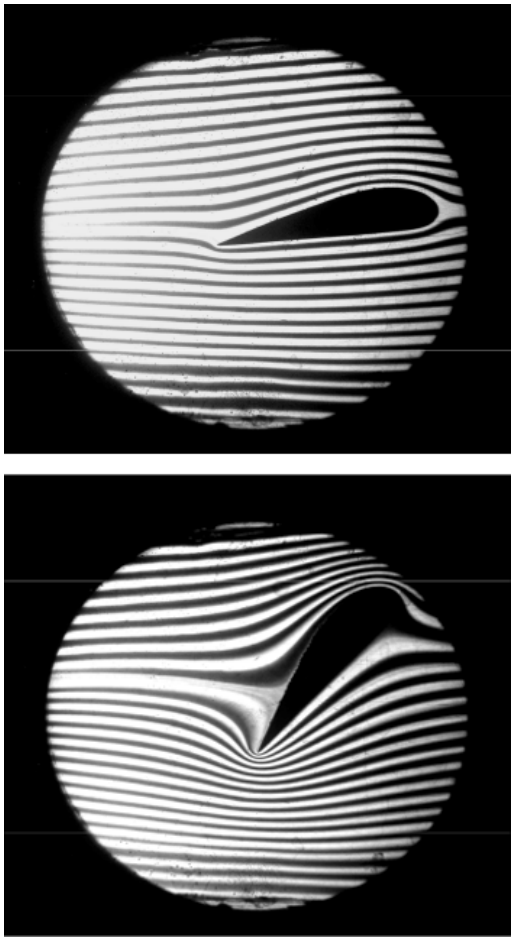


Slika 11. *Još jedan prikaz putanje projektila*

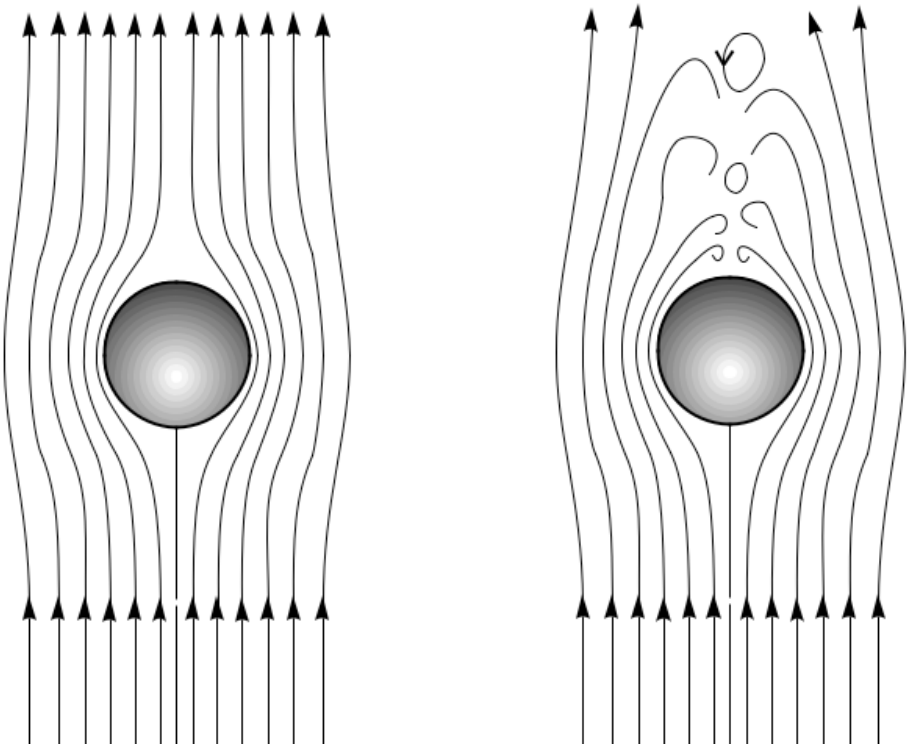
Pri gibanju projektila, pa prema tome i torpeda u viskoznom sredstvu, javlja se vrtloženje – turbulencija koja dodatno stvara otpor gibanju sredstva. U hidrodinamici dana je veza izmedu faktora otpora sredstva i Reynoldsova broja [6]. Pri malim brzinama strujanje oko tijela koje se giba malom brzinom je laminarno, prema slici.



Slika 12. *Laminarno – slojevito strujanje fluida oko posebne prepreke*



Slika 13. *Fotografije laminarnog strujanja na uređaju* Helle-Shaw



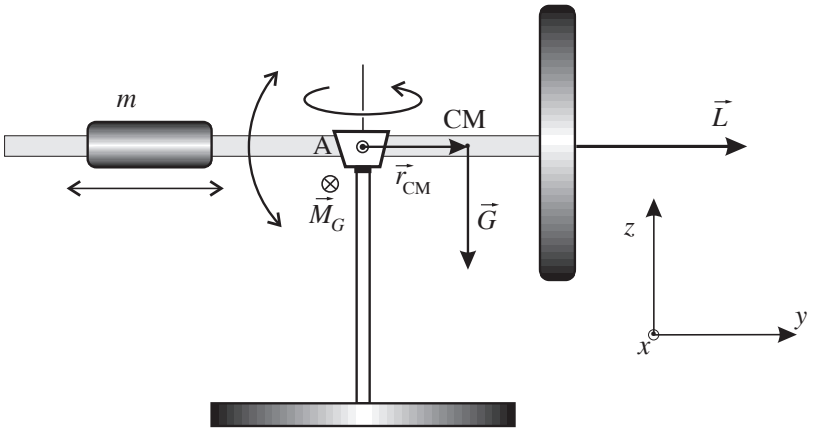
Slika 14. *Prijelaz s laminarnog na turbulentno gibanje*

Kada se brzine povećaju dolazi do vrtloženja koje uzrokuje silu otpora, prema slici. Vanjska balistika je dio balistike koji se bavi gibanjem metka ili projektila nakon što napusti cijev oružja ili oruđa; uzima u obzir sve te učinke, opisuje ih i formulira matematičkim modelom i ugrađuje u diferencijalne jednadžbe gibanja projektila koje se gotovo isključivo moraju rješavati sofisticiranim numeričkim procedurama.

DODATAK D1: GIBANJE ZVRKA I PRECESIJA

Rotacija tijela poduprtog izvan CM. Precesija. Kotač prema slici može rotirati oko osi pa ima kutnu količinu gibanja s obzirom na točku *A*. Uteg *m* može se pomicati duž osi *s* tako da se mijenja položaj CM pa se time postiže da na kotač (cijeli sustav) može djelovati vanjski moment sile oko horizontalne osi kroz točku *A* ili ga ne mora biti ako CM padne točno u točku *A*. Cijeli uređaj se može slobodno rotirati i oko vertikalne osi.

Ako *m* postavimo tako da je CM u *A*, tada je **L** neprestano uperen u istom smjeru.



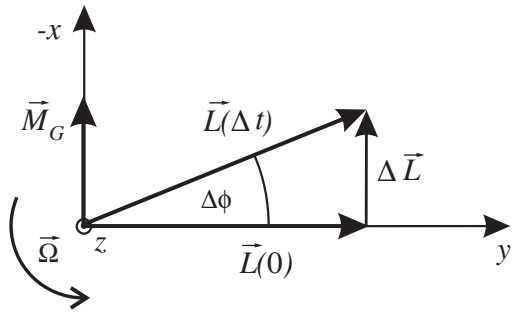
■ **Slika 15.** *Tijelo rotira oko vlastite osi, a djeluje i vanjski moment sile* $\mathbf{M}_G$ *koji pokazuje „u" papir i uzrokuje precesiju tijela.*

Međutim, sada namjestimo položaj utega tako da desna strana kotačem (koji rotira i ima vlastitu kutnu količinu gibanja **L**) „pretegne". Onda oko horizontalne osi kroz *A* postoji moment sile $\mathbf{M}_G$ koji dolazi od težine **G** koja djeluje u CM. Moment sile „gleda" u papir. Taj vanjski moment daje promjenu količine gibanja

$$\mathbf{M}_G = \frac{\Delta \mathbf{L}}{\Delta t}, \tag{D1-5}$$

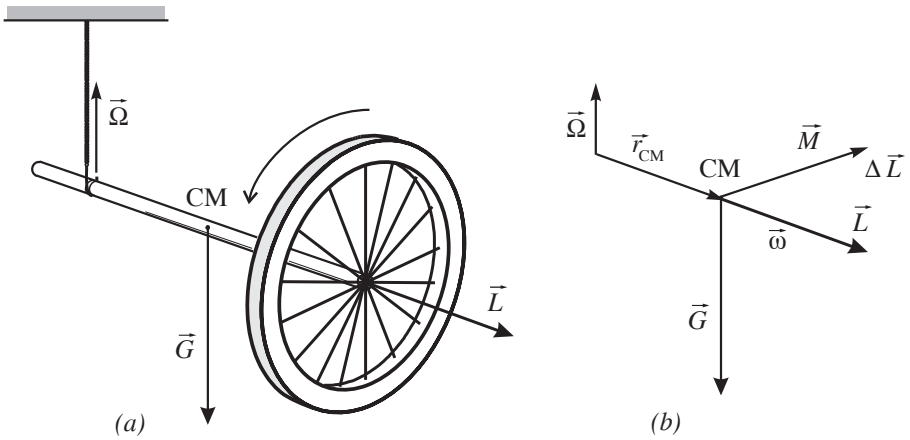
tj. za vrijeme Δt **M** će uzrokovati promjenu Δ**L** u smjeru $\mathbf{M}_G$, tj. „u papir". Taj je smjer okomit na **L** pa se **L** neće mijenjati po iznosu već samo po smjeru. Zato će se oko točke *A* u horizontalnoj ravnini oko vertikalne osi pomaknuti os s kotačem i masom *m*, odnosno u vremenu Δt promijenit će se kut orijentacije osi za $\Delta\phi$ pa će zbog vanjskog momenta sile doći do rotacije cijelog sustava oko vertikalne osi kutnom brzinom $\vec{\Omega} = \Delta\phi/\Delta t\,\hat{k}$.

Takvu rotaciju zovemo precesija. Brzina i smjer precesije ovise o smjeru vanjskog momenta sila i o veličini **L**-a. Svakako, ako je **L** = 0, kotač će jednostavno slijediti djelovanje momenta i past će. Kada je (neki) vanjski moment sile $\mathbf{M}_v$ različit od nule i postoji **L**, onda se on „troši" na mijenjanje **L**-a, ali ne nužno samo „na padanje". Ako uteg *m* pomaknemo prema kraju osovine tako da CM prijeđe na drugu stranu od točke *A*, promijenit će se i smjer precesije, jer će se promijeniti smjer $\mathbf{M}_G$-a, a time i $\Delta\mathbf{L}$. Smjer precesije može se promijeniti i promjenom smjera rotacije kotača, tj. promjenom **L**-a po smjeru.



■ **Slika 16.** *Pogled odozgo na situaciju na prethodnoj slici. Kutna brzina precesije $\vec{\Omega}$ pokazuje u smjeru z osi koja izlazi „iz papira".*

Spektakularan je prikaz precesije kada se kotač jako zarotira i zatim objesi na komad užeta. „Umjesto da padne", kotač počne precesirati oko užeta u smjeru djelovanja $\mathbf{M}_G$-a („u papir" prema slici).



■ **Slika 17.** *Upečatljiv prikaz precesije kotača koji kao da prkosi sili teži (a). U (b) su prikazani (samo) smjerovi vektora – „sudionika" u precesiji.*

Kako se postupno kutna brzina rotacije kotača smanjuje, tako raste kutna brzina precesije. To možemo pokazati tako da napišemo jednadžbu rotacije:

$$M_G = \frac{dL}{dt} = G r_{\mathrm{CM}}, \qquad \text{pa je} \qquad dL = G r_{\mathrm{CM}} dt. \tag{D1-6}$$

Pomak dL postignut je za vrijeme dt i odgovara pomaku u kutu $d\phi$, tj. $dL = L\, d\phi$ ili

$$d\phi = \frac{1}{L} dL = \frac{1}{L} G r_{\mathrm{CM}}\, dt = \frac{G r_{\mathrm{CM}}}{I\omega} dt, \tag{D1-7}$$

pa je kutna brzina precesije Ω jednaka

$$\Omega = \frac{d\phi}{dt} = \frac{G r_{\mathrm{CM}}}{I\omega} \tag{D1-8}$$

i kako kutna brzina rotacije ω (spina) pada, kutna brzina precesije Ω raste.

Zbog precesije javlja se i kutna količina gibanja $\mathbf{L}_p$ čiji vektor pokazuje u vertikalnom smjeru, duž užeta. Ako je $\omega \gg \Omega$, iznos vektora $\mathbf{L}_p$ je vrlo mali pa možemo uzeti da je (i dalje) vektor **L** horizontalan.

Iz prethodnog razmatranja vidimo da je neobičan rezultat da rotirajući kotač ne padne, jednostavno razumjeti: ako je $\omega = 0$, tj. ako je $\mathbf{L} = 0$ (u $t = 0$), onda moment $\mathbf{M}_G$ uzrokuje rotaciju *oko horizontalne osi*. Ta rotacija proizvodi **L** (u $t > 0$) u istom smjeru kao i $\mathbf{M}_G$. Prsti desne ruke po „pravilu desne ruke" pokazuju smjer padanja, a palac pokazuje u smjeru momenta, odnosno u smjeru povećanja **L**-a. Ako je $\omega \neq 0$, onda postoji $L \neq 0$ (u $t = 0$). $\mathbf{M}_G$ proizvede $\Delta\mathbf{L}$ koji se nadoda postojećem i rezultantni **L** „ne proizvede padanje" već malo zaokrenutu rotaciju. $\mathbf{M}_G$ je uvijek 90° ispred **L**-a i također mijenja svoj smjer brzinom precesije!

Zemljina precesija

Gibanje Zemlje neposredan je primjer i realizacija prije opisanoga precesijskoga gibanja.

Zemlja rotira oko vlastite osi s periodom $T = 1$ dan. Os je nagnuta 23,45° u odnosu na vertikalu na ravninu koja je određena godišnjom putanjom Zemlje oko Sunca. Ako promotrimo gibanje Zemlje u referentnom sustavu vezanom za Zemljin CM, vidimo da se Zemlja deformirala zbog rotacije pa na Zemlju djeluje Mjesec tako da daje moment sile koji po iznosu ovisi o njegovu položaju, ali koji ima smjer uvijek okomit na os rotacije. Na Zemlju djeluje i Sunce koje također, zbog nesferičnosti „nagnute" Zemlje, daje moment sile. Taj ukupni (slabi) moment sile daje sporu precesiju vektora kutne količine gibanja čiji je period oko 25.300 godina. Danas vektor kutne količine gibanja pokazuje točno

(minus 1°) prema zvijezdi Sjevernjači (Polaris). Za 13.000 godina „sjevernjača" će biti neka druga zvijezda, ali za još sljedećih 13.000 godina ponovno će sjevernjača biti Sjevernjača.



Slika 18. *Grčki filozof i astronom Hiparh iz Nikeje*

Za takvo gibanje znali su već stari zvjezdoznanci: Hiparh iz Nikeje u Maloj Aziji (oko 190 g. pr. K.) otkrio je precesiju uspoređujući svoja mjerenja položaja zvijezda s podacima svojih prethodnika stoljeće i pol prije. Hiparh je izračunao (bez objašnjenja uzroka) da precesija iznosi 46" na godinu, a Ptolomej je izračunao vrijednost 36" na godinu. Precesiju je prvi objasnio Nikola Kopernik u svom djelu *De Revolutionibus* 1543. kada je izračunao vrijednost od 50,2".

Hiparha se smatra izumiteljem trigonometrije, a izračunao je sunčani dan do 6 minuta točnosti te napravio prvi katalog zvijezda, koji se rabio više od tisuću godina.

DODATAK D2: GIBANJE TIJELA UZ SILU OTPORA. TURBULENCIJA.

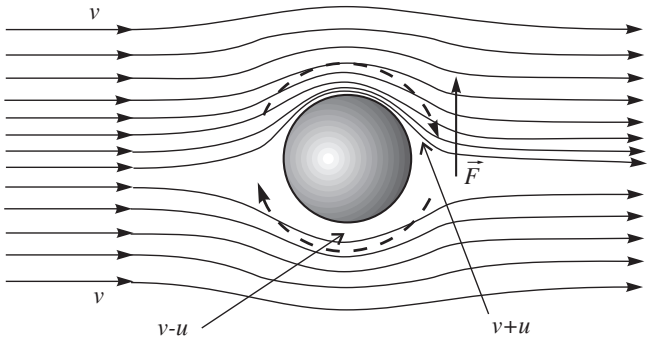
Jednadžba gibanja uz silu otpora

$$\begin{aligned} &(1) \quad m\frac{d^2}{dt^2}x = 0 \qquad (2) \quad m\frac{d^2}{dt^2}y = -mg \qquad \text{ili} \\ &\qquad m\frac{d}{dt}v_x(t) = 0 \qquad\qquad m\frac{d}{dt}v_y(t) = -mg, \end{aligned} \tag{D2-9}$$

i njezina rješenja [7]

$$\begin{aligned} x(t) &= \frac{v_0 \cos\alpha}{k}\left(1 - e^{-kt}\right) \\ v_x(t) &= v_0 \cos\alpha e^{-kt}, \\ y(t) &= -\frac{g}{k}t + \frac{g + v_0 k \sin\alpha}{k^2}\left(1 - e^{-kt}\right) \\ v_y(t) &= -\frac{g}{k} + \frac{g}{k}\left(1 + \frac{k}{g}v_0 \sin\alpha\right)e^{-kt}. \end{aligned}$$

Putanje gibanja tijela dane su prije kao balističke krivulje.



■ **Slika 19.** *Magnusov efekt (učinak) – rotirajuća lopta u struji fluida*

Kod rotirajućih se projektila u viskoznom sredstvu javlja dodatna sila zbog zanošenja fluida tijelom. Taj efekt zovemo Magnusov efekt, a prikazan je jednostavnom situacijom rotacije kuglice (teniske loptice, primjerice). Magnusov efekt ne javlja se pri gibanju torpeda jer ono ne rotira, već je stabilizirano žiroskopom.

4. POGOVOR

Problemima rotacije krutog tijela, žiroskopa i gibanjem tijela u sredstvima s otporom te balistikom (torpedom posebno) bavili su se istaknuti znanstvenici-predavači sa zagrebačkog Sveučilišta V. Vrkljan [7], M. Paić [8] i V. Lopašić [9]. Tu valja posebno istaknuti S. Hondla, docenta hidrodinamike, koji je ujedno bio i voditelj doktorskih disertacija iz tog područja. Ovaj je rad svojevrstan sažetak njihovih istraživanja i rezultata. Dragocjeno je uvijek pogledati malo u prošlost visoke nastave i istraživanja na ovim prostorima jer uvijek nas iznenađuje originalnost ideja i promišljanja ljudi koji su stvarali današnju visoku razinu nastave i znanosti na Sveučilištu u Zagrebu.

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SUMMARY

The motion of gyroscopes (tops) in its most general form is one of the most involved problems in classical mechanics. It is well known that gyroscope is an essential element in components regulating stability of ships, air planes as well as projectiles (in air and water). Recently, it has been employed in relativistic gyroscopic satellites. In this presentation, a general theory of gyroscopic motion will be given and some of its applications will be discussed. Also the projectile motion in the air will be described, and some short movies concerning gyroscope experiments will be shown. In the presentation, emphasis is given to the works of our engineers and scientists who have devoted part of their research to gyroscopes (Dvořák, Lopašić, Bazjanac, Pajić).

Keywords: *top, history of top and gyroscope research in Croatia, precession, top in external ballistics*

MACH'S HERITAGE UNDER GORJANCI

Machovo nasljeđe pod Gorjanci

Marjan Hren*

SUMMARY

Last year, in the local community of Mali Slatnik, we decided to make an important step, i.e., to design the Mach learning path. *In the mid February of this year we remember the 100th anniversary of the death of the great physicist Ernst Mach. One of his major achievements was to design the photography of supersonic motion in the Rijeka torpedo factory. From time to time he lived and worked on his father's farm in Veliki Slatnik, 75 km north of Rijeka.*

His father Johann Mach was an educated humanist and connoisseur of science. In 1858, he and his Moravian family arrived in Novo Mesto, where he bought a mansion. At home and at Mach Hill he raised silkworms. He also educated his neighbor villagers. Towards the end of the 19th century, a girls' school was founded on his property in Šmihel, the family Mach thus having indirectly helped to educate Dolenjska girls.

Very little is known about the Mach family, although some people make every effort to shed light on this name. In 1995, a group of talented students produced the Mach's anthology, an extensive work of the Association of teachers of Dolenjska showing the functional cycle of the silkworm jamamay and the interpretation of life and work of the Mach family.

We designed the Mach Valley Routes along the Slatenska stream around Mach Hill to the mansion where Ernst Mach lived. The path points contain information related to the writer J. Trdina and Johann Mach's unfortunate daughter Wilhemine. The 9-km-long learning path will be marked with information regarding Mach. The promoters include the Institute for Protection of Cultural Heritage, the Institute for Nature Conservation of Slovenia and other experts. We operate with a great desire to enlighten young generations and to preserve the heritage.

Last year, we established the Mach Heritage Society under Gorjanci. *Marjan Hren wrote the book* Slatenska Valley and Mach – Heritage under Gorjanci, *which is in the process of publication.*

Keywords: *Johann Mach, Ernest Mach, Veliki Slatnik – Rijeka, Mach's Heritage, jamamay, Mach's learning path*

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SAŽETAK

U mjesnoj zajednici Mali Slatnik prošle smo godine odlučili poduzeti važan korak – napraviti Machovu obrazovnu stazu. *Sredinom veljače ove godine obilježavamo stotu godišnjicu smrti velikog fizičara Ernsta Macha. Jedno od njegovih najvećih postignuća bilo je stvaranje ultrabrze fotografije u riječkoj tvornici torpeda. Mach je povremeno živio i radio na imanju svoga oca u Velikom Slatniku, 75 kilometara sjeverno od Rijeke.*

Njegov otac Johann Mach bio je humanistički obrazovan i poznavatelj znanosti. Godine 1858. sa svojom je moravskom obitelji došao u Novo Mesto gdje je kupio obiteljsku kuću. Kod kuće i na Machovu brijegu bavio se uzgojem svilene bube i obrazovanjem svojih suseljana. Krajem 19. stoljeća na njegovu je zemljištu osnovana djevojačka škola u Šmihelu. Tako je obitelj Mach indirektno pomogla u obrazovanju djevojaka Dolenjske.

Malo se zna o Machovoj obitelji iako su se neki potrudili istražiti to ime. Godine 1995. grupa nadarenih studenata napravila je izbor Machovih djela, opsežan rad Udruge učitelja Dolenjske, u kojem je prikazan funkcionalan ciklus svilene bube jamamay, *kao i tumačenje života i rada obitelji Mach.*

Zacrtali smo Machovu stazu dolinom potoka Slatenska, oko Machova brijega, do obiteljske kuće u kojoj je Ernst Mach živio. Na točkama te staze nalaze se informacije vezane za pisca J. Trdinu i Wilheminu, nesretnu kćer Johanna Macha. Devet kilometara dugačka Machova obrazovna staza *bit će označena informacijama o Machu. U tome nam pomaže* Institut za zaštitu kulturne baštine, Institut za očuvanje prirode Slovenije *i drugi stručnjaci. Velika nam je želja prenijeti znanje mladim generacijama i očuvati nasljeđe.*

Prošle smo godine osnovali udrugu Machovo nasljeđe pod Gorjanci. *Marjan Hren napisao je knjigu* Dolina Slatenske i Mach – nasljeđe pod Gorjanci, *koja je u postupku izdavanja.*

Ključne riječi: *Johann Mach, Ernest Mach, Veliki Slatnik – Rijeka, Machovo nasljeđe, jamamay,* Machova obrazovna staza

PUNOM PAROM! – INDUSTRIJSKA BAŠTINA KAO ALAT U MUZEJSKOJ EDUKACIJI

Full Steam Ahead! – Industrial heritage as a tool in museum education

Katarina Ivanišin Kardum*, Markita Franulić**

SAŽETAK

Punom parom! *je pilot-projekt – edukativna aktivnost koju smo počeli provoditi u Tehničkom muzeju* Nikola Tesla *u travnju 2015. Cilj je projekta što cjelovitija prezentacija nekih od strojeva iz naših zbirki. Riječ je o stručnim vodstvima kroz stalni postav tijekom kojih se pokreću pojedini izloženi strojevi i time zorno prikazuje njihova izvorna funkcija. S projektom smo započeli periodičnim pokretanjem novoobnovljenih, funkcionalnih parnih strojeva Odjela transformacija energije. U projekt su, uz kustosa, uključeni muzejski pedagog i restaurator te vodiči – demonstratori. Osim prezentacije funkcionalnog rada parnih strojeva najširoj javnosti, kako bi ih posjetitelji mogli doživjeti i upoznati u njihovoj cjelovitosti, cilj je bio ispitati održivost ovakve prezentacije tehničke baštine tijekom cijele godine. Tražili smo odgovor, koliko je to moguće i uputno s aspekta zaštite i konzervacije, kakve je posebne mjere zaštite potrebno poduzeti i slično. U planu je održati tridesetak prezentacija godišnje, otprilike svaki peti vikend i jedan radni dan u svakome petom tjednu. Rad parnih strojeva dokumentirat će se u filmovima koji će biti prikazani na tablet-računalima uz strojeve, putem aplikacije proširene stvarnosti (*Augmented Reality*). Tako će i korisnici koji ne mogu prisustvovati samoj demonstraciji pokretanja strojeva, moći posredno doživjeti taj aspekt njihove prezentacije. Dok je korištenje energije pare u pogonskim strojevima tvornica i prometalima (vlakovima, brodovima) sad već pitanje daleke prošlosti, veliki udjel proizvodnje električne energije koju danas koristimo generira se parnim turbinama (izumi* Sir *Charlesa Parsonsa davne 1884.) u termoelektranama te plinskim i nuklearnim elektranama.*

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Prezentacijom kojom se predmete iz fundusa stavlja u suvremeni kontekst, posjetiteljima se ukazuje i na smisao muzejskih predmeta u stvarnom životu.

Ključne riječi*: parni strojevi, industrijska baština, muzejski predmeti, održivost prezentacije, proširena stvarnost*

SUMMARY

Full Steam Ahead! *is a pilot project we started at the Technical Museum Nikola Tesla in April 2015. The aim is to communicate more fully to our visitors the story of some of our museum objects – engines from our collections; "More fully" meaning that where appropriate we started periodically using authentic museum objects for demonstration purposes. We started the project in the Energy Transformation Department, with a very valuable collection of steam engines (hence Full Steam Ahead!). The project is done in collaboration with the restaurateur, curator and museum educator of the Technical Museum Nikola Tesla. The idea behind the project is to test the possibilities of the new display of these recently restored museum objects. It includes demonstration of their functionality so that the visitors can see them in action and gain a unique experience. So far, following the guidelines of our Museum restaurateur, the demonstrations are performed every fifth weekend. During this year the plan is to continue with periodical demonstrations, but also to video record them. This is so that we can offer this experience to all our visitors, as in fact a very few can attend the actual demonstration. The film of the engines in action will be available alongside the steam engines displayed on tablets via Augmented Reality Application. Our main concern is to bring into balance the benefit of our users – the demonstration of function which characterises objects, with the sustainability of such demonstrations – for them not to cause any permanent and irretrievable damage to the objects. While the use of steam in factories, on railways and roads is a matter of distant history, the electricity we use today is most often generated at power stations by modern steam turbines, invented by Sir Charles Parsons in 1884. The presentation that puts museum objects into contemporary context, interprets to the visitors the very importance of museum objects in contemporary world.*

Keywords: *steam engines, industrial heritage, museum objects, sustainability of demonstration, augmented reality*

TORPEDO WORKERS AND THE WORKING CLASS OF FIUME

Radnici *Torpeda* i radnička klasa Rijeke

Ivan Jeličić*

SUMMARY

The aim of this paper is to discuss the role of Torpedo workers in the formation and consolidation of the labour movement of Fiume. Historiography claims that Whitehead's workers remained mostly passive towards class ideology and socialism due to the detailed organisation of life around the factory, their skillfulness, high wages and, more generally, Robert Whitehead's paternalism. Though the image of exception can be more easily confirmed that disputed, nevertheless the Torpedo workers' role inside the working class movement is yet to be fully defined.

The slow spread of the socialist ideology on the Hungarian Adriatic shores was one of its main features. An explanation of this negative characteristic was not only the apparent tensions between nationalities, but also primarily the deficiency of a large working class. Since the Torpedo factory was one of the largest industries in Fiume, which employed a number of workers, it is crucial for the study of socialist ideology to analyze the issues of its workers. As said above, certainly the late formation of the socialist movement in Fiume was in a relation with the advantageous position of Whitehead's workers. However, the presence of Torpedo workers in class organisations prior to the socialist controlled trade unions, demonstrates a connection between Torpedo workers and the labour movement. Thus, through data present in the State Archive of Rijeka regarding members of class organisations, socialist organisations and finally, police lists of communists, this paper will try to exhibit how Torpedo workers were also part of the working class of Fiume and not simply an elite above the rest of the labour force.

Keywords: Torpedo, *working class, workers organisations, socialism and communism*

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SAŽETAK

Ovim se radom želi razmotriti uloga radnika tvornice Torpedo *u stvaranju i jačanju radničkog pokreta Rijeke. Historiografija tvrdi da su Whiteheadovi radnici bili uglavnom pasivni prema ideologiji klase i socijalizma zbog dobro organiziranog života oko tvornice, zbog toga što su bili vješti u radu, zbog visokih plaća te, općenitije, zbog Whiteheadova paternalizma. Iako se iznimka može lakše potvrditi nego osporiti, ulogu radnika* Torpeda *u pokretu radničke klase tek treba do kraja definirati.*

Sporo širenje socijalističke ideologije na obalama mađarskog Jadrana bila je jedna od njezinih glavnih osobina. Objašnjenje te negativne karakteristike nije samo u očiglednim napetostima između nacionalnosti, već prije svega u pomanjkanju brojne radničke klase. Budući da je tvornica Torpedo *bila jedna od najvećih u Rijeci, s velikim brojem zaposlenih radnika, želi li se istraživati socijalistička ideologija nužno je analizirati pitanja u vezi s radnicima te tvornice. Kao što je već rečeno, kasno stvaranje socijalističkog pokreta u Rijeci bilo je povezano s povoljnim položajem Whiteheadovih radnika. Međutim, prisutnost* Torpedovih *radnika u klasnim organizacijama prije socijalističkih sindikata, pokazuje vezu između radnika* Torpeda *i radničkog pokreta. Uz pomoć podataka koji se nalaze u Državnom arhivu Rijeke s obzirom na članove klasnih organizacija i socijalističkih organizacija, te policijskih popisa komunista, ovaj će rad pokušati pokazati kako su radnici* Torpeda *isto tako bili dijelom radničke klase Rijeke, a ne samo radnička elita.*

Ključne riječi: Torpedo*, radnička klasa, radničke organizacije, socijalizam i komunizam*

MILITARY-TECHNICAL INSTITUTE IN KRAGUJEVAC

Vojnotehnički zavod u Kragujevcu

Dragica Jovanović*

SUMMARY

The cultural-historical complex of the Military-Technical Institute in Kragujevac is the oldest surviving entity of the urban industrial landscape in Serbia. The first building of the MTI's complex, Gun Foundry Building, *was built in the period from 1851 to 1853. As the oldest factory complex in this region of Europe, it was a vestige of the beginning of industrialization. Armory factory in Kragujevac, as it was originally called, became the largest military factory. The factory from the second half of 20th century is well known as* Zastava Kragujevac, *one of the biggest industrial giants of ex-Yugoslavia.*

Keywords*: military, industrialization, Kragujevac, industrial landscape*

SAŽETAK

Kulturno-povijesna cjelina Vojnotehničkog zavoda u Kragujevcu najstarija je sačuvana cjelina urbanog industrijskog krajolika u Srbiji. Prva zgrada u kompleksu VTZ-a bila je zgrada Topolivnice *koja je sagrađena između 1851. i 1853. Kao najstarija tvornička cjelina u ovom dijelu Europe označila je početak industrijalizacije. Tvornica koja se prvobitno zvala* Oružarnica, *postaje najveća vojna tvornica. U drugoj polovici 20. stoljeća poznata je kao tvornica* Zastava Kragujevac *koja je bila najveći industrijski gigant bivše Jugoslavije.*

Ključne riječi: *vojska, industrijalizacija, Kragujevac, industrijski krajolik*

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NAVAL HERITAGE OF BAY OF BOKA KOTORSKA FROM THE XIX AND XX CENTURY

Mornaričko nasljeđe zaljeva Boke kotorske iz 19. i 20. stoljeća

Dražen Jovanović*, Ilija Mlinarević**

SUMMARY

Boka Kotorska is the largest bay in the Adriatic, and a specific cultural and geografic entity, positioned in the South Western part of Montenegro. Its geomorfological characteristics are significant, just like its strategic position.

The following characteristics marked Boka Kotorska as a significant point of military marine and military marine industry.

From the period of Austro-Hungarian monarchy (until 1918), Boka Kotorska was one of the most important military bases, thanks to its geographical position and morphology of the terrain. It retained the status of important military base and became a significant strategic point for the Vienesse Court. This was emphasized on the eve of the Great War (World War I), when this part of the coast witnessed the bombing of Lovcen and from Lovcen, the launching of the German and Austro-Hungarian submarines to missions across the Mediterranean and a great mutiny of the sailors in 1918.

A turbulent history characterizes, also, a period of WW II from the very begining (sinking of the "Zagreb" destroyer), to the magnificent victory and liberation. The Socialistic Yugoslavia consistently continued the development of naval and civil marine traditions.

The original naval and seaplane base in Kumbor, and the Naval Arsenal in Tivat, were responsible for industrial, military and maritime development of Boka Kotorska from the Austrian period to the end of the Socialist Yugoslavia. Their success is connected with the names of many people as Miroslav Shturmberger, submariner and constructor of torpedo and mine arms, Maximilian Sterneck, Admiral of the Austro-Hungarian Navy, whose idea was to establish the Naval Arsenal in Tivat (Teodo) in 1889, as well as many other people.

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The Arsenal was constructed in the late 19th century in Tivat, as a military base, in order to strengthen the Austro-Hungarian fleet in the Southern Adriatic. It was an important entity of shipbuilding industry of Mediterranean, and its function was to supply and maintain military vessels and their systems.
The seaplane base in Kumbor was constructed in 1913. During WWI, its hydroplanes flew to the recon and bombing missions over the Montenegro, Italy and Albania. In the Kingdom of Yugoslavia, it was the base of the Third Seaplane Command, the strongest part of the Yugoslavian naval aviation. During the April war in 1941, the planes from Kumbor attacked the enemy bases in Albania and Italy and Axis' ships in the southern Adriatic.
The impressive historical background of these complexes, is the main motive and an inexhaustible source of new, inspirative information from the field of naval history of Boka Bay.

Keywords: *Boka Bay, Military maritime, Arsenal Tivat, Kumbor, Shtumberger, Shterneck*

SAŽETAK

Boka kotorska najveći je zaljev na Jadranskom moru i specifična kulturološka i geografska cjelina koja se nalazi u jugozapadnom dijelu Crne Gore. Značajne su njezine geomorfološke karakteristike i njezin strateški položaj.
Slijede karakteristike koje su Boku kotorsku označile kao važnu točku za ratnu mornaricu i njezinu industriju.
Od vremena Austro-Ugarske Monarhije (sve do 1918.) Boka kotorska je zahvaljujući svome geografskom položaju i morfologiji terena bila jedna od najvažnijih vojnih baza. Zadržala je status važne vojne baze i postala značajna strateška točka za bečki dvor. Posebno je to došlo do izražaja uoči Velikog rata (Prvi svjetski rat) kada je ovaj dio obale doživio bombardiranje Lovćena te bombardiranje s njega, lansiranje njemačkih i austrougarskih podmornica u misije po Mediteranu i veliku pobunu mornara 1918.
Turbulentna povijest karakterizira i razdoblje Drugoga svjetskog rata od samog početka (potapanje razarača Zagreb*) sve do veličanstvene pobjede i oslobođenja. Socijalistička Jugoslavija dosljedno je nastavila razvoj mornaričke i civilne pomorske tradicije.*
Izvorna mornarička baza i baza hidroaviona u Kumboru, kao i pomorski Arsenal u Tivtu, bili su odgovorni za industrijski, vojni i pomorski razvoj Boke kotorske od vremena Austrije do kraja socijalističke Jugoslavije. Njihov je uspjeh vezan za imena raznih ljudi poput Miroslava Shturmbergera, člana posade mornarice i graditelja torpeda i oružja s minama, Maximiliana Sternecka, admirala Austrougarske mornarice, čija je ideja bila osnivanje pomorskog Arsenala u Tivtu 1889., i mnogih drugih.
Arsenal je bio izgrađen potkraj 19. stoljeću u Tivtu kao vojna baza, da bi se ojačala austrougarska flota u južnom Jadranu. Bila je to važna cjelina brodograđevne industrije u Mediteranu, a funkcija joj je bila izgradnja i održavanje vojnih plovila i njihovih sustava.
Baza hidroaviona u Kumboru izgrađena je 1913. Za vrijeme Prvoga svjetskog rata njezini su avioni letjeli u izvidne misije i misije bombardiranja nad Crnom Gorom, Italijom i Albanijom. U Kraljevini Jugoslaviji tu je bila baza Treće komande hidroaviona, najjači dio Jugoslavenske ratne avijacije. Za vrijeme travanjskog rata 1941., avioni iz Kumbora napadali su neprijateljske baze u Albaniji i Italiji te brodove sila Osovine u južnom Jadranu.
Impresivna povijesna pozadina ovih kompleksa glavni je motiv i neiscrpan izvor novih, nadahnjujućih informacija iz područja pomorske povijesti Bokokotarskog zaljeva.

Ključne riječi: *zaljev Boka kotorska, ratna mornarica, Arsenal Tivat, Kumbor, Shtumberger, Shterneck*

SALCHER & MACH'S TEACHERS (ON CENTENNIAL OF MACH'S DEATH)

Salcherovi i Machovi učitelji (u povodu stogodišnjice Machove smrti)

Stanislav Južnič*

SUMMARY

Salcher and Mach were educated in Inner Austria and Vienna. Mach was additionally tied to the University of Prague where Mach and his idol Doppler taught. Mach's father studied in Prague, taught teenager Ernst at home, and welcomed Ernst's holidays in his farm in Veliki Slatnik. There Ernst developed his practical-experimental approaches although his mother and father died in Slatnik before Salcher's measurements in Torpedo Factory.

During his undergraduate and graduate studies Salcher heard almost opposite descriptions of the heat phenomena. Salcher's teacher of physics and mathematics in Grammar School of Klagenfurt was a Benedictine Karl Robida from Ljubljana sub-orb who criticized the new Clausius' kinetic theory of gases. He prematurely detected Hertz's waves and Grove's sputtering, and described the reversibility paradox with old-fashioned vibration theory of heat. Salcher's only teacher of theoretical physics in his first student year in Graz was Robida's friend Simon Šubic who rejected early statistical mechanics of Robida's student Jožef Stefan and Stefan's student Ludwig Boltzmann. The second international Electric exhibition was in Crystal Palace Chandelier, beginning on March 4, 1882. Stefan was the technical-scientific leader of 3rd Viennese international electric exhibition in 1883 where Salcher, Mach, and former Salcher's Rijeka assistant Julius Puluj exhibited their instruments. Up to that time Stefan already reformed physics curriculum in Habsburg Monarchy with almost all important chairs occupied by adversaries of his kinetic theories. Stefan's victories repeated the century earlier reforms of Bošković's followers in the same schools of Habsburg monarchy where Bošković's fans kept their chairs even after the suppression of Bošković's Jesuit order. The notable exceptions of both reforms were Prague chairs of Joseph Stepling and Mach. Stefan, Mach, and Salcher's academic ancestor, the Habsburg pioneer of photography Andreas Ettingshausen, was trained in Viennese Bomabardierschule *in Bošković's spirit of professor Jurij Vega.*

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Bošković's universal attraction theory of points-centers of force developed into Stefan-Boltzmann's kinetic molecular collisions with a sort of prolonged Bošković' influence.

Keywords: *Peter Salcher, Ernst Mach, Karl Robida, Rudjer Bošković, Supersonic photography in Rijeka Torpedo Factory, History of Physics*

1. JESUITS

In Rijeka, Salcher continued the work of Rijeka Jesuits' professors of physics mostly born in Croatia and Gorizia. No Rijeka professor of physics was born in Carniola. Jesuits born in Carniola held other professorships and three of them became Rijeka rectors.

Several Rijeka professors of physics taught in Ljubljana, among them Leopold Morelli (*1702) as professor of casuistic in 1738 after his lectures on physics in Rijeka and Gorizia, and Johannes Baptist Brignoli in 1741 as professor of physics in Rijeka and in Ljubljana in 1743. In 1747 Johannes Baptista Cortivo (*1706 Rijeka) was professor of casuistic in Ljubljana after his lectures on physics in Rijeka where he taught casuistic later. The Tyrolean Johann Joris (*1714) taught physics in Rijeka, Klagenfurt, and Graz before he became a school prefect in Ljubljana. In 1767-1768 Gregor Schöttl taught physics in Rijeka and later in Ljubljana. Just Brignoli and Schöttl taught physics in Rijeka and Ljubljana. No Jesuit taught mathematics in Rijeka because of lack of money. Most of all twenty-six Rijeka Jesuit professors of physics tightly collaborated with their Gorizia colleagues because more than half of them (14) taught physics in both colleges and three (Michael Göttner, Ignazio Vitnich, Volfgang Kognigovič) taught physics in Rijeka and mathematics in Gorizia. The collaboration between Jesuit colleges of Rijeka and Gorizia in physics was therefore more intensive than the collaboration with all other colleges summed together. Three Rijeka Jesuit professors of physics taught the same subject in Zagreb, and other two in Klagenfurt, Graz, and Ljubljana. Rijeka professor of physics M. Göttner from Linz later taught mathematics in Buda, Cluj, and Košice. No Rijeka professor of physics taught mathematics in Graz or Vienna, but five of them including Göttner specialized mathematics in those two universities. Rijeka native Franjo Orlando and his student A. Capuano began their nautical-mathematical lectures in Trieste and continued in Rijeka with Josef Andreas Novak (Novagh) who was a Jesuit novice in Trenčin in crucial year of 1773 and became Rijeka professor of logic, metaphysics, practical philosophy, natural laws, ethics, and politics. Capuano was a descendant of Marcel (Marcello) Capuano who headed Trieste citizens' delegation which asked for Trieste Jesuit college in Vienna in 1617. In Rijeka Nautical school Orlando taught arithmetic, algebra, geometry, trigonometry, and nautical geography, while Capuano taught trigonometry, mathematics, double bookkeeping (scriptura duplex), astronomy, and nautical arts. All three published exam theses of 1776 and 1777 with Capuano's on Bošković's physics. In 1777 the

exam theses were published in Ljubljana with Italian translation of work of Newton's collaborator Colin MacLaurin.[1]

In 1777/78, the Academy of Rijeka was canceled. Capuano and Novak removed to Zagreb professorships. Capuano eventually returned to his native Trieste to teach mathematics and nautical-hydrography after 1783. In 1796 Capuano passed away and Orlando's student (1772-1774) Michele Andreas Stadler di Breitweg replaced him. In 1808/09, the domestic Pater-professor Petar Faribolto (Faribault) tried to renew Orlando's Rijeka nautical chair, but he passed away in the same year. The special nautical Rijeka courses were offered in 1825 attached to Rijeka Grammar school from 1835 to 1841 until they developed into a separate Maritime Academy in 1857/58 and 1866-1914.

Before Salcher no Rijeka professor of physics taught mathematics in Klagenfurt, but two taught physics there: the future Rijeka rector Francesco Xavier Petrić (*1674 Cres) and Johan Baptist Joris (*1714) from South Tyrol. Several Rijeka rectors previously taught mathematics-physics in Klagenfurt, like the physicist Franciscus Coballius (*1651) from Kamnik and the only Klagenfurt (and Linz) professor of mathematics among Rijeka rectors, the Rijeka native Josef Bardarini (*1708). Josef specialized mathematics in Vienna and taught physics in Gorizia. Several others taught in Klagenfurt before they got the chair for casuistry in Rijeka, among them the physicists Johann Ostrich (*1630) from Radgona, Franc Ksaver Obermayr (*1693) from Linz, and Ignatius Conti (*1712) from Trieste. Joannes Nepomuk Untersinger (*1711) from Velesovo in Carniola studied physics in Klagenfurt before he became the professor of physics in Zagreb and taught casuistry in Rijeka. The mathematician Franciscus Radieucig's (*1725) godparents were Nicolas count Strassoldo and Felizitas countess Orzon. Radieucig from noble Gorizian family was very instrumental in spreading Bošković's ideas in Slovenian-Croatian milieu. He may had heard something about them during his Gorizian studies of physics with Josip Zanchi of Rijeka. The Slavic Radieucig personally met Bošković and was among the first to talk about his ideas while he taught humanities (Trieste 1747/1748), physics (Zagreb 1756/57 and Gorizia 1759/60), mathematics (Klagenfurt 1761/62 and Ljubljana 1763/64), casuistry (Rijeka 1762/63 and Gorizia 1764/65-1770/71). He returned to Rijeka in 1771/72 to head the congregations, and met the end of his order as catechist in Gorizia. There he spent his last 35 years in company with his younger brother Leopold (*1729) who came to Rijeka after Francisus left as the prefect of humanistic studies in 1764/65 and 1765/66.

In average, the Rijeka professors of physics held one and the half char of mathematics or physic elsewhere, but Rijeka rectors did not teach so much technical stuff. The works of one third of Rijeka physicists as well as rectors are preserved. Most of them discussed physics.

[1] Capuano, 1777.

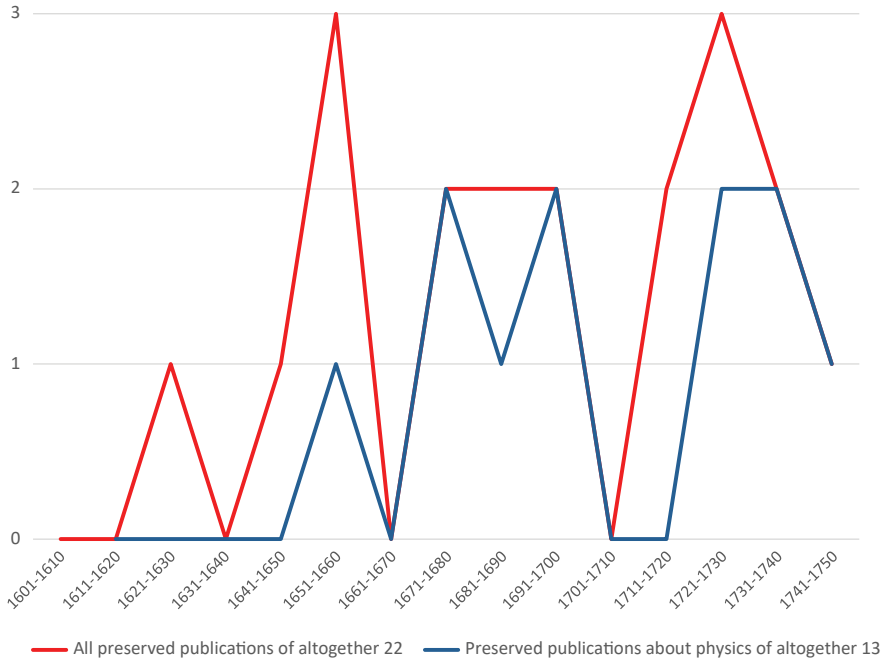


Figure 1. *Preserved works of Rijeka rectors and professors of physics*

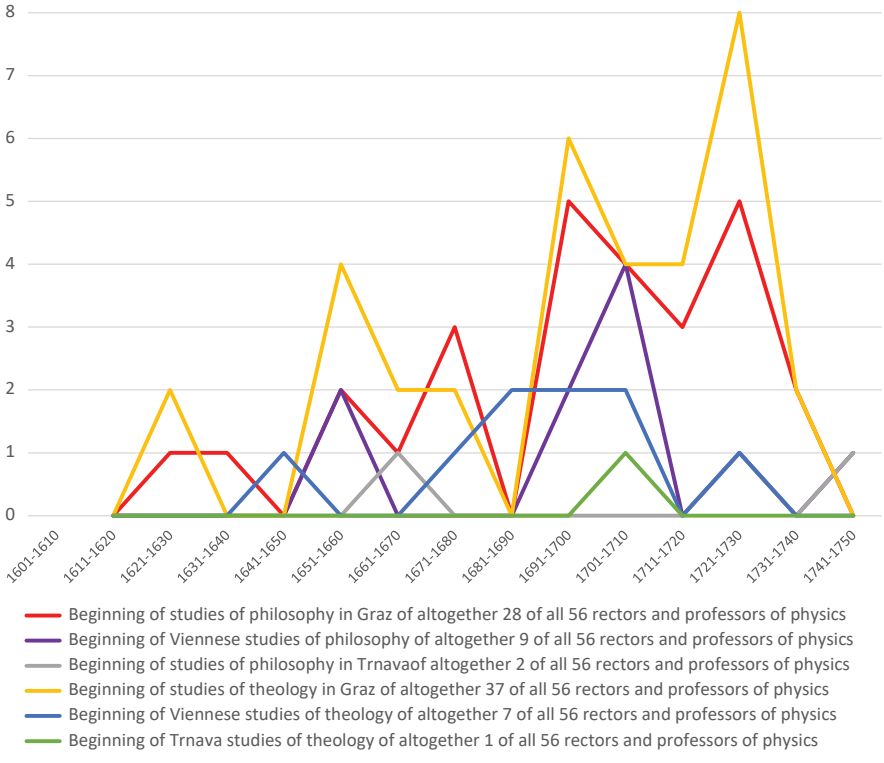


Figure 2. *Studies of 56 Rijeka rectors and professors of physics*

2. JESUITS' NETWORK: KLAGENFURT, GRAZ, TRIESTE, VIENNA, PRAGUE

Salcher formed as physicist in Klagenfurt, Graz, and Trieste before he came to Rijeka, and Mach did the same in Vienna, Graz, and Prague. All those places were scientifically and educationally advanced compared to Rijeka before the establishment of Torpedo Factory and Maritime Academy. They exported their Literati to Rijeka especially in times of over 1500 professors of physics and mathematics in Jesuits' colleges of Austrian-Bohemian provinces.

Technically trained Jesuits were mostly the professors of mathematics of Bošković's sort. After the Theresian reforms, the technical experts included professors of physics within philosophy. In the mid-18th century their field was professionally divided among professors of logic-metaphysics of Storchenau's profile, and the professors of physics. Despite of those reforms in all colleges except Graz and Vienna professors of philosophy still rotated, but not any more in three-year cycle by in dual cycle between physics and logics-metaphysics. Thes were partly professionals in their faculties of philosophy where the studies were shortened from three to two years. In the Austrian province, they had more physics-mathematics professorships compared to the Bohemian province, therefore an expert had more chances for employment. The Bohemian chairs for mathematics and physics-philosophy developed only in Czech Prague and Moravian Olomouc which later moved to Brno. After Emperor Leopold I's bulla on 1/10/1702 both chairs were also in Silesian Wroclaw, but the area was ceded to independent province after Frederic the Great conquered Silesia for Prussia. As the Bohemian province, the Austrian province also commanded three main colleges in Duchy-Austrian Vienna, Inner-Austrian Graz, and Hungarian-Slovakian Trnava. Many later professors of physics and mathematics studied in Graz especially before the Thirty Years War while Prague or Olomouc were not that much popular among the future professors of Austrian province. Graz Jesuit university had the unique role in mid-European milieu.

■ **Table 1:** *Technical sciences in Austrian Jesuit Province*

College	Professors of mathematics-physics fields (number of local professors of mathematics; all professors of mathematics including those who locally taught just physics; specialized mathematicians who never taught mathematics (locally))	Mathematics-physics chars&mathematical specializations including the domestic ones of colleges with philosophical faculty/ mathematical chairs and specializations	Number of preserved works (all, physics, mathematics, astronomy)	Beginnings of philosophical/ theological studies in Graz, Vienna, or Trnava in percentage
Vienna	280 (106, 350, 18 (80))	712 (253%)/350	192 (79%), 79, 19, 13	36/39, 31/40, 6/3
Graz	245 (64,50)	655 (268%)	183 (75%), 65, 17, 10	44/53, 27/32, 5/2
Trnava	186 (101)	496 (235%)	128 (60%), 35, 9, 10	36/33, 23/30, 18/30
Klagenfurt	151 (45,52,5)	379 (241%)	84 (53), 12, 10, 2	39/54, 36/31, 4/5
Košice-Banská Štiavnica	130 (41)	276 (215%)	67 (52%), 22, 3, 1	25/28, 21/25, 28/38
Linz	105 (32)	288 (277%)	69 (66%), 13, 5, 3	46/38, 39/60, 3/1
Ljubljana	83 (22)	217 (261%)	59 (71%), 27, 8, 1	41/58, 34/27, 5/8
Gorizia	83 (15)	200 (241%)	45 (54%), 22, 3, 3	43/38, 16/18, 2/1
Zagreb	78 (5,18)	158 (205%)	44 (57%), 15, 5, 2	38/49, 8/11, 11/11
Passau	64	148 (231%)	35 (54%), 10, 2, 0	25/37, 28/24, 2/2
Cluj-Timisoara-Alba Iulia	59 (20)	147 (249%)	44 (75%), 5, 2, 4	11/9, 13/16, 16/23
Buda	59 (19)	182 (308%)	37 (63%), 10, 1, 4	12/36, 34/31, 31/31
Rijeka	27 (1)	67 (248%)	9 (33%), 7, 0, 0	67/70, 15/15, 0/4
Györ	21	56 (267%)	11 (52%), 3, 2, 1	14/29, 29/29, 29/38
Rijeka professors of physics/with rectors included	27/56	101 (194%)	18 (35%), 11, 0, 0	52/67, 17/17, 4/2

Maribor (all Jesuits)	64	32 (51%)	19 (30%), 4, 3, 0	10/8, 18/34, 8/11
Ljubljana:all 1449 Jesuits	397 (66)	739 (51%)	330 (23%), 69, 20, 10	35/40, 18/40, 29/2
Prague (with some physicists missing)	106 (57, 60)	83 (213%)	19 (49%), 6, 2, 3	10/14, 5/2, 0/0, Prague 23/13, Olomouc 8/3
Olomouc (with some physicists missing)	78 (45)	66 (206%)	9 (28%), 3, 1, 3	4/12, 4/2, 0/0, Prague 19/4, Olomouc 13/3
Požega professors of physics	6	11 (183%)	3 (50%), 1, 0, 0	7/50, 0/0, 17/50
Serbian technically trained Jesuits	54	46 (83%)	8 (15%), 3, 1, 0	19/33, 26/9, 7/13
Important Varaždin Jesuits	158	124 (78%)	47 (30%), 17, 2, 1	48/55, 13/13, 9/13
Important Trieste Jesuits	43 (1)	70 (167%)	23 (35), 14, 0, 1	43/48, 20/24, 2/0
Professors of mathematics-physics in Ukraine: Ungvarinum = Uzhorod/Lemberg = Lvov = Lviv	10	24 (240%)	5 (50%), 1, 0, 2	20/0, 20/50, 0/0
All Physicists-mathematicians (mathematicians)in Austrian/Bohemian Province with specializations	1447 (388, 388, 64)/184 (496/102)	Altogether Austrian&Bohemian provinces professors of mathematics and physics 1447	Austrian province professors of Mathematics 260; Austrian professors of philosophy-physics 1075; lecturing in both fields: 189	

In Austrian province besides Graz, Trnava and Vienna many other smaller colleges also developed chairs for philosophy-physics and mathematics. The Hungarian areas of Trnava, Košice, Cluj, Györ, and Buda formed Hungarian-Slovak-Romanian professors born in 1720s and 1730s. At the same time in mid-century the major centers as Theresianum or Trnava established the new University Departments of civil and military Architecture for Ignatius Lampl (Lampel, *1714) connected with his chair of mathematics. Lampl' successors were: later Ljubljana rector Christian Rieger (*1714 Vienna), Italian Johannes Izzo (Izzó, *1727 Košice), Ignacius Schiffermiller (*1727 Linz), later Ljubljana architect Jožef Jakob Liberatus Maffei von Glattfort (*1742), and Franciscus Xaver Riedel (Riedl). Almost a quarter of century after Vienna in 1769 in Trnava the chair for architecture was established for Peter Spaitz (Spaics,*1735), and for Trnava-Viennese architect Ignaz Rauch. In Trnava, the chair of practical geometry and geography influenced by Bošković's geodesy was established in 1762 and the chair for geography was established in 1767 for Andreas Bernolak (*1727). The guardians of individual mathematical-physical and astronomical-collections of museums and observatories, and heads of Departments of Mechanics were employed in Vienna and Graz. Just before the suppression of Jesuits the chairs for mechanics and agriculture were established even in the smaller colleges including G. Gruber's Ljubljana or Ptuj-native Antun Raišp's Varaždin. Only F. Orlando's Trieste-Fiume and Gruber's Ljubljana developed the chairs for nautical sciences. Trnava and Trenčin employed the prefect of printery who certainly involved some technical abilities. One of them was mathematician-astronomer from Ljubljana Franc Breckerfeld. Trnava was the Hungarian-Slovakian equivalent for Austrian Vienna or Bohemian Prague, but Košice or Olomouc Universities were hardly match for Graz University. If we count the number of professors of mathematics-physics and their preserved works in that field the best score had the oldest university of Prague, and Vienna with its nearly four hundred professors of mathematics, physics, and related fields.

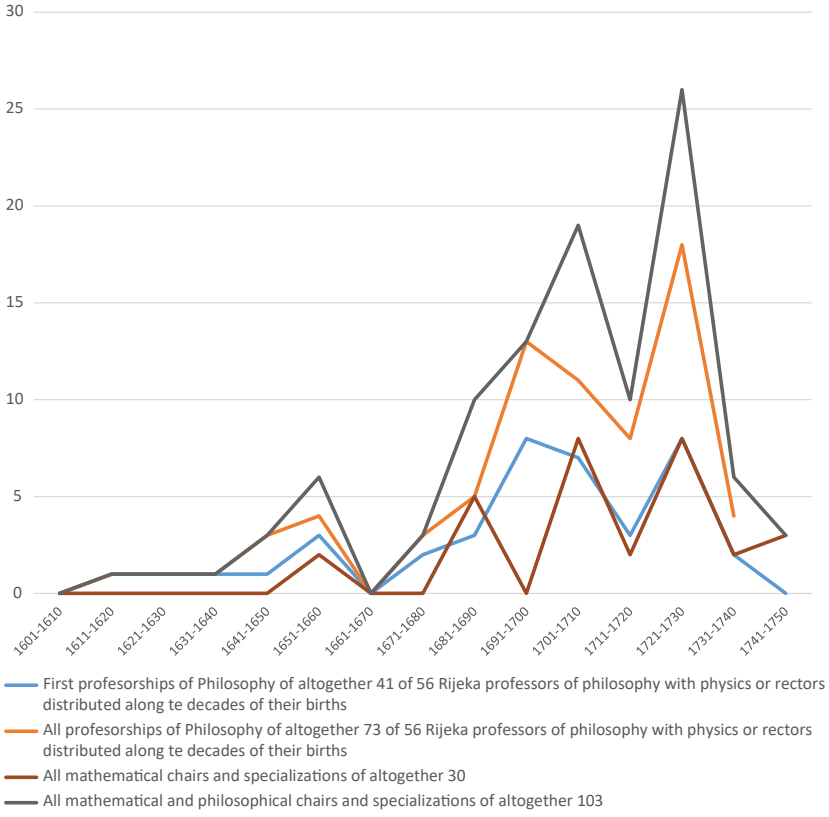


Figure 3. *Lecturing chairs of Mathematics and Philosophy of Rijeka Rectors and Professors of Physics*

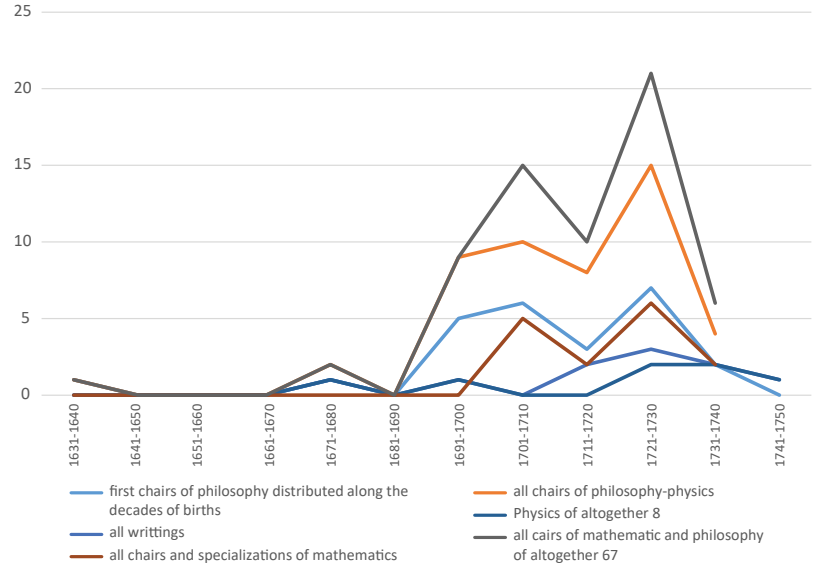


Figure 4. *27 Rijeka Professors of Philosophy with Physics-Chemistry, their Lecturing and Preserved Works*

At least fifteen hundred professors of mathematics and/or physics were employed in Austrian-Bohemian Jesuit Provinces. 1247 (86%) of them taught physics, 388 (27%) mathematics, and 215 (15%) both in Austrian and Bohemian provinces. At least 64 Jesuits who specialized mathematics in Vienna, Graz or Trnava never taught mathematics or physics. At least 259 professors of mathematics and/or physics were employed in Bohemian Province (Prague,Olomouc,Wroclaw). 144 (56%) of them taught physics, 106 (41%) mathematics and 22 (9%) both, but at least 200 professors of physics replacing each other every year in Prague, Olomouc, and Wroclaw from the century-period 1623-1727 were not taken into account. Before Theresian reforms the Jesuit catalogues listed professors of mathematics and physics on the end of notes because those professorships were just a step from lower-school teaching of Masters to the professorships of theological faculty except in *Collegio Romano* of Clavius, Grienberger, Kircher, and Bošković.

Austrian Jesuits province employed professors of physics over fifteen hundred times in different colleges, some of them several times in the same location. The number of all professors of mathematics was 60% of all professors of philosophy with physics and logics-metaphysics because the professorships of mathematics became the domain of Jesuits relatively late and mathematicians usually held their chairs for several years compared to the professors of physics who were a part of trienium up to the Theresian reforms. The number of those professorships was smaller in Bohemian province.

The Jesuits did not hire their own mathematicians before Henricus Blyssemius from Bonn in Prague in 1561 and Gabriel Morales from Spain in Vienna in the same year because they had no worldwide success in that field before C. Clavius. Up to the times of Marcus Marci the Jesuits tried in vain to gain the total control of the universities of Prague and Vienna including their mathematics, while in Graz they had no competitors. A generation later in 1587 the new university of Graz chair of mathematics was founded for Laurentius Lupius of Loraine, but also Olomouc did not have local mathematician before the famous Grienberger in his student days of the same year 1587. Trnava had much older university compared to Graz, but the Jesuits hired no mathematician there and in nearby Košice before the mid-17th century, in 1641 and 1658 respectively. Their main problem was a shortage of money because of the Turkish assaults. From 1561 to 1762, Jesuits from Prague employed one professor of mathematics and later two of them for lower and higher mathematics. The former taught in the first year of philosophical studies and the later also had to deal with one, later with two-years mathematical specialization of the masters of arts. They also hired *Praefectus Speculae astronomicae* from 1750 to 1773. In Vienna and Graz, the progress in the same direction was somewhat quicker and in Vienna they established more professional university positions for mathematicians.

In smaller colleges, most mathematicians did not teach their mathematics. For example, in Ljubljana 19 Jesuit professors of mathematics taught mathematics before 1773/74, but other 49 former or later professors of mathematics performed other duties, 29 of them after the establishment of Ljubljana higher studies in 1704/05. Ljubljana obliviously needed twenty mathematicians even before it had its own chair for mathematics! As much as 397 professors of physics and mathematics were employed in Ljubljana, but just 83 (21%) of them taught physics or mathematics there. 94 Ljubljana Jesuits went through mathematical specialization mostly in Graz and Vienna and five of them in different universities. Almost all of them specialized after the establishment of Ljubljana higher studies in 1704/05 because the specialization process of Ch. Clavius' Roman type became common in Austrian province relatively late. 1/3 (32) of those specialized mathematicians later taught mathematics including two of those who specialized in different universities. Other two thirds learned the applied mathematical know-how, but did not use it in teaching. With those facts in mind, we could imagine the Jesuits' knowhow as a military-disciplined collective society network where the able nonprofessional mathematicians acted as advisors. Even Rijeka with no professional mathematician employed, accumulated some mathematical knowhow to discuss the practical mathematical challenges with insiders or with non-Jesuits.

In Ungvarinum=Uzhhorod in Ukraine later provincial Stephanus Dinarić (*1668) and his older companion from Linz Anton Stieff (*1660; †1729) began philosophical lectures in 1699. But the regular Ukraine chair for philosophy was established in Lemberg=Lvov=Lviv for Faustyn Grodzicki in 1744 later for Rijeka-native Ignatius Rain (*1737), and also for the famous Bošković's friend Joseph Liesganig after the first secession of Poland when Lvov became a part of Habsburg Galicia in 1772.

The provincial Dinarić forced the establishment of Jesuit Colleges in Timisoara and Beograd after Turks (temporarily) left the area in 1718. Fifty-four Serbian Jesuits with chairs of mathematics-physics elsewhere preferred Viennese philosophical and Graz theological studies. They lectured on technical stuff less frequently compared to Rijeka rectors-physicists and produced less books than others because their destination was oral missionary work among the predominantly illiterate people of mixed religious affiliations. Varaždin and Trieste Jesuits produced comparable number of works compared to Rijeka rectors-physicists, but Trieste Jesuits had the highest number of mathematics-physics chairs comparable only to Györ. Varaždin and Maribor-based Jesuits filled less mathematics-physics chairs than Serbian-based Jesuits. The reason was in connection of Varaždin and Maribor Jesuits with the dangerous work on Turkish borders where other skills were much more important compared to the publication of books.

The professors of technical stuff from Buda held the greatest percent of technical chairs because they worked in newly established wealthy institution with modern professors in 1685 after the Turks left the area. Zagreb and Košice relatively isolated universities had the lowest percent of technically-oriented professors. Graz and Cluj professors had the most of their written works preserved, and Rijeka with the lowest score was more than twice their minor. Klagenfurt had relatively best score in mathematical but not in physics texts and Trnava was excellent in astronomy as shown in number of authors with preserved texts. Both philosophical and theological studies in Graz were far the most popular for future Rijeka and Zagreb professors of physics, but the Hungarian professors of Buda, Cluj and Györ were the only ones which preferred Vienna and Trnava. Rijeka rectors did not hold so many chairs of philosophy and mathematics as their subordinate professors of physics. They still preferred university of Graz although considerably less compared to their local professors of physics. They produced similar amount of preserved works but were more concentrated on theology and not on physics as their subordinated professors of physics were. All Maribor and Ljubljana Jesuits produced an amount of preserved works comparable to Rijeka physicist but held relatively much less technical chairs. The preference of Graz philosophical studies was twice greater for all Ljubljana Jesuits compared to professors of mathematics-physics among them. They much more frequently studied philosophy in Trnava even compared to Vienna, certainly also for their preparation for east missions on Turkish border. Požega established the regular chair for physics only in the last decade in 1762 with Martin Szabolovich from Križevci, Rijeka-Born-Graz-trained Gorizia-mathematician Franc Borgia Peri (*1729), and local-born-Trnava-trained Zagreb-physicist Mirko Mihalj (*1730; †1779) as one of the most important followers of Bošković.

In view of technical sciences, the worst were the colleges without lectures in mathematics and physics in Belgrade, Petrovaradin, Maribor, Varaždin, Timisoara, Leoben, or Steyr. They only occasionally hosted some of them, for example an astronomer F. Weiss in Steyr, or in 1666 mathematician-optician Z. Traber and physicist Johann Lindelauff, and later mathematician-biologist Michael Franz Xaver Eder in Leoben, or Johann Werdnig (Werdnigg,Brdnik) from Slovenji Gradec in Judenburg. Slightly better off were colleges with only one professor for philosophy who rotated in a philosophical triplet between logic, philosophy, and physics until the last years of Jesuits' schools in Požega, Passau, Györ, Rijeka, and Zagreb. In Trieste, Györ and Zagreb in the last Jesuits' years they employed the additional professor of nautical sciences or mathematics. In the same time in 1762 the Mining Academy was established in Slovakian Banská Štiavnica with Jesuits Nicolaus Poda von Neuhaus (1766-1771), Ptuj-Born Karl Tirnberger from 1772 to 1773, and local mathematician Ignaz Roys (*1705; †1777), as well as the ex-Jesuit Ignaz von Born from 1769 to 1770. All of them were involved in technical issues. In 1669 Zagreb Jesuits had

achieved the rights of university which didn't belong even to the technically much more advanced and wealthier college in Klagenfurt. Klagenfurt of Carinthia sought in vain for the status of a university because it had no political independent history compared to Croatian Zagreb.

On a slightly higher level were colleges which employed three or at least two lecturers of philosophy with a physicist as one of them. They usually hosted the professors of mathematics, but sometimes he was not employed because of the money shortage as we see in colleges in Gorizia, Ljubljana, and after a later introduction of the chair of mathematics also in Buda. The colleges with regular lectures in mathematics and physics but without the privileges of the university were in the Romanian Cluj, Upper Austrian Linz, and Klagenfurt. The Jesuits of Cluj accomplished good astronomical observations. In the highest category were the universities in Graz, Slovakian Košice, and Trnava, which were comparable to Olomouc. Vienna and Prague as the imperial cities with established universities figured high above the rest. The universities of Graz and Trnava were comparable among each other, while in Trnava much more effort was put in local astronomical observatory which was removed to Buda-Pest a decade after the suppression of Jesuits. The Jesuits of Graz had much more contact with the Viennese who were their only equal. Certainly, most of the Jesuits' stuff employed in Trnava and other major Universities were locals, after the early years when the help of better educated Jesuits from Habsburg Netherlands was desperately needed.

Of course, various colleges had their local advantages: in 17th century Klagenfurt hosted a residence for third probation in Dobrla Vas (Dobrldorf) as did Judenburg, Banská Bystrica, Alba Iulia, and occasionally later also Eger or Leoben. The novitiates were mostly in Trenčin, Vienna, Brno, and Leoben. Pleterje was a healing destination, but many times also the final resting place for ill Jesuits. These features meant that many Jesuit professors had to visit a college in Klagenfurt, at least in the early years. Their connections of course greatly enriched the local technical sciences.

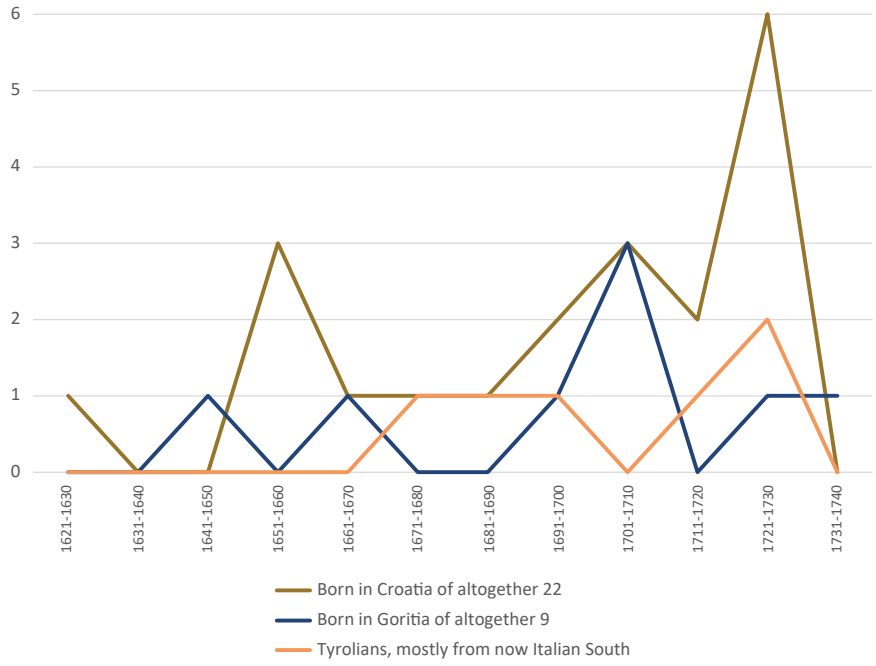


Figure 5. *Most frequent places of births of Rijeka Rectors and professors of philosophy with physics*

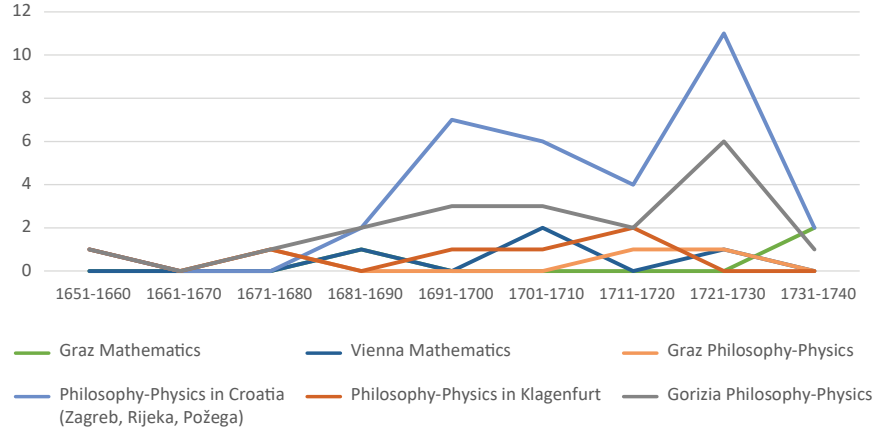


Figure 6. *Rijeka Professors of Philosophy on most frequent mathematics and Philosophy chairs*

The comparisons between technically trained experts in Austria (and Bohemian) Jesuit province it is essential to understand the dynamic of Jesuits' network staff exchange. Particularly only the Universities of Vienna, Graz, and Trnava hosted over two hundred technical experts, while Klagenfurt or Košice had over a hundred of them, and in Gorizia or Ljubljana they welcomed about hundred professors of technical fields. Graz professors of philosophy and mathematics held more chairs in Vienna as in all other colleges together. Trnava and Linz were the second most common destination for technical experts, but the mathematicians were much more popular in Linz. The Viennese technical experts behaved similarly because their lectures in Graz were more frequent than in all other colleges summed together. After Graz, Linz followed again, but Klagenfurt was more frequent than Trnava. For technical oriented professors from other colleges Vienna and Graz have not been the most common destination for professors of philosophy with physics. For example, Klagenfurt technical oriented professors were frequently exchanged with Passau, often also with Gorizia and Ljubljana. The mathematicians from Klagenfurt often taught in Vienna or Graz. They were ahead of Linz and Ljubljana, where the Jesuits employed the mathematicians much later. The Klagenfurt professors of mathematics-physics were slightly less common in Trnava because of the traditional boundaries between Austria and Hungary. Even if the reverse is not true, the Trnava professors of mathematics frequently lectured in Graz and Vienna, much more than the professors of physics.

Table 2: *Bošković and Stefan's followers in the academic positions of Habsburg Monarchy and Nearby*

Institution	Bošković's followers	Bošković's antagonist	Stefan's followers	Stefan's antagonist
University Vienna/1751-1806/1817-1818,1821-	J. Liesganig, Scherffer (1751-1783); Anton Ambschell; Franc Samuel Karpe (1786-1806)	Maximilian Hell, Remigio Döttler	A. Ettingshausen (1817-1818, 1821-1866), Grailich; Stefan, Loschmidt	Mach 1895-1898
Bombardierschule Vienna/1782-1802/1816-1817	Jurij Vega		A. Ettingshausen	
Academy Vienna/-/1863, 1865-			Stefan 1863, 1865-	Andreas Baumgartner, Mach
Polytechnic Vienna			Johann Philip Neumann	
Theresianum	Johann Schöttl (1754-1757; 1762-1763); Paul Mako (1757/1758-1774)		Tivadar Puskás	
University Graz/1763-1804/1864-1865,1869-	Biwald 1763-1804; Leopold von Wisenfeldt 1771-1773		Viktor von Lang 1864-1865; L. Boltzmann 1869-, Klemenčič	Mach (1865-1867), Simon Šubic
Graz Polytechnic/-/1865-1871,1886-1920			Ferdinand Lippich 1865-1871, Albert Ettingshausen	
Styrian Natural History Society			Boltzmann 1869-	Šubic
University Buda /1765-1769/1872-1876	Antun Radić (1765,1766); Ivan Horvat 1768-1769	Franz Weiss (1777-1785); Janos Sajnovics (1773-1784)	Kololman Szigeth Szily	
Buda Grammar School /-/1857				Šubic
Pest Grammar School /-/1858-1861				Šubic

Institution	Bošković's followers	Bošković's antagonist	Stefan's followers	Stefan's antagonist
High Real School Pest /1860-1861/1858-1861				Šubic, Martin Sekulić
University Trnava/Budapest	Anton Radić (1763-1764); Ivan Horvat (1770-1792); Mako (1774-1782); Johan Alber	Weiss 1761-1777	Loránd Eötwös	
University Prague /1766-1804/1874-1919	Jan Tessánek 1759-1763,1770-1778, Stanislaus count Wydra (1766-1804)	Joseph Stepling (1748-1778)	Ferdinand Lippich 1874-1919	Mach 1867-1895
Prague Polytechnic /-/1865-1883				Schmidt 1865-1883
Prague *Královska Česká společnost nauk*	President Jan Tessánek 1784	Bernard Bolzano 1818-1848		Baumgartner 1864
University Olomouc	Jan Pawlik 1764-1773; Tessanek 1768-1769; Karpe 1774-1786			Baumgartner
University Czernovicz: 1876-				Alois Handl
University Lvov /1766-1799/1862-1872	K. Scherffer (1773-1783); Ignjat Martinović (1783-1791); J. Liesganig (1766-1799)			Alois Handl 1862-1872
University Innsbruck /1772-1773/1819-1821,1895-1901	Franz Seraphin Zallinger		Andreas Ettingshausen 1819-1821, Ignac Klemenčič 1895-1901	
Higher Studies Ljubljana /1760-1785/1870-1874	Biwald (1755-1757); Johann Schöttl (1759/60,1760/61), Johann Pogrietschnig (1763-1769), G. Schöttl (1769-1775), their students Franc Samuel Karpe and Jurij Vega; A. Ambschell (1773-1785)		Joseph Finger 1870-1874, Luka Lavtar 1873, Borštner	
Higher Studies Novo Mesto /1803-1816/	Teofil Zinsmeister, Kastul Hieber		Grammar school: Bernard Vovk, teacher of Klemenčič	

Institution	Bošković's followers	Bošković's antagonist	Stefan's followers	Stefan's antagonist
Higher Studies Gorizia /1810/1872-1907	Ambrozij Redeskini		Grammar School: Anton Šantel in	
Higher Studies Klagenfurt /1759-1805/1873-1883	Johann Schöttl (1758/59); Franc Wulfen (1764-1805); Leopold Apfaltrer (1765-1773)		Grammar School: Vincenc Borštner	K. Robida
North Italy (University Pavia, University Milano, Florence, Torino Brescia) /1764-1819/1850	Bošković, Sigismundus Hochenwart, A. Volta	Paolo Frisi, Gerdil, Louis Lagrange, Scarella, Gian Rinaldo Carli	Gabrio Priola	
Higher Studies Trieste /1754-1773/1863-1885	F. Orlando, A. Capuano		City Real High School Trieste Nicolo Vlacovich	
Zagreb /1778-1797/1875-1911	Redeskini's theology in Zagreb 1778-1793. In academy: Anton Pilippen 1770, Franc Ksaver Volkovič 1771, Anton Kukec 1777-1797			Former Mach's Prague assistant-professor Vinko Dvořák
Higher studies Rijeka /1767-1782/	G. Schöttl 1767-1768, F. Orlando 1773-1784, A. Capuano 1775-1782			
Maribor High Real School /-/1877			Robert Spiller	
Maribor Grammar School /1773/1891	Peter Halloy		Josef Hirschler	
Koper /1760-1763/1858-1863		Gian Rinaldi Carli	Nicolo Vlacovich	
Dresden Polytechnic and Technical High School /-/1876-1900			Toepler 1876-1900	Georg Helm 1888-1919
Leipzig University /-/1900-1902			Boltzmann 1900-1902	Wilhelm Ostwald
Berlin University /-/1884		Moses Mendelssohn 1759-	H. Helmholtz	

The only relevant non-Bošković's scientific (astronomical) milieus in Habsburg monarchy were Maximilian Hell's in Vienna and J. Stepling's in Prague. Hell visited his astronomic collaborators Franz Weiss and Sajnovics in spring 1776 and they probably shared their opinion on Bošković which may include Beijing Jesuit Hallerstein who published his works with Hell. Hell-F. Weiss-Sajnovicz-Hallerstein provided another conservative Jesuit Astronomical-Habsburg-circle besides Bošković-Scherffer-Liesganig one as shown in only preserved Hell's cool letter to Bošković congratulating his Pavia appointment on 27/2/1764, and the lack of both to cite each other in their discussions of the moon of Venus and of Aurora Borealis. Bošković wanted Liesganig to help his measurements in California, and later invited another ex-Jesuit Christian Mayer. In 1771/1772 the sharp quarrel Lalande-Hell took place after Lalande's letter to Bošković in 1772.

Besides the people who personally lectured on Bošković's theory the decisive influence for his acceptance came from the upper-society circles of Belgian minister plenipotentiary former Herman Boerhaave's Leiden and Würzburg student Johann Karl Philipp count Cobenzl (*1712; †1770), Jesuit Austrian provincials, rectors, and ministers of Viennese colleges. Among them was the Rijeka-Born Josephus Zanchi (*1710; †1786) as minister of Theresianum under the rector Mathias von Pock who served between 13/1/1754-1758. In 1747-1748 just before Bošković's fame, Zanchi published his four books on physics supporting Newton and criticizing Voltaire according to the Jesuit Noël Regnault. Zanchi's 1748 textbook of physics was dedicated to the Emperor's brother Duke-governor of Habsburg Netherlands and in the same year Zanchi published Duke's genealogy while Duke was in constant quarrel with Cobenzl who liked Voltaire and Bošković. Zanchi's important subordinate was rector after 24/4/1770 (or 1767-1773) Lower-Styrian physicists-mathematician-economist Theodor Kravina von Cronstain. All three were decisively involved in Bošković visit at the Teresianum where Pal Mako de Kerek Gede as professor of mathematics in 1756/57, Kravina as professor of physics in 1756/57, and Johann Schöttl as prefect of philosophy in 1756/57 held mathematics and physics lectures-examinations in early May 1757. Bošković also collaborated with the custodian of Natural History museum Nicolaus Joseph baron Jacquin after the former head of mathematical museum and later rector Kravina founded it in 1767.

3. SALCHER'S TEACHERS

Before Salcher's era the Jesuit monopoly in education was over but the heritage was still felt in the system of learning and in inherited Bošković's ideas. The Jesuits taught physics and mathematics for more than a century in Klagenfurt. Their heirs Benedictines leaded the Lyceum, later Grammar school

of Klagenfurt from 1807 to 1871 including the times of Stefan and Salcher's studies there. The Benedictine K. Robida was a classmate, teacher of physics and mathematics in Josef Stefan's final Matura-graduation year of 1852/53. Later in 1867/68 we find Robida in the same role in P. Salcher's class. Robida taught chemistry in 6th class according to A. Baumgatner's textbook which was not used any more in 1860s. It was replaced with Schabus' textbook *Grundzüge der Physik* in 8th class which Salcher still used in Rijeka until he published his own textbook in 1881. The other Klagenfurt teacher of physics Columbian Pauer (Pauler) used Pisko's textbook instead of A. Kunzek's in 3rd and 4th class in 1865 as did N. Lebinger in 1866.[2] Robida taught Stefan physics four hours per week on gases, liquids, light, sound, gravity, statics, and dynamics of bodies in 7th class, and seven hours per week in last 8th class on heat, electricity and magnetism. Later in 1857-1862 and 1865 Robida taught mathematics one hour per week in 8th class and physics three hours per week in 8th class. In 7th class he taught three hours per week chemistry, statics, motion, waves, and acoustics, and in 8th class magnetism, electricity, heat, optics, and astronomy-meteorology.[3]

Robida bought Stöher's rotation apparat for his physics laboratory in 1852. In 1856/57 Robida acquired six new instruments among them diamagnetic apparatus and rubber electrostatic influential machine, two aerometers and one stereoscope with six views (*Ansichten*) developed by Wheatstone in 1839 and Brewster in 1849. In 1857/58 Robida got apparatus for electromagnetic variations and two microscope-photographs probably by seventeen years earlier Ettingshausen's design. Marine-Academy, which was then still in Trieste, acquired electrification machine in 1845.[4] Robida probably shot the first modern photographs which Salcher examined a decade later as Robida's student before he became the Graz student of the promotor od *schlieren* photography method August Toepler, which became the fundament of Salcher Rijeka photographic supersonic experiments. In the same year 1857/58 Abbot of the Benedictine monastery of St. Paul in Klagenfurt donated to Grammar school the centrifugal machine and ozone-meter which alludes that the Benedictines had physical laboratory also in their monastery. In 1860/61 and in Salcher's freshman year 1861/62 Robida got seven and eight new apparatus which were not listed. In 1864/65 in Salcher's 5th class Robida got Wave (*Schwingung*) – machine[5] which Salcher used two years later in the course of mechanics in his 7th class. In 1869/70 Robida got eight apparatus including influential machine of Holz, Galvano-plastic (galvanoplasicher) apparat.[6] Robida also taught Salcher

[2] *ProgrammKlagenfurt* 1870: 29, 31.

[3] *ProgrammKlagenfurt* 1865: 82.

[4] Salcher, 1902: 43.

[5] *ProgrammKlagenfurt* 1865: 88.

[6] *ProgrammKlagenfurt* 1870: 31.

mathematics in 6th class in 1865/66, 7th class in 1866/67 and in final 8th class in 1767/68.[7] Robida was Salcher's classmate in final 8th class and head of Benedictine College of Klagenfurt in Salcher's last three years when the Benedictines still controlled Salcher's Grammar school.

Teachers of physics in Klagenfurt in Salcher's times were Josef Winter 1856-1863 in Grammar school, Columbian Pauer 1859-1870- in lower grammar school, and Norbert Lebinger 1865/66 in lower grammar school. In 1849 Robida published the very first physics in Slovenian language, but he had no Croatian luck and Slovenian was not accepted as official language in grammar schools of Robida's lifetime.

From 1866 to 1875 Robida was the head of the Benedictine college of Klagenfurt, also during Salcher's final three years. Robida published his scientific works in two books (1860, 1866), two Leipzig *Zeitschrift* papers (1864,1865), and several papers in less important Viennese and Klagenfurt journals as were Klagenfurt Grammar School Programs (1854, 1857, 1858, 1861, 1862), Carinthia (1848, 1860, 1864, 1865), and *Zeitschrift für öst. Gymn.* (1863). He accomplished altogether fourteen works besides his Slovenian language textbook of 1849. Robida retired in 1874 just after Salcher got Ph. D. in Graz on 31/5/1872 after his 1st Rigorosum in 1871,[8] just before Boltzmann met his future wife Jetti on yearly journey of teachers in May 1872. She began her extraordinary Graz studies in winter semester of 1872/72, Word exhibition in Viennese Prater was opened on 1/5/1873, and the great depression black Friday 9/5/1873 followed.[9] In that time in 1872 Boltzmann published his *Weitere Studien*, and next year he left for Vienna University. Mach taught in Graz from 19/4/1866 until March 11/3/1867 and left for Prague just before Salcher arrival. Mach's replacement was Johann Frischauf (*1837; †1924) as ordinary professor of mathematics in Graz 1867-1906. Frischauf obtained his habilitation in Vienna in 1863 almost simultaneously with Mach and his textbooks were used in Rijeka after 1880s instead of Paris Academician Étienne Bézout's (*1730; †1783).[10]

Salcher certainly learned some Slovenian in Klagenfurt 1861-1868 and used it in his one semester teaching in Graz k. k. I Staatsgymnasium (1872/73), in both of his years in *Staatsoberrealschule* (State High School) in Trieste (1873/74, 1874/75), and in Croatian Rijeka later after 18-19/8/1875 just after his 27th birthday. Nicolo Vlahović (*1832) taught physics as director in Trieste *Civica Scuola Reale Superiore Autonoma* (today lyceum Oberdan) after the autumn of 1863. In school Journal Vlachović's colleagues Adolf Stossich (*1824 Rijeka)

7 *ProgrammKlagenfurt* 1867: 56-57, 1868: 63.

8 Medica, 2011: 310.

9 Flamm, 1995: 33, 35-36, 38.

10 Flamm, 1995: 81; Salcher, 1902: 41.

published on Natural History in 1865-1868, G. Derase and M. Derase published on optics in 1871-1875. In Salcher's State High School of Trieste Gustav Werner (*1835) was professor from 1865 to 1868 and published on acoustics and optics in 1867. August Vierthaler (*1838) who was promoted to the rang of professor of chemistry and natural History in Split in 1866, taught in Salcher's State High School of Trieste in 1872,[11] and Salcher replacement Libor Peiker (*1835) wrote on buoyance in 1878, and on optics-chemistry in 1879/1881 under the title *Della scomposizione dei compost racemici* with the discussion of Arago, Seebeck, and Biot.

4. MEMBER OF ZAGREB ACADEMY ŠUBIC

Simon Šubic (*1830; †1902) taught theoretical-mathematical physics in Graz as the only professor of physics from 16/7/1866 until 1868, and the only theoretical physicist until 16/8/1869. He taught Salcher in his freshman year 1868/69 before Boltzmann took of the course between June/September 1869[12] and 8/8/1873 when Šubic was left only with mechanical theory of heat and meteorology as assistant professor.

Private docent Šubic began his Graz University lectures on theory of heat with two hours per week in winter semester of 1866/67 two years before Salcher's arrival. Šubic continued to teach theory of heat in Graz University in winter semesters until his retirement in 1902, therefore full 36 years. But Šubic's approach soon felt out of the mainstream and therefore also out of main interest of Graz students' who preferred mainstream lectures of Boltzmann's followers.

On 11/3/1867 Mach suddenly left Graz and took the professorship in Prague. Šubic was forced to took over even Mach's lectures of physics for the students of Medicine Faculty. On 31/5/1867 the Moravian Karl Hummel retired and Šubic became the only physicists in the University of Graz. In that way, his earlier habilitation of July-August 1866 proved to be really in the interest of Graz University as Mach and other Šubic's friends predicted. After Mach's departure Šubic expanded his lectures on theory of heat also to the higher mechanics and the analytical mechanics of fluids and gases. In winter semester 1867/68 Šubic also supplied on former Hummel's chair with the lectures on experimental physics five hours per week. In summer semester in 1868 Šubic continued just with the lectures on theoretical physics, heat, the least square method, electricity, and magnetism. In summer semester of 1867/68 nobody lectured on experimental physics in Graz. Šubic published his lectures on the least square method a decade later in the RAD of Zagreb Academy.

[11] Vierthaler, 1872.

[12] Jungnickel&McCormmach, 1986: 61.

In 1868/69 Salcher's freshman year Toepler took over experimental physics while Šubic continued with his lectures on theoretical physics in the middle of the struggle for theoretical physics chair which Sacher and his fellow students certainly felt. Kirchhoff did not support Šubic in July 1867 and 19/12/1867, and Stefan explicitly rejected Šubic in favor of his assistant Boltzmann on 8/4/1869. On 11/8/1869 Boltzmann won the race and disappointed Šubic went ill. On 29/7/1869 Toepler proposed Šubic for the post of extraordinary professor for physics without salary and the rector Krones supported the deal. Šubic went angry and wrote to the emperor himself, but the furious minister turned him down on 3/7/1870 which made Šubic persona Non-Grata forever, he was even more unwelcome than a "socialist" Mach. Šubic continued to teach theory of heat and meteorology in Graz University and Salcher later used Šubic's meteorological lectures in his own textbooks after he became the head of Rijeka meteorological station in 1880. The Rijeka astronomical observatory established in 1840 was moved to Pula in 1866[13] before Salcher arrival.

The other aspects of physics in Graz was grouped around thy Styria Natural Historical Society (Naturwissenschaftlicher Verein für Steiermark) established on April 4, 1862. Salcher certainly read the publication of the society and probably attended some lectures. Šubic was a regular member from 1867 to 1870, Toepler from 1869 and Boltzmann from 1871. On 25/5/1871 Toepler became the vice-president of the society and after his departure Boltzmann took over his post in 1880. Mach was not a member, but he lectured several times for the society.

In 1862 and 1865 of his Graz times Mach was obliviously still a promoter of atoms. August Toepler (*1836; †1912) managed in good relations with all including Salcher, Mach, Šubic, and Boltzmann. In 1870 he published a paper together with Boltzmann, and on 14/7/1870 Toepler was a witness in Graz on Boltzmann's marriage with Jetti-Henriette von Aigentler (*1854; †1938), the first female student of mathematics and physics in Graz. Between 1856-1858 Toepler studied chemistry in Poppensdorf Agricultural College in Royal Technical Institute Berlin and in 1860 he took his Ph. D. in University of Jena on efficient water pumps.

[13] Salcher, 1902: 75.

■ **Table 3:** *Interesting Lectures in Naturwissenschaftlicher Verein für Steiermark and Graz University Teachers of Physics during Salcher's Studies*

Mach 28/10/1865	Plateau's figures with weightless fluids illustrating molecular forces	
Mach 23/2/1867	Helmholtz' vibratory microscope	
Toepler 29/1/1870	Induced Electricity-Siemens dynamo	
Toepler 1872	Mathematical paper	
Mathematical (Theoretical) Physics		
Chair	Associate Professor	Assistant Professor
2/3/1864-1865 Lang (extraordinary)	19/4/1866-11/3/1867 Mach	16/7/1866-16/8/1869 Šubic
	September 1869-30/8/1873 Boltzmann	16/8/1869-september 1902 Šubic
Experimental Physics with Institute		
Chair		
Toepler 1868-21/7/1876		
Boltzmann 1/9/1876-1/9/1890		

5. NON-MAINSTREAM PUBLICATIONS OF SALCHER'S TEACHERS ROBIDA AND ŠUBIC

Šubic published a critique of Stefan's extension of Dulong-Petit theory for gases (1859) in July 1862. Šubic's two critiques of Clausius of 1864 were published just in *Wien. Anzeiger* and later in *RAD* in Zagreb, and his critique of Boltzmann's equipartition was published in *Wien. Anz.* and prestigious *Ann. Phys.* after Loschmidt's negative critique which prohibited the publication in leading Viennese academic journal Wien. Sitzungsberichte. In that way Salcher began his studies against the newborn statistical mechanics and continued in his second year with the chief promotor of it, Boltzmann. Toepler taught Salcher as Graz freshman-newcomer from August 1868 to 21/6/1876 with Andreas's nephew Tesla's fan Albert von Ettingshausen as assistant between 1872-1875. The Physical Institute of Graz opened in 1874 as the best in Habsburg monarchy, but Toepler felt from the second floor to the basement of the institute by accident just after it was finished on Christmas 1875. In February 1875, soon after Salcher's graduation, Mach presented for Viennese Academy his new instruments. Mach and his mechanic of Prague Albert made the polarization apparatus with rotating analyzer simultaneously with the Englishman William Spottiswoode (*1825; †1883) in *Phil. Mag.* Šubic presented Mach's apparatus on the Meeting of Natural Historians in Graz, in section for physics and meteorology in September 1875, where Mach himself provided the explanation. Šubic published a long description of apparatus[14] and recommended it to the

[14] Šubic, 1876: 131-137.

Habsburg Minister for the standard use in the secondary schools. Mach was eight years Šubic's younger. They briefly meet in Viennese university where Šubic studied between 1852-1856 and Mach between 1856-January 1860. In Graz University, they taught together one year in 1866-1867 just before Salcher's arrival.

Stefan and Salcher's teacher Robida published vibration theory of longitudinal waves of electricity in 1857 with Grove's cathode sputtering of metals with platina five years after Grove and several months before Plücker. On 19/1/1842 for the Royal Institution William R. Grove (*1811;†1896) predicted the great role of photography in science. In the same paper Robida published the detection of Hertz's waves three decades before Hertz from the electrified electroscope of Fechner and dried cell of Zamboni. Grailich's assistant Blaserna was unable to repeat Robida's experiment and therefore Grailich refused to accept Robida's discovery in his critique of 1858.[15]

In book published in Klagenfurt in 1860 Robida stated that mass of all molecules are equal in non-kinetic theory of solid state. He used Ampère's wave theory of heat, amplitude of the change of molecular radius, invisible longitudinal component and visible transversal component of light vibrations. Robida published molecular theory of light in *Programs of Klagenfurt Grammar school* of 1861 and 1862 as the continuation of his book of 1860. Robida wrote a critique of Clausius' kinetic theory and also sent it to Leipzig *Zeitschrift für Mathematik und Physik* on November 10,1863. Clausius' answer was posted from Zürich eight months later on July 10, 1864 stating that Robida's velocities of molecules of gas are really dependent of height of atmosphere because of the influence of gravity, but that fact could be neglected in the cases of great speeds when the molecules collide so often that the gravity had no time to influence. Robida thought that the collisions between molecules are rare because of greater distances between molecules in the higher areas of atmosphere. Therefore, the debate was a kind of a dialog of the deaf because of the different generational approach of both protagonists.

Clausius did not answer to similar critiques of Simon Šubic published in 1863 and 1864 in *Wien. Ber*., which was also an arrow against August Karl Krönig who nearly outran Clausius with his own kinetic theory. The *Zeitschrift für Mathematik und Physik* also published J. Stefan and E. Mach's papers at least in abbreviated form. Josef Loschmidt published a critique of Boltzmann's reversibility paradox similar to Robida's earlier publication of 1864.[16] In 1865 Robida criticized Krönig's kinetic theory stating that the attraction between molecules should be also taken into account and not just repulsion during the collisions. The universal attraction was the basis of Bošković's theory as the

[15] Medica, 2011: 309.

[16] Loschmidt, 1876: 139.

universal repulsion during molecular collisions was the basis of the early vulgar Krönig-Clausius kinetic molecular theory. In a way Bošković's universal Habsburg attraction theory of point-center atoms was not opposite to Stefan's universal Habsburg (predominantly) repulsion theory because both relied on (almost) point-like atoms-molecules. Both won disciplined success in Prussian-like military blitzkrieg manner although the main protagonists in both cases were non-Prussians, namely Slavic Bošković and Stefan. Mach was a kind of enfant terrible of a monumental kind which Bošković did not meet in his lifetime before Immanuel Kant. Mach's anti-atomism went far beyond the disregard of ether of Robida, Šubic, or Šubic's friend Tesla's teacher Martin Sekulić. Mach's view seems to be the greatest and last critique of ancient atoms. Bošković's chief supporter in Rijeka was G. Schöttl. Klekler could have been Rijeka chief supporter of Stefan's ideas while Salcher could act as the intermediate Mach's Trojan horse. Before his Rijeka professorship Klekler taught mathematics Mihailo Pupin in High Real School of Pančevo in similar Military Krajina milieu as was Tesla and Sekulić's. Pupin disliked Klekler as he was not Tesla's friend, but Tesla seems to win the third alternative-current blitzkrieg after Bošković and Stefan as the native of the same semi-Slavic milieu.

In fact, Salcher achieved much higher court and academic positions compared to Mach even without the membership of Viennese academy, because Salcher became a court counsellor, member of many academies including the Australian one. Mostly because of his philosophical fame Mach became known physicist. In that light, it is not surprising that Salcher did not publicly follow Mach's anti-atomism and with his fame in military circles never became a persona non-grata candidate as was freethinker Mach occasionally was. In his semi-military position Salcher was not allowed to share publicly radical-liberal views of Mach or Bernard Bolzano. Mach had the problem how to photograph the supersonic bullet because the knowhow and the guns were considered a military secret. Salcher as military-related-physicist with many mutual friends seemed far the best choice for Mach. Their mutual friend who gave advice to Mach to write to Salcher in 1885 was former Rijeka professor of nautical sciences in Rijeka after 1861 Julius Peterin (Giulio) who retired in 1893. In 1870 in *Wien. Ber*. he published *Über die Bildung elektrischer Ringfiguren durch der Strom der Influenzmaschine*.[17]

Salcher's teacher Robida based his research on solids where he did not distinguish between the radius of molecules and the distance between them, while the theory of matter of Krönig-Clausius and Boltzmann-Stefan was based on gases with the long distances between molecules. Robida and Krönig both criticized Dalton's law of partial pressures of gases. In his booklet on meteorology of 1866 published in Klagenfurt with the calculation of the height of atmosphere Robida used the interpolation polynomic and barometric

[17] Salcher, 1902: 78.

equitation. Already on 19/11/1847 Robida published in *Verein zur Förderung der Industrie und Gewerbe in Innerösterreich, dem Lande auf der Enns und Salzburg* with the praise of archduke Johann. Robida also published in *Vorträgen im naturhistorischen Museum für Kärnten*.

In Robida's Klagenfurt Grammar School branch Salcher's academic ancestors were the Jesuits Joseph Herbert, Josef Walcher, Bošković's friendly collaborator K. Scherffer, and the Nestor of all of them Erasmus Frölich. In Boltzmann-Toepler's Graz University branch Salcher's academic ancestors were Stefan, Petzval, Ettingshausen, Josef Wolfstein (*1773; †1849), Ignaz Lindner, Jurij Vega, and Carl Friderich Gauss. Mach's Viennese university academic ancestors were also Petzval, Ettingshausen, Wolfstein, Lindner, and Vega, Vega's teachers Gabriel Gruber, and Scherffer. In that way, Mach and Salcher were both academic descendants of close Bošković's friend Scherffer and of the Bošković's follower Vega. While Salcher's model might be Mach, Mach idols were Gauss, Wöhler's Gottingen student Johann Friedrich Herbart's follower Franz Karl Lott (*1807; †1874) and Christian Doppler. Doppler studied mathematics in Viennese polytechnic Institute 1822-1825, philosophy in Salzburg, and higher mathematics, mechanics and astronomy in Viennese University until 1829 when he became the assistant of the professor of higher mathematics and mechanics in Vienna Adam baron Burg (*1797;†1882). In 1835 Doppler moved to the post of professor of mathematics in Prague Real School and a year later to Polytechnic. He stayed in Prague until 1847 where his research of colors of moving stars was published with the Royal Bohemian Society. Ernst's father Johann Mach was just two years Doppler's younger and well aware of Doppler's achievements.

The Bohemian Franjo Mathon (*1829) researched the kinetic theory of heat for the Yearly Program of his Rijeka Grammar School in 1855 just before Rudolph Clausuis published his mean-steam theory. In 1853 professor of physics in Rijeka Marine Academy was artillery first lieutenant J. Adolf and afterwards Emil Stahlberger (†1875).[18] As a replacement for Albrecht von Tegetthoff admiral's brother from Maribor who taught hydraulics from 1864 to 1871, from 1871/1873 to 1878 Karl Klekler taught mathematics as Salcher's collaborator in Rijeka. He published textbook on geometry in 1877 and study of tides between Zadar and Trieste in 1880 for Adria-Commission.[19] Previously in Pančevo High Real School Klekler taught Mihailo Pupin and published there in Program on thermodynamics in support of the kinetic theory *Die Grundzüge der mechanischen Wärmetheorie*.[20] Klekler lectured on basic and after 1877 also on higher mathematics in correspondence with later Salcher's lectures on mechanics and physics in Maritime Academy of Rijeka. In 1874-1875 Klekler

[18] Salcher, 1902: 43.

[19] Salcher, 1902: 77.

[20] Program Pančevo, 1869: 3-18.

and Salcher shared the assistant for mathematics, mechanics and physics, the future cathode ray researcher Ukrainian Julius Puluj (*1845; †1918) who published two papers supporting kinetic theory of heat in *Wien. Berichte* in his Rijeka times. Puluj published his theory of transport of electricity in rarefied gases with wave theory of cathode rays (electrons) discussed as professor in Prague in 1888 when his colleague Mach prepared Rijeka experiments. Josef Luksch was professor in Rijeka between 1870-1894 and lectured on physics, later on geography and history. He and Julius Wolf collaborated with Julius Konrad Natterer (*1860; †1901). Julius researched Mediterranean seas for the chemistry institute of Vienna. He was a son of the famous researcher of the highest pressures Johan A. Natterer (*1821; †1900) who also pioneered photography like Ettingshausen and their younger contemporary Mach.

As a Rijeka colleague of supporters of kinetic theory Klekler and Puluj, and collaborator of the chief opponent of kinetic theory E. Mach, what opinion did Salcher support? In his five textbooks 1881-1903 including *Das Klima von Fiume-Abbazia* of 1884, one textbook-chapter (1883), and experimental contributions (1883, 1883-1892) Salcher did not express his physical-philosophical insights. Much more illuminating were his publications in *Mittheilungen aus dem Gebiete des Seewesens*,[21] and at least seven short papers which he published in *Zeitschrift für den physikalischen und chemischen Unterricht* of Berlin from 1890 to 1910. Ernst Mach and Bernhard Schwalbe founded that journal with Mach serving as co-editor of Friedrich Poske (*1852; †1925) from the first issue of 1887/88 until after his retirement in 1901. Salcher published three papers under Mach's editorship beginning with double paged *Wechelswirkung zweier Magnete* in 1890, and two other in 1892. Salcher continued to publish there after Mach's retirement in 1904, 1906, and 1907 when Alois Höfler (*1853; †1922) already replaced Mach. Mach widely published in *Zeitschrift*, for example on thought-experiment in first paper of 1897 issue. Atomists like Kelvin, J. J. Thomson and Rutherford on Röntgen rays also published there, as well as Boltzmann's favorite student Ignac Klemenčič from Trebnje near Veliki Slatnik. Stanko Plivelić (*1868; †1925) from the Grammar School of Zemun published in *Zeitschrift* on radiometer and vacuum lamps.[22] *Zeitschrift* reported on Marconi's radio-experiments. The other novelties also found their place in its pages which were therefore not at all limited to Mach's positivistic followers.

[21] Salcher, 1902: 78.

[22] Plivelić, 1897: 32.

6. E. MACH'S TEACHERS

The collaborations between Rijeka and Gorizia Jesuits' physicists was more intensive than all other connection of Rijeka Jesuits. The fruitful collaboration of Rijeka physicists with other academic institutions continued most effectively during Salcher-Mach supersonic photography experiments. Which elements did Mach's academic ancestry bring to his duet with Salcher?

E. Mach's father and teenage tutor until Ernst's 15th birthday was Johann Nepomuk Mach (*1805; †1879). Johan studied in Karl's University of Prague as a year and a half younger fellow of Doppler. In 1840 Johann acquired a great property in Untersiebenbrunn in Marchfeld between Vienna and Bratislava in Lower Austria near the borders which enabled Ernst to grow up in countryside. In the time of Ernst's birth Johann Mach was in Zlín in eastern Moravia a tutor of the children of baron Breton and Josephine born Lanhaus,[23] probably a relative of Johann Mach's wife. Later Johann took care for the knowledge of the children of future inner and educational minister of the troubled years 1848-1849 Franz Seraph Stadion count Warthausen (*1806; †8/6/1853) and his wife Kunigunde. In 1858 Johann Mach and his family moved from their land property of Lower Austria to the similar estate which they purchased with the manor of Veliki Slatnik in Carniola. During their resettlement twenty years old Erns was in the middle of his Viennese studies. Ernst's grandfather Joseph Mach was also a landowner. The father of Ernst's mother Josepha Lanhaus was Wenzl Lanhaus who administrated estate Chirlitz of Brno and projected roads which Ernst admired. Ernst studied three years and graduated with Matura with Piarist Monks in Moravian Grammar school of Kremsier (Kroměříž). The town never had a Jesuit college which probably provided it with different educational climate. Ernst did not applaud his learned-reserved professor of physics, but until the end of his life Ernst was in contact with his professor of Natural History, Frančišek Xaver Wessely (Veselý, *1819; †1904) who taught in Kroměříž from 1854 to 1881 and described the local flora in detail.[24] Ernst was not always the best student and also learned some carpentry as a youngster. After a religious youth, he preferred atheism probably already in the times when he became Ettingshausen's student in Vienna. In Vienna, the academic positions of physicists were inherited like in old-times guild because many powerful physicists were related to the noble Ettingshausen including his sons-in-law Grailich and Anton Schrötter von Kristelli, and brother-in-law A. Baumgartner. But the Spring of Nations of 1848 brought the change not just for the small capitalists like Machs, but even for the poor city-sub-orb workers like Stefan's parents.

[23] Carus, 1911: 22.

[24] Carus, 1911: 24.

Ernst's youngest sister Wilhelmina Mach loved the domestic servant which brought Ernst in 1870s to his family home of Veliki Slatnik to help his widowed and almost blind elderly father to solve the trouble which was acute in spite of traditionally liberal Mach's approach. Wilhelmine eventually had to spend the rest of her sad days in Viennese Monastery. Ernst's mother Josephine died ten years before her husband and before Wilhemina's affair which the writer Janez Trdina described in his funny novel Cursed Walnut.[25] After Johann's death in late 1879 the property in Slatnik passed to Tadej Merk (Merkel, *1811; †1911), the president of Viennese Chamber of Commerce and Ernst's uncle, brother of Ernst's mother. Merk intended to give Slatnik to his sick son for his proposed natural live on fresh air, but the boy, Ernst's first cousin, died in Italy on his way from Israel. Merk therefore donated the property to the community and the locals used the sales money to erect the primary school Šmihel by Novo Mesto. After his father's funeral Ernst probably did not see Slatnik very often also not during his visit to Salcher in Rijeka in 1887 because of the bad railway connection between the sites although the air distance is just 75 km. The route to Veliki Slatnik was not an easy one because the railway stations were as far as Krško and Grosuplje. The railway was extended to Novo Mesto only in 1894 and to Karlovac in 1914. On his ride from Prague or Vienna to Rijeka Ernst therefore did not cross Novo Mesto.

On 4/3/1840 Ettingshausen was the first to make a photograph through microscope with Daguerre design. Doppler was the head of the Viennese Institute for physics from 1/4/1850 to spring 1852. After he went ill, Ettingshausen replaced him and he later taught Mach. Doppler researched the changing frequencies of radiated light from stars because of their moving through vacuum in 1842 in Prague. Mach published a book on Doppler's theory in 1873 and was fascinated with his thinking and character, as was the Bohemian mathematician Bolzano.

7. CONCLUSION: RIJEKA SUPERSONIC PHOTOGRAPHY

The second international Electric exhibition began in Crystal Palace Chandelier on 4/3/1882. Mach's chief opponent J. Stefan was the technical-scientific leader of 3rd international electrical exhibition in Vienna beginning on 11/8/1883. Stefan was especially interested in lamps and dynamos. Puluj exhibited the portable lighter in the box of wood and ebonite 20x25 cm connected with six Bunsen's cells, and Mach and Salcher also exhibited very near each other but did not met there or earlier during Salcher's Graz studies according to Mach's letter sent from Prague to Rijeka on 25/1/1886.[26] Mach got

[25] Mach, 1912, 1913.

[26] Salcher, 1902: 76.

the idea of ultrasonic photography during the previous Paris 1st international Exposition of Electricity (electric exhibition) which run from August 15 through to 15/11/1881 in *Palais de l'Industrie* with an associated international congress. On exhibition, the promotor of spirituality and fourth physical state in cathode ray tubes William Crookes comparatively tested the efficiency of Edison, Swan, Maxim, and Lane-Fox incandescent lamps, as Stefan did two years later in Viennese exhibition. During the Parisian exhibition Mach heard the lecture of the Belgian ballistic, permanent examiner of Military School, first president of Belgian Electro-Technical Committee Louis-Henri-Frédéric Melsens. To test Melsens' hypotheses about the disrupting effect during impact of projectile supposedly caused by suppressed air which is carried along with the projectile imagined only by examination of the target fragments and published in *Comptes rendues de l'Académie des sciences de Paris* in tome 65 (1867), tome 74 (1872) and finally in tome 93 in 1881 under the *title Sur le passage des projectiles à travers les milieu résistants, sur l'écoulement des solides et sur la résistance de l'air au mouvement des projectiles* Mach exchanged letters with Salcher from March 1886 to January 1887 and also in 1892 and sometime between 22/3 and 16/4/1887 visited Salcher in Rijeka in one of the first successful team work. On 21/3/1887 Salcher-Mach's team success was presented to Viennese academy and their collaboration lasted until 1894 when Salcher's supplier in Rijeka Joseph Wanka (*1967) got Mach's positive opinion for his dissertation on *Condenstationsschwingungen* with measurement of specific heats of saturated steams published in *Wien. Ber*. of 1893 and became full professor in Rijeka in 1899.[27] Mach published historical studies of mechanics, heat, optics and acoustic but not on electricity and magnetism because they were not in the domain of human senses. Maxwell explained them with invisible fields in Stefan-Boltzmann's direction, but probably not in Mach's manner. According to Mach, the history of mechanics shows that science is organically developing system which continually adapts in natural development on Darwin's principle of selection as naturalistic interpretation of Kant.

Mach-Salcher experiment was just in time, but Michelson-Morley experiment one year later 1887 as their thermodynamically equivalent continuation from acoustics to light was premature and should be repeated in space conditions with diminished-eliminated ether-drift. Mach-Salcher worked a half of century after Daguerre's invention of photography in 1820 with William Henry Fox Talbot first obtained a chemically stable negatives in 1835, but Michelson-Morley measured ¾ of a century before the launching of the first satellite in 1962 according to the French astronomer Charles Nordmann (*1881; †1940) in 1922.

[27] Smokvina, 2011: 165; Medica, 2011: 310; Salcher, 1902: 78.

E. Mach supported kinetic theory in 1862 (*Wien. Ber.*) and 1865, but refused it in his 1872 book. So, his unique transformation against ancient tradition happened in-between in Graz or more probably in Prague. Foreign supporters of Mach's critique of kinetic theory were *Energetiks* W. Ostwald and Helm, but also some Habsburg literati were on Mach's side with Robida and Šubic included. Viennese professor of mineralogy and petrography the Moravian Gustav Tschermak (*1836; †1927) refused Stefan's (1858) extension of Dulong-Petit's law for gases. In 1893 he proposed Mach for Stefan's replacement instead of Boltzmann. A. Baumgartner as the president of Viennese academy also disliked the kinetic theory. In his battle against kinetic theorists Mach probably even prematurely printed his history of thermodynamics to diminish Boltzmann's success after Boltzmann's victory in debates with Ostwald and Helm in Lubeck in 1895.

In never-ending struggle between (Mach's)positivism and (Bošković-Stefan's) statistical atomism, Stefan was certainly the winner. Almost all important chairs in Habsburg monarchy were occupied by his favorite atoms-fans except Mach's in Prague. Stefan's blitzkrieg reform nearly repeated a century earlier success of Bošković's protagonists, who also won most of important chairs in monarchy, but failed in J. Stepling's Prague University. Bošković was invited to Prague and Hungary during his Viennese stay in September 1757, but he probably never put his foot there. Mach's extreme positivism did not alienate Salcher and others from his experimental collaboration in 1886-1892. Stefan promoted similar atomism compared to Bošković's point-centers of (attractive) force, although Stefan's focus passed to gases with (predominantly) repulsion theory of kinetic molecular collisions.

Two generations after both centuries of Jesuits' education ended in 1773 with Bošković's ideas surviving. Bošković's physics influenced Stefan and had an impact on Mach-Sacher's measurements in Rijeka, but it was explicitly opposite to Mach's exceptional aversion towards atomism, the unique after the antique, probably shared with Mach's father. Mach's Bohemian-Viennese background was different and more cosmopolitan compared to Salcher's Klagenfurt-Graz-Trieste-Rijeka (Inner Austrian) approaches to the modern thermodynamics. Mach published books and important papers against kinetic theory, while Salcher cited Mach's books in his own textbooks but did not cross the border which will put him outside the mainstream. Such move would hardly do any good for Salcher's semi-military carrier.

Except E. Mach who later changed his mind about atoms, almost all Viennese graduates followed Ettingshausen and Stefan's footsteps. The Viennese education of Stefan's times was the different path to success compared to the Jesuits' way, but both accomplished similar results. The mutual result was a quick endorsement of similar ideas in physics all around the Habsburg Monarchy. In the first case the goals were Bošković's point-centres of force, and in the second case statistical theory of entropy and atoms was on stake.

Stefan, Boltzmann and most of other Ettingshausen's students imagined ether with eternally moving molecules like bigger molecules of ponderable matter. Robida, Šubic (and Sekulić) were against ether, and Mach certainly also. Atomic kinetic theory of ether and matter had its strong opponents in Robida and Puchl who preferred the wave theory of heat.

On 17/2/1880 Mach lectured on theory of Radiometer in Prague (German) Association of Natural History Lotos with N. Tesla probably also attending. Before Mach lectured many times for Lotos on optic and acoustics experiments and J. Geitler lectured on cathode rays in Litoměřice in 1896. In 1883 Mach developed George Berkeley's ideas of rotating water in vessel in vacuum which would not attain Newton's concave shape, but we still have no decisive experiments. In 1913, soon after he ended his lectures on the former Mach's chair in Prague, Einstein wrote to Mach to support his non-concave shape. Although Einstein never fully included Mach's principle with the changeable gravitational constant into his General Theory of Relativity, Einstein was always under strong influence of Mach's ideas. Einstein as one of the chief admirer of Mach's positivism contributed much to the atomism with explanation of Brownian motion in 1905. In that time Einstein worked in Bern and Zürich as neighbor of Mach's collaborator F. Adler and Heinrich Greinacher (*1880; †1974) who invented magnetron as a new opportunity for measurement and calculation of the mass of electron in 1912 in Zürich. In the same time, Lenin worked for a year in Zürich libraries to produce the devastating critique of Mach's philosophy as Adler reported to Mach on 23/7/1909 after studying specific heats with Einstein.

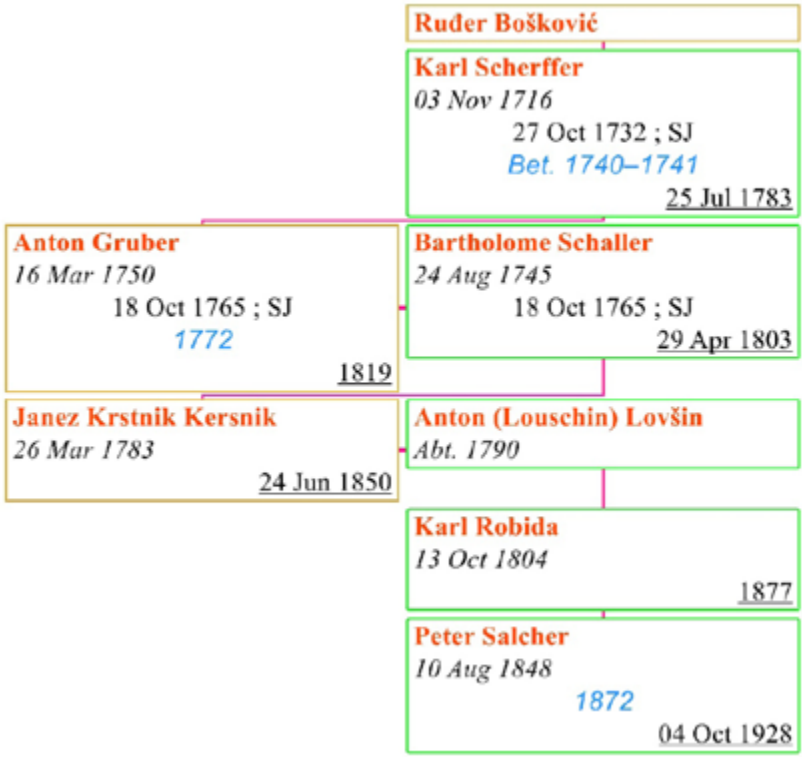


Figure 7. *Academic ancestors of P. Salcher according to his Klagenfurt Grammar School Studies. Ljubljana professor of mathematics A. Gruber was a younger brother of more famous Jesuit general G. Gruber.*

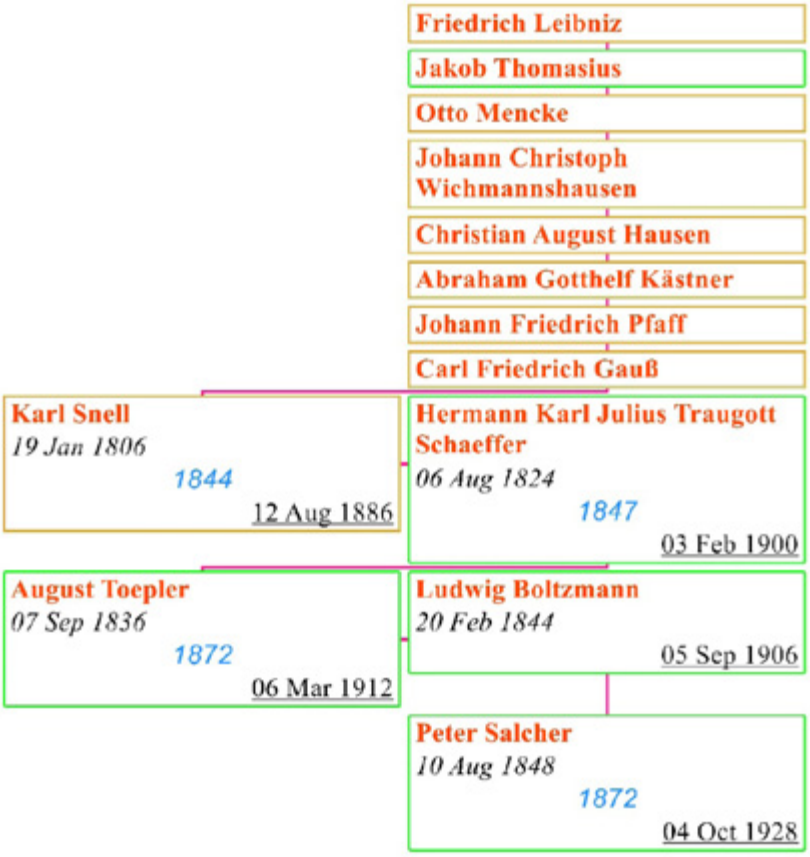


Figure 8. *Academic ancestors of P. Salcher according to his Graz University Studies with Toepler leading to the famous Gauß.*

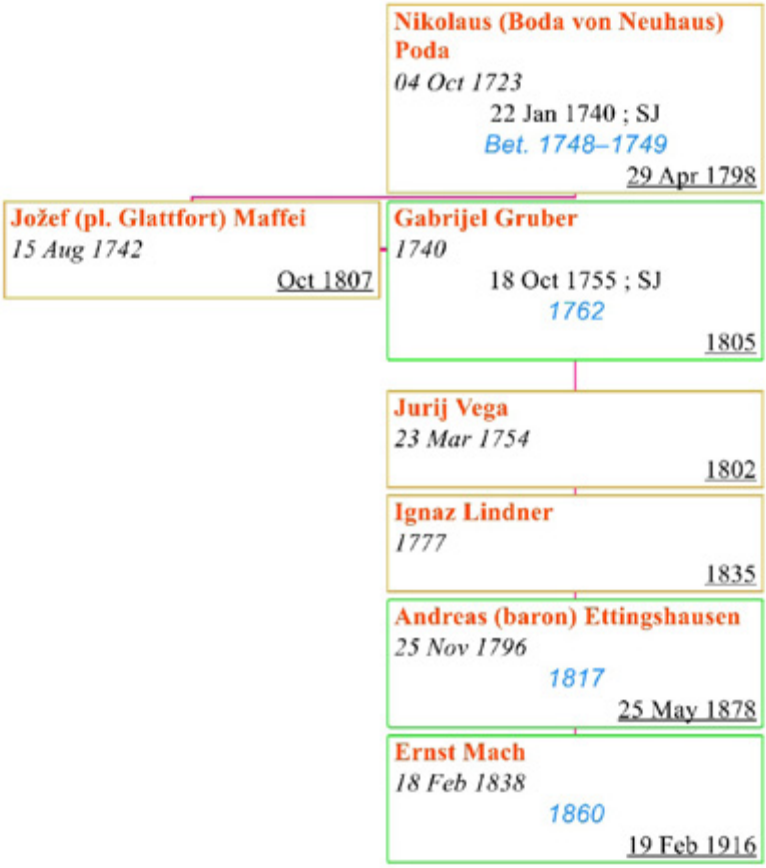


Figure 9. *Academic ancestors of Ernst Mach according to his Viennese University School Studies. Most textbooks of best Slovene mathematician Jurij Vega contain Bošković's curves.*



Figure 10. *Facebook of Mach&Salcher's common academic relatives*

The liberal E. Mach loved his rhetoric questions about atoms: "Have you observed one?" which have lost their arrows through electron microscopes. Mach decisively influenced the first Salcher's photographs of the **invisible** supersonic flight disturbances in Rijeka Torpedo factory. Mach will probably challenge the "lost generation" of string theorists which still keep us waiting for unified theories.

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SAŽETAK

Salcher i Mach školovali su se u Unutrašnjoj Austriji i Beču. Mach je bio povezan i sa Sveučilištem u Pragu na kojemu je predavao zajedno sa svojim idolom Dopplerom. Machov otac studirao je u Pragu, podučavao Ernesta kao tinejdžera kod kuće i provodio s njim praznike na svojoj farmi u Velikom Slatniku. Tamo je Ernst razvio svoj praktički i eksperimentalni pristup, iako su mu majka i otac umrli u Slatniku prije Salcherovih mjerenja u tvornici Torpedo.

Za vrijeme svojih prijediplomskih i diplomskih studija Salcher je čuo gotovo suprotne opise fenomena topline. Njegov nastavnik fizike i matematike u gimnaziji u Klagenfurtu bio je benediktinac Karl Robida iz predgrađa Ljubljane, koji je kritizirao novu Clausisovu kinetičku teoriju plinova. Robida je otkrio Hertzove valove prije službenog otkrića, kao i Groveovo pucketanje te opisao paradoks reverzibilnosti sa zastarjelom vibracijskom teorijom topline. Jedini Salcherov učitelj teoretske fizike na njegovoj prvoj godini na fakultetu u Grazu bio je Robidov prijatelj Simon Šubic koji je odbacio raniju statističku mehaniku Robidova studenta Jožefa Stefana i Stefanova studenta Ludwiga Boltzmanna. Druga međunarodna izložba o elektricitetu otvorena je u londonskom Crystal Palace Chandelieru *4. ožujka 1882. Stefan je bio tehničkoznanstveni voditelj Treće bečke međunarodne izložbe o elektricitetu održane 1883., na kojoj su Salcher, Mach i bivši Salcherov riječki asistent Julius Puluj izložili svoje instrumente. Do tada je Stefan već bio reformirao nastavni program fizike u Habsburškoj Monarhiji u kojoj su sve značajne katedre imali protivnici njegovih kinetičkih teorija. Stefanove pobjede ponovile su na taj način stotinu godina starije reforme Boškovićevih sljedbenika u istim školama Habsburške Monarhije u kojima su Boškovićevi sljedbenici zadržali svoje katedre čak i nakon zabrane Boškovićeva jezuitskog reda. Značajne iznimke obiju reformi bile su praške katedre Josepha Steplinga i Macha. Stefanov, Machov i Salcherov akademski prethodnik, habsburški pionir fotografije Andreas Ettingshausen, obrazovan je u bečkoj* Bomabardierschule *u Boškovićevu duhu profesora Jurija Vege.*

Boškovićeva opća teorija privlačenja točaka sila razvila se u Stefan-Boltzmannova molekularno-kinetička suprotstavljanja s nekom vrstom produženoga Boškovićeva utjecaja.

Ključne riječi: *Peter Salcher, Ernst Mach, Karl Robida, Ruđer Bošković, supersonična fotografija u riječkoj tvornici* Torpedo, *povijest fizike*

ZNAČENJE POVIJESNOG I STRUČNOG ISTRAŽIVANJA PRI ZAŠTITI TEHNIČKE BAŠTINE

Significance of historic and expert investigation during the preservation of movable technical heritage

Zoran Kirshoffer*

SAŽETAK

Tema je ovoga rada utjecaj kvalitetnoga povijesnog i stručnog istraživanja na završne rezultate konzervatorsko-restauratorskih projekata pri zaštiti pokretne tehničke baštine. Svrha je promjena zatečenog stanja predmeta jer im se pri dobro planiranim i izvedenim zahvatima obnove vraća izvorni oblik i stanje iz vremena kada su bili proizvedeni, kao na primjeru podmornice CB-20.

Zbog neodgovarajuće pripreme za muzejsko izlaganje materijali u unutrašnjosti i izvana počeli su pokazivati znakove istrošenosti izazvane raznim čimbenicima (razne vrste korozijskih procesa uzrokovanih razlikom u potencijalima metala). Zbog toga je EDS-analizom provedena metalografska analiza materijala vanjskog trupa i zavarenih spojeva.

Ključne riječi: *konzervatorsko-restauratorski projekti, podmornica CB-20, korozija, EDS-analiza*

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SUMMARY

The topic of this paper is the influence of quality historic and expert investigation on the final results of the conservation-restoration projects during the preservation of movable technical heritage. The purpose of that is the change of the initial form and condition into the original look, form and condition from the time when the object was produced, on the example of the CB-20 submarine.
The unsuitable preparation of the CB-20's for its museum display has led to the wearing out of the interior and exterior materials due to various corrosion processes induced by the difference of materials' potentials. Because of that we provide the EDS analysis of the base hull material and the EDS analysis of the weld material.

Keywords: *conservation-restauration projects, submarine CB-20, corosion, EDS analysis*

THE POLISH NAVY AND TORPEDOES DEVELOPMENT TILL 1939

Poljska mornarica i razvoj torpeda do 1939.

Antoni Komorowski*

SUMMARY

In 1918, after 120 years of partitions and enslavement, a reborn Poland began; a slow and laborious process of rebuilding and reconstructing many branches of economy, industry, and other fields. It was the time of strengthening the borders and rebuilding the army. Despite many complications, the Polish Navy was in blossom. It had been brought to life by Józef Piłsudski on November 28th 1918.

The marine forces were developed mainly using loans which were given to Poland through international negotiations. At this time, Poland's main lender and army partner was France. It was there where our very first battleships and their cannons were ordered. The very first orders were two destroyers and three underwater minelayer as well as their guns, cannons and weaponry, in the sense of artillery, mine and torpedo weapon. The process of gaining new vessels was also built up by English loans, which were used to buy the next two destroyers as well as their equipment. Other torpedoes were thus bought in Great Britain.

In this paper we present certain details concerning the main aspects of the ships and torpedo weaponry in Poland in the given time period.

Keywords: *Navy development, torpedoes, credit*

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1. INTRODUCTION

Polish Navy was born in 1918 and during the process of its development, it had to face numerous difficulties – staff, equipment, technical, and others. The cadre was formed by specialists coming from three areas of partitions – Russian, German and Austria-Hungarian. There were no ports as well as no place to make it naval headquarters. A rather small, only 140 kilometers long area of the Polish coast was home of two fishing harbours which were impossible to turn into naval bases. Despite the difficult conditions, the very first Polish Navy base was created in Puck, with its wet dock the size of 40x60 meters, and it was impossible for the naval vessels to stay there.

During the interwar period there were four new ports built in Poland: Gdynia, Jastarnia, Władysławowo, and Hel (this was strictly naval harbour). Only Gdynia and Hel were destined to become bigger ones with wharfs and naval fleet supply. The enlisted port investments were realized due to the loans given to Poland by France.

The plans concerning the development of the Polish war fleet were ambitious and long-term. In the often-changing concepts the main idea was to remember that Poland's biggest opponent will be the Soviet Union, but there were also plans to build warships capable of taking part in Atlantic and oceanic war actions.

One of the very Polish warships – torpedo carriers – were torpedo boats given to Poland by the Ambassador Council in 1919 when the German fleet was divided. Their names were ORP *Podhalanin*, ORP *Krakowiak*, ORP *Kujawiak*, ORP *Mazur*, ORP *Ślązak* and ORP *Kaszub.* All those ships were ready for duty only after neccesary renovations were conducted in 1921[1].

The enlisted ships were the very first carriers of 450 mm caliber torpedoes, which were bought in France. As the ships' exploitations advanced, some of the double 450 mm caliber torpedo launchers were changed into newer ones. Also newer types of torpedoes were bought (Table 1). Further TBs (torpedo boats) were the underwater minelayers built in France, type *Wilk*, destroyers type *Wicher*, as well as destroyers type *Grom* built in England, and submarines type *Orzeł* built in Holland. Those ships will be described in a more detailed way further on.

[1] Komorowski A., *Broń torpedowa 1868-1990*. Gdynia 1992, p. 152.



Figure 1. *Torpedo boat ORP* Mazur *(Source: Polish Navy archives)*



Figure 2. *Destroyer ORP* Wicher *(Source: Polish Navy archives)*

2. BACKGROUND & ANALYSIS

Before the ordered ships came to Poland a decision was made to build a new war harbour in Gdynia, which was opened as quickly as April 1923 and was named "Temporary war harbour and fishermen shelter." The Gdynia port was consequently and steadily being extended and developed and in 1939 was almost entirely ready. Unfortunately, World War II interrupted the port's further development and the damages done by the Nazis blocked the harbour's activity for many years ahead.

Either way, the Polish Navy headquarters were established in Gdynia as well as the main war harbour and the extended infrastructure. Another investment made during the interwar period was the building of the war harbour in Hel. The Navy, as a result, was given a good and safe base for its fleet.

As years went by, Polish fleet was being enriched by newer ships. The first ones were torpedo boats, as it was mentioned above. During the next years, there were more warships coming, ordered and built abroad, in foreign shipyards. Here is the calendar of the years when all of them were successively incorporated into duty:

- 8 July 1930 r. destroyer ORP *Wicher* from France,
- 2 August 1931 r. underwater minelayer ORP *Ryś* from France,
- 31 October 1931 r. underwater minelayer ORP *Wilk* from France,
- 20 February 1932 r. underwater minelayer *Żbik* from France,
- 19 August 1932 r. destroyer ORP *Burza* from France,
- 29 March 1937 r. destroyer ORP *Grom* from England,
- 1 December 1937 r. destroyer ORP *Błyskawica* from England,
- 10 February 1939 r. submarine ORP *Orzeł* from Holland,
- 18 April 1939 r. submarine ORP *Sęp* from Holland



Figure 3. *Underwater minelayer ORP* Żbik *(Source: Polish Navy archives)*



Figure 4. *Submarine ORP* Orzeł *(Source: Polish Navy archives)*

It is clear that the Polish naval fleet acquired nine new warships, which significantly strengthened Poland's defense potential. The way the above-cited ships were used during the war campaign is an entirely different issue, which will not be mentioned in this paper.

Polish Navy also bought numerous other ships, but those were not equipped in torpedoes.

Let's take a closer look at the assessment of the torpedo weaponry of the above-mentioned ships.

The underwater minelayers type *Wilk* were equipped in six torpedo launchers caliber 550 mm and had ten extra torpedoes on board. The destroyers type *Wicher* was equipped in two triple torpedo 550 mm launchers. The built in England destroyers type *Grom* were equipped in two triple torpedo 550 mm launchers with torpedo caliber 533,4 mm reductors, and submarines type *Orzeł* were equipped in twelve torpedo 550 mm caliber launchers along with the torpedo caliber 533,4 mm reductors. The submarines this type had twenty extra torpedoes on board.

Short analysis shows that the Polish Navy, during the discussed period, used French torpedoes caliber 450 mm and 550 mm as well as English torpedoes caliber 450 and 533,4 mm.

3. RESULTS

The very first torpedoes brought to Poland to be used by the TBs were a bit obsolete French torpedoes types 1904, 1906, and 1911, caliber 450 mm, which were modeled after Whitehead torpedoes. They were manufactured in Fiume factories (type 1906M), series F/61, F/69, and F/74 and in Tulon factories, series T/32, and T/33[2]. All of the mentioned torpedo models and types had thermal propulsion and used paraffin oil as fuel and compressed air as the oxidant. Those torpedoes were used in Poland until 1937 when the torpedo boats were withdrawn from the naval fleet and disarmed.

In 1931 30 torpedoes caliber 450 mm of the modified Whitehead – St. Tropez type were bought in England. They were specially ordered (order number 8774, dated on March 20th 1930) and made in accordance with the Polish requirements. The torpedoes were equipped with thermal propulsion systems with their main elements being paraffin oil and compressed air. They were marked with letter „A" and the torpedo boats' launchers were adjusted to them[3]. Another torpedoes bought for the destroyers type *Wicher* were the French torpedoes type 1923 D (18 torpedoes) and 1924 V (44 torpedoes) for the submarines[4].

Table 1. *Torpedoes caliber 450 mm used in Poland in 1922-1937 period*

Type	Propulsion system	Length (m)	Mass (kg)	Velocity (w)	Range (km)
Fiume 1904	Engine 4 cyl.	5,5	600	36/24	0,6/2
1904 T	j.w.	5,5	600	36/24	0,6/2
1906	j.w.	5,5	650	36/24	0,6/2
1906M	j.w.	5,5	650	38,7/25,6	0,6/2
1911	j.w.	6,75	750	35/28	4/8
A (ang.)	j.w.	5,55	858	40/27	2/6

Source: CAW. Akta. KMW I. 300. 21. T.640

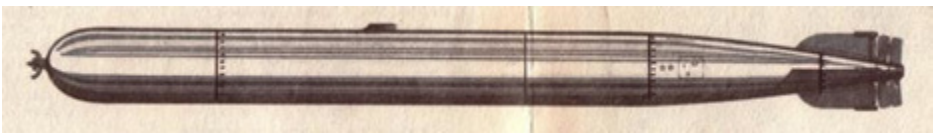


Figure 5. *Torpedo type 1924 V (Source: author's archives)*

[2] Centralne Archiwum Wojskowe (CAW) w Warszawie. Akta Kierownictwa Marynarki Wojennej (KMW) I. 300. 21. T. 640.

[3] CAW Akta KMW. I. 300. 21. T. 644.

[4] Ibidem.

Those torpedoes also had thermal propulsion system, however in this case torpedo fuel was replaced by ethyl alcohol[5]. Four-cylinder propulsion engines allowed the torpedoes very good velocity and range parameters.

Further orders concerned another types of heavy torpedoes made for destroyers made in England and the oceanic-type submarines type *Orzeł*. Those were AB 1937 type of torpedoes made in The Whitehead Torpedo Corp. Ltd in Weymouth, and their propulsion systems were based on steam am gases mixtures two cylinders of the horizontal engines. Their main working factors were paraffin oil and compressed air. They were made in accordance with specific Polish technological demands and the numbers of the designs were: 10858 A, 10858 B, 10858 C, 10886 E and 10886 B. The enlisted designs were only slightly different from each other. The purchase contract pertained fifty-four 533,4 mm torpedoes, 7,2 meters long, made in accordance with Polish 10585 project and cost 2170 English pounds. The contract was fulfilled in March 1935[6]. The English torpedoes were also used by *Orzeł* type submarines, ones which rotating launchers of the given caliber were placed in two places of the light hull. Torpedoes type AB 1937, after they were made, would go through a series of durability and maritime training ground mechanisms matching tests under Polish representative supervision. During such tests the torpedoes' velocity, course deviation, range, and draught were also checked. The results of such tests were noted down in „Certificate of the torpedo"[7].

Table 2. *Heavy torpedoes used in Poland until 1939*

Type	Caliber (mm)	Length (m)	Mass (kg)	Mass of explosive (kg)	Velocity (w)	Range (km)	Proplusion (engine)
1923 D	550	8,18	2008	240	38/33	8/14	4 cyl.
1924 V	550	6,5	1497	315	44/55	3/7	4 cyl.
AB 1937	533,4	7,2	1619	240	47/36	3/8	2 cyl.

Source: CAW. Akta KMW. I. 300. 21. T. 643

Polish maritime aviation, which had its base in Puck and was developed on the basis of the water-planes that were kept there, did not have enough of time to

[5] Thermal propulsion system, which working factor was the mixture of gases and steam, would always leave track lead behind the torpedo, because the used up products wouldn't dissolve in water. Such problem was common in the majority of the World War II era torpedoes and it was resolved only after electrical propulsion system was used (for example German G7e) as well as Walter's propulsion system, in which the used up products would resolve in water.

[6] Ibid.

[7] Certificate – it's a type of a document, where the manufacturing, training ground, and exploitation data were recorded because before a torpedo was designated for its final purpose, to become a combat torpedo, it was often used many times as a dummy equipment. In such case, it was equipped in water-filled head, which, at the end of the torpedo's run, was pushed on the surface and made the torpedo stop.

buy Italian torpedo planes CANT R5 06B. The planes of such type were able to carry torpedoes, but they weren't delivered to Poland on time. The only machine of such type that Poland got, arrived in Puck in 1939, shortly after the World War II had started and it was completely destroyed by the German air forces.

It did not interfere, however, with ordering and receiving English 450 mm caliber and 4,95 m length aviation torpedoes (Polish label „WL") between 1936 and 1937. The order was manufactured by The Whitehead torpedo Corp. Ltd. in Weymouth. Unfortunately, the torpedoes were not used neither for practice nor combat purposes[8].

4. TORPEDO TRAINING GROUND

A torpedo, according to the descriptions dated to the years of exploitation, was a machine which required precise regulation of the propulsion and steering mechanisms, as well as the helms itself. Such activities were held during the preliminary torpedo launch preparation in the naval base and the final torpedo launch preparation on the vessel. The velocity, course deviation and draught were among the most important parameters.

For the purpose of the control of those parameters, before torpedoes were given to the ships as a combat equipment, the area of the Puck Bay was used as a „torpedo training ground." It was a region of the bay which was equipped in a special, permanently anchored underwater-weapon testing ship *Gen. Sosnkowski* (1927-1931)[9] and, later on, *Oksywie* (1934-1939)[10] with types 450 mm and 550mm launchers, measurement bases with permanently anchored boats, on which there were the observers of the torpedo trials as well as a ship used for „fishing" and lifting up the torpedoes which fulfilled their run. The training ground's area was eight kilometers long and was also marked with special buoys „POL-1" and „POL-2" at its beginning and its end. The course of the dummy torpedo was pointed in the direction of the Oksywie cliff. The measurement bases were equipped in nets stretched across the training ground track so that it was possible to observe the torpedoes' run from the anchored boats situated along it. Any course deviation and changes of draught were registered by a special recorder placed in the practice head of the torpedo. In this way, the correctness of the torpedo's run was measured and checked[11].

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8 The torpedoes were made in England with accordance to the Polish requirements and order number 9974L. The contract number 640/35, dated to March 23rd 1936. The cost of the delivery of six torpedoes was fifteen thousand English pounds. CAW Akta KMW. I. 300. 21. T. 644.

9 ORP *Gen. Sosnkowski* – a historical river fleet vessel, ex D1,ex Zwiagel, L = 47,46 m, B = 7,1 m, T = 0,93 m. Weaponery 2 ckm, 1 WT 450 mm.

10 *Oksywie* – torpedo station, a former passenger-ferry ship .

11 The torpedo training ground manual, part I. CAW Akta KMW I. 300. 21. T. 644.

5. CONCLUSIONS

Based on the presented material lit can be concluded that at the very beginning of the existents of the Polish Navy, it was crucial to gain both ships and submarines armed with weaponry, artillery, and also torpedoes – in accordance with the military trends of the time.

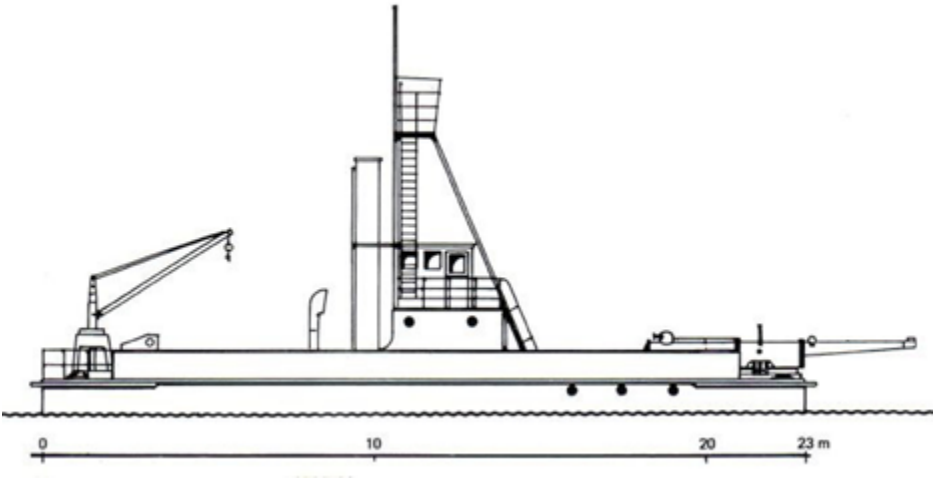


Figure 6. *Torpedo testing ground vessel* Oksywie *(Source: S. Piaskowski,* Kroniki Polskiej Marynarki Wojennej 1918-1946. *Albany N.Y. 1943)*



Figure 7. *Launching 450 mm torpedoes from the ORP* Gen. Sosnkowski *launcher (Source: Polish Navy archives)*

The lack of money to build the fleet was compensated with loans, which resulted in the limited ability to buy the newest, state-of-the-art equipment. In spite of that, French and English torpedoes 450 mm, 533,4 mm, and 550 mm were successfully used by the Polish Navy. Newly built ships were equipped in 550 mm torpedo launchers along with the smaller caliber torpedo reductors. Such solution allowed a wider usage of the owned weaponry.

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SAŽETAK

Nakon 120 godina podjela i porobljavanja rođena je nova Poljska u kojoj je 1918. započeo spor i naporan proces izgradnje i rekonstrukcije mnogih grana ekonomije, industrije i ostalih područja. Bilo je to vrijeme jačanja granica i obnavljanja vojske. Usprkos mnogim preprekama došlo je do procvata Poljske ratne mornarice. Za njezino oživljavanje na dan 28. studenoga 1918. zaslužan je Józef Piłsudski.

Mornarica se izgrađivala uglavnom uz pomoć zajmova koje je Poljska dobila međunarodnim pregovorima. U to je vrijeme glavni zajmodavac Poljske i vojni partner bila Francuska. Tako su u Francuskoj naručeni prvi poljski ratni brodovi i topovi. Prve narudžbe bila su dva razarača i tri podvodna minopolagača te francusko oružje, topovi, artiljerija, mine i torpeda. Nova plovila izgrađena su i uz pomoć engleskih zajmova, iskorištenih za kupnju dva razarača i njihove opreme. Druga torpeda su tako kupljena u Velikoj Britaniji.

U ovom radu prikazane su neke pojedinosti u vezi s glavnim aspektima brodova i oružja u obliku torpeda u Poljskoj u tom razdoblju.

Ključne riječi: *izgradnja mornarice, torpeda, zajam*

ASTRONOMICAL OBSERVATORY IN BELGRADE, SERBIA

Astronomski opservatorij u Beogradu, Srbija

Rifat Kulenović*

SUMMARY

The complex of buildings that constitute the Astronomical Observatory in Belgrade was drawn up by architect Jan Dubovi in 1929. The construction works were carried out from 1930 to to 1932, while the instruments were mounted from 1932 until 1934. It was at that time that the central building with the library, world time clock and refractor dome with Zeiss "planet searcher" was built, also the pavillions with the domes of the small and the big Zeiss refractor, the dome with the small Zeiss astrograph, the pavillion with two transit instruments Askania, finally also a workshop building. The complex was designed and constructed for the specific purpose of the Observatory so that together with the mounted instruments it makes a historical and cultural whole. The Collection consists of 43 instruments and devices that were used for observing events in the sky and the processing of the obtained data. Together with the archive material, books and magazines, the instruments make up a whole that provides insight into the activities of the Observatory and the spirit of an epoch. What is common to the instruments found at the Observatory complex is that they were made by renowned producers from the beginning of the last century, also that in the greatest part they are still in the original and working conditions. The big Zeiss refractor 650 is one of the biggest produced by Zeiss, among twenty biggest optical refractors in the world that are in the working condition.

In the year 1887, the Ministry of Education of the Kingdom of Serbia brought the decision to have the astronomical and meteorological observatory established. The proposal was initiated by Professor Milan Nedeljković as already since 1884, astronomy and meteorology made part of the study programme at the Higher Education School. The Observatory was run by distinguished professors and scientists, from 1940 until 1951 also Milutin Milanković. The calculations for his formulas of climatic changes were made at the Observatory Library.

Keywords: *history of science, astronomical observatory, cultural and spacial whole, old scientific instruments*

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SAŽETAK

Kompleks građevina koje čine Astronomski opservatorij u Beogradu projektirao je arhitekt Jan Dubovi 1929. Građen je 1930. – 1932. Instrumenti su instalirani 1932. – 1934. Tada je izgrađena središnja zgrada s knjižnicom, satnom zonom i obrtnom kupolom sa Zeissovim „tražiocem kometa", zatim paviljoni s kupolama velikog i maloga Zeissova refraktora, kupola s malim Zeissovim astrografom, paviljon s dva pasažna instrumenta Askania i, na kraju, zgrada s radionicama. Kompleks je projektiran i građen namjenski i s instaliranim uređajima čini kulturnopovijesnu cjelinu. U Zbirci se trenutačno nalaze 43 instrumenta i stroja koji su korišteni za promatranje nebeskih pojava i obradu dobivenih rezultata. Zajedno s arhivskom građom, knjigama i časopisima instrumenti čine cjelinu koja daje uvid u način rada Opservatorija i u duh jedne epohe.

Zajednički je imenitelj instrumentacije zatečene u kompleksu Opservatorija da su je izradili renomirani proizvođači početkom prošlog stoljeća te da je većinom u originalnom i radnom stanju. Veliki refraktor Zeiss 650 jedan je od najvećih koje je Zeiss napravio, a spada među dvadeset najvećih optičkih refraktora u svijetu koji su u radnom stanju.

Godine 1887. Ministarstvo prosvjete Kraljevine Srbije donijelo je odluku da se osnuje astronomski i meteorološki opservatorij. Inicijator tog prijedloga bio je profesor Milan Nedeljković budući da su već od 1884. astronomija i meteorologija bile sastavni dio plana i programa studija na Velikoj školi. Opservatorijem su upravljali ugledni profesori i znanstvenici, od 1948. do 1951. i Milutin Milanković. Proračunavanje njegovih formula klimatskih promjena obavljano je u knjižnici Opservatorija.

Ključne riječi: *povijest znanosti, Astronomski opservatorij, kulturno-prostorna cjelina, stari znanstveni instrumenti*

SWEDISH NAVAL OFFICERS AND THE INTRODUCTION OF TORPEDO AND TORPEDO-BOATS

Švedski mornarički časnici i uvođenje torpeda i torpednih čamaca

Andreas Linderoth*

SUMMARY

In 1875 Sweden ordered their first torpedoes from the manufacturer Whitehead in Fiume/Rijeka. A few years later it was decided to build special crafts to carry the torpedoes, torpedo-boats. My paper focuses on the introduction of torpedoes and torpedo-boats in the Swedish navy from 1860 until 1900. It could be argued that torpedoes and torpedo-boats were weapons which ought to suit the Swedish navy well. It was a small and relatively poor navy that could not compete with the bigger and more powerful navies of other states surrounding the Baltic. Small, relatively cheap vessels could with the help of torpedoes threaten bigger and stronger ships. A Russian invasion over the Baltic was seen as the biggest military threat.

It is sometimes claimed that military officers, not the least naval officers, are conservative and do not want to see changes in the way they handle things. Therefore, it is argued, they are cautious when it comes to integrating new technology and new weapons into their organizations. How did Swedish naval officers at the time regard torpedoes and torpedo-boats? Was there any debate regarding the new weapons or opposition to the integration of the new weapons into the Swedish navy? Did the introduction of torpedoes and torpedo-boats affect the Swedish naval strategy? The paper analyses the general Swedish military strategy at the time, naval officers' views on current and preferable future tasks of the navy. The aim is to try to explain why naval officers thought and acted the way they did when torpedoes and torpedo-boats were introduced into the Swedish navy. The paper is based on a reading of documents from the archives of the Swedish navy and essays published in two important military periodicals read by naval officers at the time.

Keywords: *Sweden, torpedoes, torpedo-boats, military technology, strategy*

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1. INTRODUCTION

In the last part of the 19th century weapons technology developed very quickly. This was of great importance for navies as they are heavily dependent upon technology. New technology can fundamentally alter previously prevailing conditions for battle and change the possibilities of a fleet to successfully solve its tasks. It is therefore very important for navies to try to keep up with the development of new weapons and equipment and try to integrate it into its organization, as to not fall behind potential enemies. It is often stated that military organizations are conservative and have difficulties integrating new ideas and technologies. Efforts to integrate new technology may lead to a debate or even conflicts between different groups regarding the tasks of the military organization.[1] In this essay I try to shed some light over the situation when torpedoes and torpedo boats were introduced into the Swedish navy from the 1870s until the beginning of the 1900s. An important aim is to try to understand how Swedish naval officers thought about new technology. I hope a closer scrutiny of the subject can contribute to the understanding of the development of the Swedish navy since the mid-1800s. The Swedish interest in torpedoes grew gradually from the early 1870s. One important reason was that the self-propelled torpedo since the late 1860s had started to develop into what seemed to be a promising weapon. In 1876 the Swedish navy bought its first batch of Whitehead-torpedoes from the factory in Fiume. A few years later, in 1880, a committee that was to advice on what types of ships would suit the Swedish navy proposed that a torpedo boat ought to be built. When a new committee approximately 20 years later, in 1901, made the proposition that Sweden needed submarines, the introduction of torpedoes and torpedo boats can be seen as have come to an end. The torpedo and the torpedo boat were by then nothing new anymore. The essay therefore focus on the years 1860-1901. The introduction of the new weapons torpedoes and torpedo boats is discussed as is eventual debates before the weapons were introduced. The aim is also to study eventual evolvement in the views of Swedish naval officers on torpedoes and torpedo boats. The essay wants to contribute to the understanding of why certain innovations are introduced into military organizations without any debate or resistance, while others are only successfully introduced after long and heated debates and still others are met with great resistance and not at all introduced or integrated. The financial situation of the organization has a great influence over decisions to buy new technology. But even if money is available and the weapon rationally would seem to fit the military organization, it is not certain that it will be introduced and successfully

[1] Christopher Martin: The Complexity of Strategy: 'Jackie Fisher' and the Trouble with Submarines, in *The Journal of Military History* 2011, p. 442; Katherine C Epstein, "No one can afford to say 'damn the torpedoes'": Battle tactics and U.S. naval history before World War I, in *The Journal of Military History* 2013, p. 491-520, William McBride: *Technological change and the US Navy 1865-1945*, Baltimore, 2000, p. 8 & p. 235

integrated. The view from within the organization on what its tasks are and should be in the future and its views on new weapons technology in general are also important to consider. In this essay I focus on the views and ideas of the people that make up the organization. The technology in itself and the qualities of the different torpedoes and torpedo boats that were in use in the Swedish navy are of less importance.

Torpedoes and torpedo boats are interesting objects of study as they in the late 1800s had a profound impact on naval tactics. They contributed to a change in the ways of doing battle on sea. Previously fleets had had to come close to each other before the battle could start. Bigger ships that could carry more guns were stronger than smaller ships with fewer guns. Torpedoes changed this as they could be placed on smaller ships which then could threaten to sink bigger and previously stronger ships. A small fleet could now potentially become a real threat to a bigger and stronger enemy.[2] Special vessels for carrying torpedoes, torpedo boats, were developed. They were to be small and fast to make it possible for them to attack the strong and big battleships and then quickly retreat. Big ships had great difficulties hitting small, fast-moving targets, as it took long time to re-load and adjust the guns. They could also not pursue the torpedo boats as they were too slow-moving.[3] Torpedoes could, in other words, potentially give the Swedish navy greater possibilities to defend itself against bigger and stronger foes. Rationally they ought to have suited Sweden well. But how did Swedish naval officers and the authorities regard the situation at the time? How did naval officers regard the fast technological development from the mid-1800s and what conclusions were drawn for the Swedish navy? How did they look upon torpedoes and torpedo boats? Did the introduction of these new weapons lead to a debate regarding how the Swedish military defense ought to be organized? Did it contribute to a change of the war plans of the navy?

There are many reasons why the Swedish case could be of interest in a wider context. Research on military history focuses to a great extent on bigger states which have taken part in military conflicts while smaller and less strong states are shown less interest. To study the conditions for a military organization in a smaller state can therefore contribute to widen and nuance the research on military history. As the main conditions of small as well as big navies are not that different from each other, research into a smaller navy could potentially be of interest even for researchers normally interested in bigger navies. It could be argued that Sweden is an especially interesting case when it comes to the introduction of new technology and weapons. The Swedish armed forces at the time were in a pretty poor state, underfinanced and had not been at war since

[2] Ronny Lindsjö: *Marinhistoria*, Stockholm, 1993, p. 141, Katherine C Epstein: *Torpedo. Inventing the Military-Industrial Complex in the United States and Great Britain,* Harvard, 2014, p. 2f & 10f

[3] Philipp Vogler: *Torpedos, U-Boote, Zerstörer. Geschichte der Flottenrüstung von 1859 bis 1914*, Bonn, 2015, p. 51f

1814. The Swedish navy had, in other words, not been able to test its weapons and other equipment or gain experiences from war for quite some time. Knowledge on new technology and ways of fighting wars at sea had to be found in other ways. As the navy had quite limited funding it also had to carefully choose what weapons systems it wanted to integrate. This could possibly lead to a stronger interest and a more intense debate regarding what technology would suit the navy's needs. It must also be noted that the navy played only a very minor role in the overarching Swedish military strategy, where the army called the shots. It was therefore of very great importance to the navy at this time to be able to update and renew its equipment and receive new weapons and ships. The navy needed to become stronger to get, from the perspective of naval officers, a more appropriate role in the Swedish overarching war strategy. The renewal of the equipment of the navy can also, in a longer perspective, be seen as a precondition for the continued existence of a Swedish navy as a separate organization. This essay tries to shed some light on the subject through an analysis of documents from the Swedish navy and from different offices in the Swedish governmental administration. As this material is of a more administrative character, for example formal decisions to buy weapons, it does not give that much help trying to understand the reasons why different decisions were made. To be able to analyze any debate or different opinions regarding new weapons technology, especially torpedoes and torpedo boats, two Swedish journals for naval and military matters have been studied, *Tidskrift i Sjöväsendet* (Journal for naval matters, abbreviated TiS) and *Kungliga Krigsvetenskapsakademins Handlingar och Tidskrift* (The Journal of the Royal Swedish Academy of War Sciences, abbreviated KKrVA).

Research on the history of the Swedish navy from the 1850s until the beginning of the 1900s is limited. The main part of the literature has been written by naval officers.[4] As interesting as many of these books and articles are, they often lack scientific quality. In general the interest from the scientific community on the introduction of new technology into the navy is quite limited. The historian Jan Glete is one important exception to the rule. He has studied organizational changes and the introduction of new technology into the Swedish navy in the years 1850-1880. He concludes that networks between naval officers and private companies are important for understanding why new technology was introduced into the navy.[5] In another book, *Navies and Nations. Warships, Navies and State Building in Europe and America, 1500-1860*, Glete discusses the introduction of new technology from a more structural perspective. He tries to understand why innovations are made and the reasons why they are introduced into naval organizations or not. Glete pays little attention to the historical agents and their views[6].

[4] Jarl Ellsén (ed.): *Swedish Torpedo 100 years 1876-1976*, Stockholm 1977, is the most prominent example.

[5] Jan Glete: *Kustförsvar och teknisk omvandling*, Stockholm, 1985

[6] Jan Glete: *Navies and Nations. Warships and State Building in Europe and America 1500-1860*, *Vol 1* & *Vol 2,* Stockholm, 1993

But like many other researchers that have taken an interest in this matter, I think it is necessary to take the views of the important agents of the time into account.[7]

Before discussing the research questions, the Swedish case is put into a wider context by considering the situation regarding torpedoes and torpedo boats in a few other countries. An overview of the Swedish military strategy and the role of the Swedish navy in that strategy are also important.

2. TORPEDOES AND TORPEDO BOATS IN OTHER COUNTRIES

At the beginning of the 1860s there existed no working device of the kind that we today would call a torpedo, a self-propelled device that travels under the surface of the water. Torpedoes at the time were either spar-torpedoes, or towed torpedoes (Harvey's torpedoes). Spar-torpedoes consisted of an explosive device attached to a long spar. When the explosive device hit the ship it exploded. It was a dangerous weapon for the attacking ship as it had to come quite close to the enemy ship to be able to hit it. The towed torpedo had a similar weakness as it was difficult to direct the explosive device toward the enemy ship and, as in the case with the spar-torpedo, the attacking ship had to come quite close to the enemy to able to use it. The device that we today call torpedo, was to a great extent developed by the English engineer Robert Whitehead. His torpedoes were self-propelled and could be set to travel a certain distance at a certain depth. A great advantage of the Whitehead-torpedoes were that they travelled beneath the surface and therefore could hit enemy ships under the water-line, the part of the ship that was the least protected. In the beginning of the 1870s special torpedo boats, small and fast moving ships, were introduced by the English yards Yarrow and Thornycroft.[8]

The English navy was the strongest European fleet and dominated the seas around the world and wanted to continue doing so. In the 1890s British naval strategic thinking found its theoretical underpinning in the ideas developed by Alfred T. Mahan. Navies ought to strive for command of the sea and try to extinguish the fleet of the opponent in one big battle. Therefore big and strongly armed ships were needed.[9] The fact that the British fleet at the time was the strongest in the world did not mean that there were less insecurity regarding the technological development and its possible future

[7] Howard J Fuller: *Empire, Technology and Seapower. Royal Navy Crisis in the Age of Palmerston*, London, 2013, p. 6, McBride, 2000, p. 6; Adam M Jungdahl & Julia M MacDonald: Innovation Inhibitors in War. Overcoming Obstacles in the Pursuit of Military Effectiveness, in *Journal of Strategic Studies* 2014, p. 467-470

[8] Vogler, 2014, p. 18 & Hans Garde & Hans Chr. Bjerg: *Torpedobåde gennem 100 år. Det danske torpedobådsvåben 1879-1979*, Copenhagen, 1979, p. 13f & 17

[9] Lindsjö, 1993, p. 177

directions. The British acted carefully in matters regarding technology and did not introduce new weapons before they had been thoroughly tried and tested.[10] They also preferred to continually improve the existing technology rather than quickly introducing new weapons in large numbers. The British navy seems to have had good knowledge of what happened within the field of torpedoes. Already in 1869 Whitehead torpedoes were tested and the navy decided to buy some. Two years later the British started producing Whitehead torpedoes of their own. In 1877 the navy bought its first torpedo boat for Whitehead torpedoes, *Lightning*. But after that no new torpedo boats were built for quite some time. One reason was that the British were interested in using torpedoes in support of their main goal: dominating the world oceans. When working toward that aim torpedo boats were of little obvious use. Instead experiments were carried out using the torpedoes on bigger ships, for example firing broadsides of torpedoes.[11]

France took early on an interest in torpedoes and torpedo boats. There were strong supporters of the torpedo. It was regarded as a relatively cheap means for a smaller fleet to threaten stronger opponents (foremost Great Britain). At first the French interest was directed toward spar-torpedoes but when the Whitehead torpedo developed and became more reliable, the interest was redirected towards it. Already in 1867 the French received information of the trials that Whitehead was carrying out in Fiume. In 1868 a French naval officer was present during tests there. But it was not until 1873 that France started trials of their own. The results were obviously pleasing as the decision was made to start producing Whitehead torpedoes domestically. In the 1880s the torpedo and the torpedo boat played decisive roles in supporting the French strategic ideas that has been named *jeune école.* Swarms of torpedo boats would in case of war leave French harbors and attack enemy ships. France built quite a lot of torpedo boats. In 1892 it had no less than 220 in use or under construction. At that time Great Britain had 186 and Germany 143 torpedo boats.[12]

Spar-torpedoes were used in the American Civil War 1861-1865 but the experiences of the war do not seem to have given the US navy an impulse to take a great interest in torpedoes. The US early on received information on the Whitehead torpedoes but chose not to buy any. Instead they wanted to develop its own torpedo. The result was the Howell torpedo that was in use from 1870 until 1896. But only 50 torpedoes were produced. After 1896, the US navy

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10 Fuller, 2000, p. 2-4, Epstein, 2014, p. 64f, Vogler, 2014, p. 85

11 Vogler, 2014, p. 83f, Richard Dunley: "The Most Resistless and Revolutionary Weapon of Naval Warfare that has Ever Been Introduced": The Royal Navy and the Whitehead Torpedo 1870-1900, in M LoCicero, R Mahoney & S Mitchell (eds.): *A Military Transformed*? *Adaptation and Innovation in the British Military 1792-1945,* Solihull, 2014, p. 68 & 75

12 Paul Halpern: The French Navy 1880-1914, in Phillips Payson O'Brien (ed.) *Technology and Naval Combat* in the Twentieth Century and Beyond, London, 2001, p. 37-41

bought Whitehead torpedoes and another domestic model, Bliss-Leavitt. As late as 1890 the US navy received its first torpedo boat. The US navy seems, in other words, not to have been especially interested in torpedoes and torpedo boats.[13] In Germany it was a different case. There the army had a great influence over society and also received the lion's share of the military funding. Until 1890 the navy was quite small and its main task was to protect the German coasts and shipping along the coasts. Torpedoes were therefore of interest. In 1871 Germany experimented with spar-torpedoes and two years later it was decided to buy Whitehead torpedoes. A few years later Germany also started producing Whitehead torpedoes domestically. In the 1870s and 1880s cruisers and torpedo boats were important parts of the German navy. Already in 1876 the torpedo personnel was organized in a corps. In the late 1800s, as Alfred von Tirpitz was in charge of the navy, the role of cruisers and torpedo boats in German naval thinking radically diminished. Tirpitz wanted big ships that could contribute to making Germany a Great Power and a nation to consult in international matters. Germany continued however to build and use torpedo boats.[14]

3. SWEDISH MILITARY STRATEGY AND THE SITUATION OF THE FLEET

In the second half of the 19th century questions concerning the Swedish military defense were among the most contested in the political debate. The Swedish army was small, not very well equipped and badly trained. The navy was from time to time partitioned into two parts, one corps in charge of the coastal defense artillery and one part that consisted of the sailing navy. These two parts of the navy fought each other for influence and money. At the same time there was a conflict with the army regarding funding. In this conflict the army was stronger and more influential and received more money. The Swedish strategic planning contributed to the strong influence of the army. It was thought that it would not be possible to stop a stronger enemy from landing its forces in Sweden. The Swedish armed forces would have to start its defense on land and fight the enemy while falling back into the central parts of the country. There, with the help of strong fortresses, the enemy would be stopped and forced to retreat. The navy played, in other words, no big part in these plans and received funding that was deemed sufficient for it to fulfill its role. The

[13] Russell Thomas: *The History of the Torpedo and the Relevance to Today's US Navy*, Internet: http://www.history.navy.mil/museums/keyport/History_of_the_Torpedo_and_the_Relevance_to_Todays_Navy.pdf

[14] Vogler, 2004, p. 97-99, Michael Epkenhans**:** Techology, Shipbuilding and Future Combat in Germany 1880-1914**,** in Phillips Payson O'Brien (ed.) *Technology and Naval Combat in the Twentieth Century and Beyond*, London, 2001, p. 58-60

navy was only to act in two or three different archipelagoes along the Swedish coast and on the bigger lakes.[15]

This situation was of great concern to many naval officers and influenced their strategic thinking. In the Swedish military journals of the 1860s it is more often argued for the need of a navy at all rather than for certain types of ships or how many ships the navy ought to consist of. Many naval officers thought it necessary for Sweden to have a navy that would be able to act not only in the coastal areas but also further away from the coast line. The navy therefore ought to have ships suitable for defense of the coast but also on the open sea. The lack of the latter type of ships, it was commonly thought among naval officers, would heighten the risk for an attack on Sweden. From the mid-1870s there are signs of a change in the Swedish strategic thinking which gave the navy a more prominent role. The symbolic turning-point is often seen to have been the ordering of a torpedo boat in 1883. This came about after a committee appointed by the government to investigate the future equipment needs of the navy recommended that Sweden ought to have not only ships that could fulfill its duties close to the coast but also ships that could venture further out to sea. In the coming years the thought that it would be a good thing to try to stop the enemy from landing his troops on Swedish soil became more influential. The navy's task would be to hinder enemy ships from securely crossing the Baltic.[16] From the 1890s on the book *Naval Warfare* by the British naval officer P H Colomb greatly influenced Swedish naval thinking. It was mainly the principle of *fleet in being* that interested the Swedes. The main point of that principle is that an attacking fleet must safe-guard and control the transport routes from its bases to the area of landing to successfully carry out an invasion. The defending fleet has to be incapacitated in one way or another. Therefore the defending navy has to try to survive until the invasion fleet is relatively close to the landing area. Then it will attack the enemy and try to sink the ships transporting the landing force. The principle of *fleet in being* was reassuring to Swedish naval officers as it was taken to mean that even a relatively small navy could act repelling on a greater state's navy. The principle of fleet in being came to make out the foundation of Swedish naval strategic thinking for many years to come – actually until the end of the Cold War.[17] The main task of the Swedish navy in war was to try to repel an invasion fleet. Different evaluations came to different conclusions but in the late 19th century it was estimated that an enemy would

[15] Bo Hugemark**:** The Swedish Navy – Auxiliary Force or Strategic Factor**?** The Navy in the Swedish Security Policy 1809-1990, in G Rystad, K-R Böhme & W Carlgren (eds.): *In Quest of Trade and Security. The Baltic in Power Politics 1500-1990, Vol II, 1890-1990,* Stockholm, 1995: p. 264f, Lars Ericsson Wolke: *Krigets idéer*. *Svenska tankar om krigföring 1320-1920*, Stockholm, 2007, p. 290 & 306-308

[16] Lars Wedin: Från fästningsflotta till högsjömarin, in *Militärhistorisk tidskrift 2004*, p. 72f, Bertil Åhlund: *Från vanmakt till sjömakt. Oscariansk sjöförsvarspolitik 1872-1905,* Stockholm, 1989, p. 1; Glete, 1993, p. 70

[17] Wedin, 2004, p. 79, Åhlund, 1989, p. 72

need to send between 15 000 and 50 000 soldiers to be able to successfully attack Sweden. It was deemed most probable that the invading army would come over the Baltic. To carry such a big invading force around 300 ships were thought to be needed. The invasion fleet would in other words have to spread over a quite a big area and therefore be very difficult to protect. The Swedish ships would have many targets to attack, it was thought.[18]

4. SWEDISH NAVAL OFFICERS' VIEWS ON NEW TECHNOLOGY AND NEW WEAPONS

From the middle of the 19th century naval technology developed swiftly and made it difficult for naval officers and other interested to try to predict the future and decide what weapons were to be bought. The quick technological development contributed to make the late 1800s into a time of an arms race in the naval arena. The fleets of the great powers experimented, with varying success, with new weapons, new types of ships and different kinds of armor.[19] For Sweden, as a small state with a small navy and limited financial resources it was very important to choose weapons which suited Swedish conditions and could be expected to have an important effect for a long period of time. Weapons which recently had been introduced could a few years later have become unmodern and more or less useless. This was a radical change as naval technology until the introduction of steam in the 1850s had changed very little for centuries. But now naval officers had to adapt to a time characterized by fast changes. Sweden tried to find its way in this new world by regularly appointing special committees that were to try to answer the question what ships the navy would need in the future. It was a time where the future of naval warfare was uncertain and that shows in the results of the committees. The committee of 1862 discussed at some length if sailing ships could be of use for warfare. The conclusion was that they possibly could be used locally to defend the coast and harbors. But in the future all warships had to be steamships. The committee of 1865 did not want to make any precise statements on what ships and other equipment the navy would need. The technological development at the time was deemed to be too quick to make a reliable prediction.[20]

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[18] Riksarkivet (RA), Sjöförsvarsdepartementets arkiv, Statsrådsprotokoll, AIa:37, Utdrag af protokollet öfver Sjöförsvars-Ärenden, hållet inför Hans Maj:t Konungen uti Statsrådet å Stockholms slott den 10 december 1875, G Dyrssen: Kunna några taktiska regler uppställas för minbåtars och hvilken role bör det rörliga minförsvaret inta vid ett försvar af våra kuster?, in *Tidskrift i Sjöväsendet* (TiS) 1886, p. 242-244, Reflektioner i anledningen af uppsatsen "Vårt sjöförsvar" i Januari-häftet af Krigsvetenskaps-Akademiens tidskrift, in *TiS* 1871, p. 84f

[19] Karl Lautenschläger: Technology and the Evolution of Naval Warfare, in Steven E Miller & Stephen Van Evera (eds): *Naval Strategy and National Security. An International Security Reader*, Princeton, 1988, p. 177f

[20] *Underdånigt betänkande angående ett tidsenligt ordnande af rikets sjöförsvar afgifvet den 22 maj 1862 af i nåder förordnade kommitterade*, Stockholm, 1862, p. 5-7

Swedish naval officers were very aware of the quickly developing naval technologies and it possibly would have radical consequences. In 1861 a writer in *KKrVA* concluded that naval equipment soon would have nothing more in common with the equipment used previously except for the fact that the ships moved on water and that gunpowder was used to fire the guns.[21] It was however much harder to try to figure out in which ways technology would develop in the coming years. When studying the Swedish military journals of the time, it seems as if the 1860s was the decade when there was the greatest uncertainty regarding the technological development. In 1863 a writer in *TiS* stated that the present was full of questions which at the moment could not be answered. They rather "led to a chaos of thoughts". The difficulties in trying to judge the technological development did not make Swedish naval officers less interested in new technology or hesitant to if Sweden ought to buy new weapons. They seem to have had an optimistic view of the future. The new technology was thought to give smaller navies, like the Swedish, a better position in relation to the bigger ones. As Sweden had limited financial resources it would be advantageous if smaller and less expensive ships could be equipped with weapons that made them relatively stronger in comparison to bigger ships. It was thought, among naval officers at the time, that a stronger state which had plans to try to invade a smaller state from the seaside now would have to more carefully than before consider the risks. Possibly it would come to conclusion that the risks would outweigh the potential gains.[22] Torpedoes contributed to naval officers' more optimistic outlook. In *KKrVA* it was in 1886 stated that "it seems as if the states that so far have had dominance of the seas now are on their way to have to abstain from it, when it can be contested by a weapon that the poorest, the smallest state can buy".[23] There were however also a few voices that were less optimistic. They were of the opinion that it was the greater powers that would gain the most from the new technology. As new equipment was expensive the stronger powers would have better possibilities of replacing it when it had become unmodern and ineffective. But even the optimists did not think that the Swedish navy ought to test any and all new equipment. The Swedish navy should not try to be a forerunner in testing and developing new technology.[24] Naval officers were rather

[21] C. B. Lilliehöök: Berättelse af föredraganden i Sjökrigsvetenskapen 1861, in *Kungliga Krigsvetenskapsakademins Handlingar och Tidskrift (KKrVA)*, 1861, p. 87

[22] F. W. von Otter: Om de fördelar som nyare tiders uppfinningar bereda för kustförsvaret och den nytta vi deraf borde kunna draga, in *TiS* 1871, p. 41, Grunder för ombildning av Sveriges sjöförsvar, in *TiS* 1865, p. 210, Tankar i sjöförsvarsfrågan, in *TiS* 1873, p. 255

[23] Tankar i Sjöförsvarsfrågan, in *TiS* 1873, p. 256, E Barnekow: Årsberättelse af föredraganden i sjökrigsvetenskap, in *KKrVA*, 1888, p. 234, C G Lindmark: Årsberättelse af föredraganden i sjökrigsvetenskap, in *KKrVA* 1883, p. 346f, C.N: Anförande i Kongl. Örlogsmanna-Sällskapet vid presidii nedläggande 15 nov 1860, in *TiS* 1860, p. 152

[24] Några ord om vårt sjöförsvar, uppläst i K.Ö.S d.19 april af föredraganden i 6:e vetenskapsklassen, in *TiS* 1861, p. 119, B. Lilliehöök: Berättelse i Sjökrigsvetenskapen, in *KKrVA* 1860, p. 155f, E Barnekow: Årsberättelse af föredraganden i sjökrigsvetenskap 1889, in *KKrVA* 1889, p. 197

cautious; new technology had to be put through hard tests, preferably by the greater powers, before Sweden ought to consider buying it. Sweden was, however, at the same time not to abstain from taking part in the technological development. The ideal would be to find the right solutions at the right time and not wait too long or buy too early.

As we have seen, there was mainly a positive view of new naval technology among Swedish naval officers. But they were cautious. Sweden ought to choose technology with great care and not be a forerunner. How this dominant view of new technology among naval officers affected the views on torpedoes and torpedo boats will be discussed next.

5. TORPEDOES AND TORPEDO BOATS – SPAR-TORPEDOES

As has already been mentioned, there were predecessors and competitors to the self-propelled torpedoes which Whitehead constructed. They affected the way naval officers viewed self-propelled torpedoes and their ideas on how they were to be used. For a shorter period of time they also acted as complementary to the Whitehead torpedoes. That makes it necessary to briefly discuss how naval officers viewed spar-torpedoes. Towed torpedoes played no great role in the Swedish navy and is therefore not included in the discussion. It is obvious when studying the sources that Swedish naval officers viewed spar-torpedoes as an important weapon. It was commonly agreed that it would not be possible to stop an enemy from entering Swedish waters. Sweden had too few ships to be able to protect its long coastal borders. But in coastal areas and the archipelagoes mines together with torpedoes were thought to give a great contribution to the defense. Spar-torpedoes were supposed to give the defender greater advantages than the attacker. They were also cheap and relatively easy to handle. This positive view is to be found relatively early on. In 1870 it was stated in an essay in *TiS* that it was "obvious that the spar-torpedo will play a great role in a coming naval war".[25] The conclusion was that no state bordering the sea should neglect acquiring torpedo boats if it was to move with the times.

Naval officers had, to be able to form an opinion on torpedoes and torpedo boats, to learn more about these innovations. As the development mainly took place abroad, this information could possibly have been difficult to come by. But when reading *TiS* and *KKrVA* today it is obvious that naval officers could relatively well inform themselves about the development of torpedoes in other countries, like Great Britain and France. Naval officers at the time, however found everything surrounding torpedoes as secretive. They were obviously not used to the amount of secretiveness that surrounded torpedoes. In 1870 *TiS* brought the first short report about the Whitehead torpedo which quite

[25] Försök med Minfartyg eller s.k. Torpedo-boats, in *TiS* 1870, p. 205f

accurately described the new weapon. Two years later the same journal followed up this first report by printing a lecture which had been held before the Royal United Service Institution, until today a British organization for debate on international security and politics. The lecturer, a British naval officer, regarded spar-torpedoes and towed torpedoes as being absolutely necessary as part in a system for harbor defense. But he also claimed that torpedoes would be of no use on their own. They ought only to be used together with guns, armor or in darkness. He was very hesitant towards self-propelled torpedoes for three reasons: it was hard for the self-propelled torpedoes to reach and maintain an appropriate speed, they had troubles keeping the depth and the original direction. The speed, 8-10 knots, was also too low to make the torpedoes effective against a ship in motion. He certainly regarded the Whitehead torpedoes as a great stride but they were still too undeveloped to be of any real use. His assessment was that rather than buying Whitehead torpedoes it would be better to try to improve spar-torpedoes and towed torpedoes.[26]

The navy also tried to gain more knowledge about torpedoes. Spar-torpedoes, towed torpedoes and self-propelled torpedoes were all of interest to the navy. Initially spar-torpedoes were given the most attention. Swedish naval officers and naval engineers regularly travelled to the United Kingdom, France, Italy, Germany and Austria-Hungary to learn more about torpedoes. They were met with relative openness and received relatively detailed information on these states' experiences. To this can be added a number of Swedish naval officers that served in other states navies as a part of their training. They reported regularly on new technology and other experiences they had made. It ought also to be noted that developers of torpedoes and torpedo boats at the time were private companies. As they wanted to sell their products to the Swedish navy, they welcomed Swedish officers and engineers to observe tests and sometimes also the production facilities. The naval officer Fredrik Henrik Ekermann was one of the most frequent travelers. He was a person of great importance to the introduction of torpedoes and torpedo boats in the Swedish navy. He travelled a lot in the 1870s and 1880s to visit production facilities, test sites and yards to study and inspect torpedoes and torpedo boats. He was also a member of a committee that was to give advice to the Secretary of the Navy on technical matters. Ekermann's views and experiences were in the late 1870s and early 1880s given great consideration by the authorities.

In 1870 Ekermann was sent to Great Britain and the USA to study their torpedoes. Britain had tested Whitehead torpedoes and were interested in them but that was not the reason for Ekermann to go there. He was to learn more about towed torpedoes. But in his report he mentioned that both Great Britain and the USA had tested self-propelled torpedoes. Ekermann also showed an interest in ships that could carry torpedoes. At the time there was an ongoing

[26] W. Dawson: Torpedos, in *TiS* 1872, p. 50 & 65f

discussion among Swedish naval officers on this matter and it was obviously also a question that interested the navy at a higher level. His report stated that the British navy still had no special vessel for the three different kinds of torpedoes that were in use: towed torpedoes, spar-torpedoes and self-propelled torpedoes. He had in the United States, however been informed that they were building two special ships designed to carry spar-torpedoes. They were to be able to make high speed, equipped with a ram and be heavily armoured on the sides. Sweden wanted to learn more about torpedo boats.[27] In late 1871 a special experts committee on mines and torpedoes were ordered by the Secretary of the Navy to make suggestions for one or, if it was deemed suitable, two different types of torpedo boats. One of the types should be suited for the more narrow passages in the archipelago and the other one for the more open parts of the archipelagoes. The committee decided that two different types of torpedo boats would suit the Swedish needs the best. It was planned to announce a competition among Swedish yards for plans for building these torpedo boats. But before the competition was announced, another committee with experts on naval technology in general, of which Fredrik Henrik Ekermann was a member, was also given the opportunity to review the propositions. The comments of this committee are interesting as it gives us further clues to the views on torpedoes and torpedo boats in Swedish naval circles. The members of the committee had basically a positive view of torpedoes. They stated that the main advantage of torpedoes were the fact that they had the same effect regardless of which ship was equipped with them. That led the committee to the conclusion that it would be possible to build many small, efficient and cheap ships. But this committee did not agree with the former committee that it would be necessary to build special torpedo boats. It thought it would be better to build scouting vessels that could be equipped with towed torpedoes. Bigger torpedo boats equipped with spar-torpedoes were, according to the committee, not necessary. They would be too expensive as they would have had to be built to be able to withstand a collision with the enemy ship. The committee did, however, find it an interesting idea to invent a device that would make it possible to equip private steam-sloops with spar-torpedoes and proposed that plans for such a device ought to be included in the coming competition.[28] The suggestions of the committee were not unanimous however. Ekermann did not agree. He was convinced that the bigger type of torpedo boats was indeed necessary. He was in favour of the suggestions of the former committee and included his own suggestions regarding the qualities of the two different types of ships.[29]

[27] Dunley, 2014, p. 68, RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:173, Nr 379:1871 Underdånigt utlåtande 9 november 1871

[28] RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:178, Infordrande af ritningar m.m. å minfartyg 1872, & Minkommittén till chefen för Sjöförsvarsdepartementet, 4 januari 1872.

[29] RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:178, Reservation C F Ekermann, 25 mars 1872

The Department of naval affairs seems to have agreed with Ekermann as his suggestions were a part of the competition which was announced in 1872. Plans for two different types of torpedo boats were wanted, for a smaller one and for a bigger one. The smaller boat was to be able to reach a speed of up to eight knots, and storages big enough to allow for coal for 12 hours running time. The crew was to consist of seven men and there would also be enough storage room for eight days supplies of water and food for the crew. The bigger torpedo boats should be able to run at a speed of 15 knots, and ought to have enough storage rooms for coal for 30 hours of running time and a crew of 25. The reward for the winning contributions were set to 3 000 Swedish crowns for the bigger ship and 2 000 for the smaller ship. This was quite a considerable reward at the time. But that did not make the competition successful – no Swedish yard could deliver the wanted plans.[30] That is perhaps not very surprising as torpedo boats were a pretty new type of ship at the time. The navy had however information that Thornycroft in England had built a torpedo boat that seemed to match the Swedish requirements. The decision was made to order one from that yard. The torpedo boat, for spar-torpedoes, was delivered at the beginning of 1875. By ordering abroad it was thought that Sweden could gain the necessary knowledge to build its own torpedo boats. The evaluation of the torpedo boat built by Thornycroft, however, showed that it did not satisfy the wishes of the Swedish navy. It was pretty seaworthy and could operate in the archipelago even under rather harsh conditions, but the maneuverability was not satisfactory as was not the speed. It was instead considered building, as previously in the suggestions of the technical committee discussed above, smaller but slower torpedo boats, as they would be cheaper.[31] According to the reports in both *TiS* and *KKrVA* abroad there was a growing interest in the Whitehead torpedoes in the early 1870s. But Swedish naval officers were not convinced of the value of such torpedoes and seem to have preferred spar-torpedoes. The commander of the Swedish naval forces that carried out exercises close to Stockholm in 1876 praised the spar-torpedoes and suggested that "every fisher boat, big enough to carry two men, and to be equipped with a spar-torpedo, can especially at night be used to cause the enemy destruction".[32] In 1877 the navy decided to prepare all its steam sloops to be

[30] RA, Sjöförsvarsdepartementet, Huvudarkivet, Registratur, B1:29, Sjöförsvarsdepartementet till Förvaltningen af Sjöärendena 5 april 1872, RA, Sjöförsvarsdepartementet, Huvudarkivet, Registratur, B1:30, Sjöförsvarsdepartementet till Förvaltningen af Sjöärendena 28 november 1873, RA, Sjöförsvarsdepartementet, Huvudarkivet, Statsrådsprotokoll, AIa:36, Protokoll över Sjöförsvarsdepartementet tillhörande ärenden 9 januari 1874, RA, Sjöförsvarsdepartementet, Huvudarkivet, Statsrådsprotokoll, AIa:37, Protokoll öfver Sjöförsvarsärenden hållet inför Hans Maj:t Konungen den 9 januari 1875

[31] RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:214, Stockholms varfs- och konstruktionsbyrå till Chefen för Sjöförvarsdepartementet 24 maj 1876, G Af Trolle: Om torpedoväsendet samt behofvet af praktiska torpedoskolors anordnande vid stationerna, in *TiS* 1876, p. 222, B.O Stackelberg: Berättelse uppläst vid Krigsvetenskaps-akademiens sammankomst den 19 Oktober 1875, in *TiS* 1876, p. 84f

[32] KrA, Marinstaben, Expeditionen, Generalrapporter, EXVI:6, Högste befälhavarens generalrapport 1876

equipped with spar-torpedoes and in 1878 there were tries with equipping private sloops with the weapon. The proponents of the spar-torpedo were attracted by the simplicity of the weapon and the fact that it could be placed on many different types of ships. The risks of the torpedoes, perhaps mainly the risk of the attacking ship being blown to pieces as the spar-torpedo hit the enemy ship, do not seem to have worried the naval officers. There seems to have been a willingness to accept rather high losses in attacks with torpedo boats.

Discussions regarding the qualities of an ideal torpedo boat continued among naval officers. At a meeting between naval officers in 1877 there seems to have been a unanimous view that a torpedo boat ought to be able to make 10 knots, that it had to be a light ship, easy to maneuver and be equipped with spar-torpedoes. There was no discussion of equipping the ship with Whitehead torpedoes. The naval officers present seem to have been convinced that spar-torpedoes were efficient weapons. In the concluding remarks it was stated that the spar-torpedo was "an efficient weapon of destruction for the arm that possesses enough bravery and skill and provided the arm is directed by a clear mind". Even as late as in the mid-1880s there were strong proponents of the spar-torpedo. In 1886 it was argued in *TiS* that the spar-torpedo was a terrifying weapon that would not soon be replaced by the self-propelled one. But it was a fact that spar-torpedoes slowly lost influence to the self-propelled ones even in the Swedish navy. Not until the mid-1890s the view seems to have become more common that the spar-torpedoes had no future. But they were in use in the Swedish navy until 1899.[33]

As has been shown: for a long time the spar-torpedoes were judged very positively by Swedish naval officers. If and how this affected their views of the self-propelled torpedoes is to be discussed in the next section.

6. WHITEHEAD-TORPEDOES

A wider interested audience was able to learn more about the Whitehead torpedo in 1870 as a report that previously had been brought in the British journal Mechanics Magazine was printed in *TiS*. It described tests with a self-propelled torpedo that could be filled with any kind of explosives and blast a hole in the strongest of ships. According to the report, the most interesting thing about the torpedo was that it could be set to go in a certain direction and at a certain depth.[34] There are few other traces in the sources of the views of the

[33] Lindsjö, 1983, p. 77, KrA, Marinstaben, Expeditionen, Generalrapporter, EXVI:9a, Högste befälhavarens generalrapport 1885, KrA, Marinstaben, Expeditionen, Generalrapporter, EXVI:26, Högste befälhavarens generalrapport 1895

[34] Den österrikiska torpedon, in *TiS* 1870, p. 58-60

Swedish naval administration and naval officers in the early 1870s. For example, no documents clearly discussing the reasons for deciding to order Whitehead torpedoes in 1875 have been found. It is therefore not possible for sure to say why Sweden chose to act at precisely this time. Sweden also bought plans of the torpedoes and a license to build their own Whitehead-torpedoes but did not start manufacturing torpedoes until 1910.

There were a lot of problems reported regarding the newly acquired Whitehead-torpedoes that ought to have influenced the view of naval officers on their efficiency and use. One important problem was the lack of accuracy. In 1875 it was reported in *TiS* that the accuracy was acceptable only up to 180 meters. That meant that a torpedo boat would have been fired upon by the enemy for several minutes before it could fire its torpedo.[35] Another report in *TiS* in 1878 stated that the lacking accuracy of the torpedo meant that the "formidable power that from time to time has been ascribed to the torpedo […] to a great part has no relevance and is built upon anything but its own merits". It ought to be noted that at this time the Whitehead-torpedoes actually were quite complicated to handle and demanded thorough care and maintenance.[36] The flaws of the new torpedoes could have been used by potential opponents to the new weapon to try to stop or halt the introduction of the new weapon into the navy. But there is nothing in the sources that points in that direction. Even in reports that discussed the problems of the Whitehead torpedoes there was a positive, even if somewhat hesitant, tone. In 1879 it was stated in *TiS* that "there is no doubt, that this mode of attacking will play a considerable role in naval warfare, but one ought not to overestimate its value […] They [the torpedoes] are indeed a terrifying means of war, which no state ought to underestimate, and against which it will be hard, but not impossible, to protect itself against".[37] The torpedoes were continually developed and with the technical improvements the views among Swedish naval officers became more positive. In 1890 a report in *KKrVA* meant that there were not much to complain about regarding the newest Whitehead torpedoes. The developers had succeeded in integrating quite big qualities regarding speed and explosive power. It wat thought that if the torpedo hit a ship it would hardly be able to continue its participation in a battle. The conclusion was that the torpedo was very capable of doing what it

[35] RA, Sjöförsvarsdepartementet, Huvudarkivet, Statsrådsprotokoll, AIa:37, Protokoll öfver Sjöförsvarsärenden hållet inför Hans Maj:t Konungen den 9 januari 1875, RA, Sjöförsvarsdepartementet, Huvudarkivet, Statsrådsprotokoll, AIa:38, Protokoll öfver Sjöförsvarsärenden hållet inför Hans Maj:t Konungen den 10 januari 1876, RA, Sjöförsvarsdepartementet, Militärtekniska byrån, Inkomna skrivelser 1876-1877, E, Förteckning på ritningar till Whiteheads torpedo (1876), RA, Sjöförsvarsdepartementet, Huvudarkivet, Registratur, BI:32, Till Förvaltningen af Sjöärendena ang. uppgörande af kontrakt om inköp af Whiteheads uppfinning af torpedos, 21 maj 1875, B.O Stackelberg: Årsberättelse av föredraganden i sjökrigsvetenskap 1875, in *TiS* 1876, p. 85f

[36] B O Stackelberg: Årsberättelse av föredraganden i sjökrigsvetenskap 1877, in *TiS* 1878, p. 118-121

[37] Torpeden och minan i sin historiska utveckling intill nyaste tiden, in *TiS* 1879, p. 257

was meant to do, if used correctly.[38] As the gyroscope was added to torpedoes in the late 1890s positive views among Swedish naval officers were strengthened. The gyroscope made the torpedoes more reliable as they were more stable in their trajectory under water. In 1897 *TIS* printed a positive report where it was concluded that the torpedo, thanks to the gyroscope, had turned into a "naval weapon in its true sense, a weapon that strongly will […] contribute to increasing a ship's strength".[39]

To sum up, there was on the whole a positive, if however cautious, view of torpedoes among Swedish naval officers. If the torpedo hit its target it would inflict serious damage. The problem was the lack of accuracy. The torpedoes were not seen as a kind of wonder weapon but rather as a complement to other weapons. As the torpedoes developed and became more reliable the views among naval officers turned more positive. It was, however, not enough only to have torpedoes. They needed to be brought close enough to the enemy to be of any real use. Special ships, torpedo boats were developed abroad for this purpose. How did Swedish naval officers view this new type of ship?

7. TORPEDO BOATS FOR WHITEHEAD-TORPEDOES

What types of ships the Swedish navy needed was continually discussed, most intensely during the first twenty of years of the time period we're interested in here. In the journals there were many different opinions to which ships would be best suited for the Swedish navy. There were also several official investigations into the matter. The suggestions of these investigations often led to more official proposals from the government to the parliament regarding money for building ships to the navy. At the time of interest to this essay there was no permanent funding for new warships. Therefore the government every year needed to ask the parliament for money for building the ships the navy wanted. The parliament often did not confirm the propositions of the government to the full value and only confirmed parts of the propositions. The navy, in other words, seldom received the kind of funding it wanted.

When the navy in 1875 had decided to order Whitehead torpedoes, investigations started into which ship would be most suited to be equipped with them. A Swedish naval engineer travelled to England and France to try to find out more about torpedo boats and eventually also to try to get hold of plans to build such ships. He was successful and returned with two sets of plans. He was not the only one to travel abroad in this matter. Ekermann had in Germany been able to get hold of another set of plans. The advisory committee on naval technology studied the plans but came to the conclusion that no one of the

[38] Årsberättelse af föredraganden i sjökrigsvetenskap, in *KKrVA* 1890, p. 20

[39] Flottan under sistförflutna året, in *TiS* 1897, p. 97

three ships would be good enough for the Swedish navy. They proposed instead to modify a type of ship that recently had been built in Sweden and make it into a useable torpedo-vessel.[40] It was decided to start negotiations with an English yard, Thames Ironworks. The aim was to receive knowledge that would enable Swedish yards to build future torpedo vessels for the navy. Thames Ironworks had recently built a torpedo boat for the British navy. The company declared itself willing to build a ship according to the wishes of its Swedish counterparts. But internal discussions between different parts of the Swedish bureaucracy stalled the process for such a long time that the yard would not be able to finish building the ships in time for the next summer. That was necessary as then would the torpedoes ordered from Whitehead be delivered and had to be tested. Therefore it was decided to try to find a Swedish yard which could build the ship. The resulting ship, *Ran,* was built by the Swedish company, Bergsunds Mekaniska verkstad, by using the plans drawn up by Thames Ironworks. *Ran* was the first Swedish torpedo ship built for being equipped with Whitehead torpedoes. It would have a crew of 65, was built to make 13 knots, equipped with one torpedo-tube in the ship's bow and could carry twelve torpedoes. It was a pretty big ship and can therefore not be seen as a model for future Swedish torpedo boats. The experiences showed that the ship could not fulfill the Swedish requirements and wishes. One reason was that the Whitehead torpedoes did not have the range and accuracy, the Swedes had hoped. The shooting distance turned out to be no more than 275-300 meters.[41] Abroad new types of torpedo boats, smaller and faster, were being developed. In 1878 therefore, Ekermann and another naval officer Y Christersson were sent to England and France to study the newest developments within the field. The report of Christersson led to a decision to once again build a torpedo boat abroad to try to keep up with the advances within the field. It was decided to contact the English firms Thornycroft and Yarrow. Both were willing to build torpedo boats for the Swedish navy, boats that would make 18-20 knots. But it turned out that the building time for the boat would be nine months. That would make it the wrong season to bring it home to Sweden. The boat would

[40] RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:208, Militärisk-tekniska byrån till Chefen för Sjöförsvarsdepartementet 12 oktober 1875, RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:209, Chefen för Mariningenjörstaten till Chefen för Sjöförsvarsdepartementet 18 december 1875, RA, Sjöförsvarsdepartementet, Huvudarkivet, Statsrådsprotokoll, AIa:37, Protokoll öfver Sjöförsvarsärenden hållet inför Hans Maj:t Konungen 15 oktober 1875, & Protokoll öfver Sjöförsvarsärenden hållet inför Hans Maj:t Konungen 22 december 1875, RA, Sjöförsvarsdepartementet, Militärisk-Tekniska byrån, Koncept, B:1, Militärisk-Tekniska byrån till Chefen för Sjöförsvarsdepartementet 12 december 1875, RA, Sjöförsvarsdepartementet, Registratur, BI:32, Sjöförsvarsdepartementet till Förvaltningen af Sjöärendena 15 oktober 1875

[41] RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:246, Marinförvaltningen till Chefen för Sjöförsvarsdepartementet 11 juli 1879, RA, Sjöförsvarsdepartementet, Huvudarkivet, Statsrådsprotokoll, AIa:42, Protokoll öfver Sjöförsvarsärenden hållet inför Hans Maj:t Konungen 11 juli 1879.

not be ready for use until next summer. Therefore it was decided to build the boat on one of the Swedish naval yards. The result was the torpedo boat *Rolf*. It was launched in 1880 and is often seen as the first real torpedo boat of the Swedish navy.

Journeys abroad were important means for the navy to gather information regarding torpedoes and torpedo boats. It was common to send naval engineers to the yards abroad that built ships for the Swedish navy. The aim was not only to get more information on the actual ship but also to receive more knowledge on the construction of torpedo boats in general. When the torpedo boat *Hugin,* which was being built in England, was nearing its completion in 1884 an engineer was sent to the yard. His instructions are typical and shows that the journeys abroad had wider aims than just getting to know the actual ship. The journey home from England was to go via France where he should try to find information on the torpedo boats being built there. The information collected on the journeys was time from time of great importance for Swedish decisions to continue building torpedo boats. That showed in 1881 when the tests with the new, domestically built, torpedo boat *Rolf* were still in progress. But the developments within the field were very swift abroad and it was decided that one of the two torpedo boats that the navy had already received funding for ought to be built at a foreign yard. The order was given to Thornycroft. In the internal documents of the navy it is clearly stated that a journey that Ekermann had made to that yard to study a torpedo boat built for the Danish navy, was crucial for the decision.[42]

There are not many documents in the source material that offer clues to the views of Swedish naval officers on torpedo boats. There seems, however, not have been any open opposition or protest against the plans on building torpedo boats. That would have shown in the journals studied. There was, however, an ongoing discussion regarding the qualities of the torpedo boats. Were they to be bigger and more seaworthy, carry more supplies, and be able to journey out to sea for a longer time or should they be smaller (and cheaper), faster and easier to maneuver? The solution was to have two different types of torpedo boats, smaller torpedo boats to be used in the archipelagoes, and bigger ones that could venture out on sea with the armored cruisers. There seems to have been almost unanimously positive views on torpedoes and torpedo boats among naval officers. But the positive views did not lead them to want to introduce the new weapon in a quick and radical way. They wanted to keep the spar-torpedoes which were seen as very useful even at a time when the Whitehead

[42] RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:267, Marinförvaltningen till Chefen för Sjöförsvarsdepartementet 2 januari 1882, RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:258 ,Marinförvaltningen till Chefen för Sjöförsvarsdepartementet 12 januari 1881, RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:287, Utdrag ur protokollet 13 juni 1884, RA, Sjöförsvarsdepartementet, Huvudarkivet, Konseljakter, EI:288, Marinförvaltningen till Chefen för Sjöförsvarsdepartementet 22 juli 1884.

torpedoes had developed into rather reliable weapons. The Swedish navy slowly but steadily introduced new torpedoes and torpedo boats. The introduction of torpedoes and torpedo boats does not seem to have caused any debate regarding the strategic plans of the navy. Perhaps because they fit very well into these plans? How naval officers wanted and planned to use the new weapons and ships is an important question which will be discussed in the following section.

8. HOW DID SWEDISH NAVAL OFFICERS WANT TO USE TORPEDO BOATS?

How new weapons are to be used in the best and most efficient way is seldom obvious when they are introduced and the views on the matter can change when more experience is gained. But in the case of torpedoes and torpedo boats there seems to have been little change in the thoughts on how to use them. The torpedo boat was early on seen as a vessel that would sneak out of its hiding-place in the archipelago and surprise the enemy. Three or four torpedo boats ought to work together and attack the enemy from different directions. They also needed support from bigger vessels which could protect them with their fire (by creating a smoke screen in which the torpedo boats could hide but also by damaging the enemy ships). The bigger ships could also carry supplies for the torpedo boats to extend their endurance.[43] In 1886 current and future possible tasks of torpedo boats were discussed in an article in *TiS*. It was suggested that they should be able to accompany the other vessels of the fleet out onto the open seas. When the enemy fleet neared the Swedish coast the torpedo boats should to try to break through the convoy's protective screen of ships and sow death and destruction among the ships which transported the troops. In the archipelago the torpedo boats could be given more independent roles. They would defend mine-fields, break up blockades, and attack the enemy. An important task would be reconnaissance. Torpedo boats were viewed positively after many of the yearly exercises with the fleet. P. Virgin, the commander in chief of the squadron of 1885 meant that "torpedo boats with self-propelled torpedoes as well as spar-torpedo boats seem currently to be one of the weapons which are most useable, of a high value for battle and offer a tremendous resource for defending the coast and the archipelago". Virgin was of the opinion that the navy needed nine bigger torpedo boats and 33 of the smaller kind.[44] After the exercises in 1887 Virgin continued to praise the torpedo boats. They could not only attack at night when

[43] C S:th: Vidare om minbåtar, in *TiS* 1879:1, p. 30, Torpeden och minan i sin historiska utveckling intill nyaste tiden, in *TiS* 1879, p. 131

[44] Krigsarkivet (KrA), Marinstaben, Expeditionen, Generalrapporter, EXVI:8, Högste befälhavarens generalrapport 1885, K P: Förbättringar inom torpedväsendet och derigenom ökadt värde af torpedbat, in *TiS* 1897, p. 98

they were hard to detect, but also at broad daylight. He was of the opinion that a swift attack by many torpedo boats would make it hard for the ships under attack to defend themselves. One of the torpedo boats would surely make it close enough to fire its torpedoes. Close enough had actually to be quite close. During the exercises self-propelled torpedoes had to be fired from a range of within 400 meters to be regarded as successful. Spar-torpedo boats needed to come even closer, within 50 meters of its target.[45]

The tasks of the torpedo boats in war were very risky. Many of the writers in *TiS* and *KKrVA* were certain that there would be quite big losses within a group of torpedo boats. The commander of the ships would have to not scare easily. In 1877 one writer stated that "Each and every one who commands such a ships must focus his thoughts on getting *to* the target to fulfill his task of destruction, not on staying alive and *returning* from the target".[46] Quite big losses seem to have been acceptable to the naval officers of the time. In TiS in 1879 it was deemed acceptable if five out of eleven torpedo boats survived an attack – if the torpedo boats had managed to sink an enemy ship.[47]

9. CONCLUSION

It is important for a military organization to successfully update its technology as not to lose strength in relation to its potential enemies. Military organizations are often seen having troubles integrating new technology that potentially will strongly affect its way of fighting. After the mid-1850s the naval technology developed quickly. The times were regarded as troublesome by naval officers as Swedish strategic plans strongly favored the army. The navy lacked resources to renew its ships and equipment. Then torpedoes and torpedo boats entered the stage. These were innovations that ought to suit a navy like the Swedish navy which lacked great financial power and would have to defend itself against a more powerful enemy. The essay tries, by studying the introduction of torpedoes and torpedo boats, to analyze how Swedish naval officers regarded the development of new naval technology and which conclusions they drew for the Swedish navy.

Judging from the views of naval officers on torpedoes and torpedo boats in the years 1860-1901 there does not seem to have been any general resistance to new technology and innovations in the Swedish fleet. Many naval officers chose a cautious view on technology; it could be introduced after it had been thoroughly tried and tested (preferably by the greater powers). Torpedoes, spar-

[45] KrA, Marinstaben, Expeditionen, Generalrapporter, EXVI:10, Program för eskaderns krigsöfningar i Östergötlands och Södermanlands skärgårdar den 20-23 augusti 1888, KrA, Marinstaben, Expeditionen, Generalrapporter, EXVI:9a, Rapporter rörande minbåtsanfall den 18-19 augusti 1887

[46] C. St:h: Vidare om minbåtar, in *TiS* 1879, p. 29

[47] Torpeden och minan i sin historiska utveckling intill nyaste tiden, in *TiS* 1879, p. 337f

torpedoes as well as self-propelled ones, seem to almost unanimously have been viewed positively, but not uncritically. Torpedoes and torpedo boats fit well into the plans of the navy on how to fulfill its tasks in case of war. The war that the navy prepared for was an invasion by a stronger enemy (Russia was seen as the most probable attacker) where the Swedish ships would attack the enemy, not the least the ships transporting troops and equipment needed for an invasion. Even if there in general was a positive view on torpedoes and torpedo boats it was discussed how much resources ought to be spent on these weapons and what kind of torpedoes and torpedo boats were needed. It is obvious in many of the articles and discussions on the matter that naval officers view on torpedoes and torpedo boats can be seen as having had a common starting-point. There was a common structure of thoughts among Swedish naval officers. The core was the current and preferred future role of the navy. The strong dominance of the army in the strategic planning of how to best defend Sweden in case of war was of great importance. Naval officers had to position themselves in relation to the dominance of the army. The navy was a junior partner to the army and would have to leave the leading role to the army and fulfill a more supportive role. Naval officers welcomed the development abroad where many countries increased their spending on naval equipment and built rather large naval forces. But they did not think such a development would be possible in Sweden and did not try to argue for a big and strong navy. The mental limits within which the discussions regarding ships the navy would need and could possibly get funding for were pretty well defined. The naval officers had a relatively common view on the possible way a war would have to be fought and on the role of the navy in such a war. In a time when the technological conditions for the ways wars could be fought at sea, these limits seem to have given the naval officers a stable and pretty coherent view on what ships the navy needed. At the same time, the development of new naval technology could give naval officers strength to argue for a more important role for the navy in the overarching Swedish military strategic planning. The new technology, as for example torpedoes and torpedo boats, could make it possible for a smaller navy to give an important contribution to a defense against a stronger enemy. Naval officers could argue, and did so, that Sweden with the help of the navy could better defend itself and perhaps even repel a potential enemy from attacking. Torpedo boats could attack much bigger and stronger ships at much better odds of success than previously possible. The introduction of torpedoes and torpedo boats therefore can be said to have contributed to a change in Swedish strategic war plans towards a strategy focused on hindering the enemy from setting foot on Swedish soil.

SAŽETAK

Godine 1875. Švedska je naručila prva torpeda od proizvođača Whiteheada iz Fiume/Rijeke. Nekoliko godina poslije odlučeno je da se izgrade specijalna plovila koja će prevoziti torpeda, torpedni čamci. Moj se rad usredotočuje na uvođenje torpeda i torpednih čamaca u Švedsku mornaricu od 1860. do 1900. Može se raspravljati o tome jesu li torpeda i torpedni čamci bili oružja koja su trebala odgovarati i Švedskoj mornarici. Bila je to mala i razmjerno siromašna ratna mornarica koja se nije mogla natjecati s većim i moćnijim mornaricama drugih zemalja koje su okruživale Baltik. Mala, relativno jeftina plovila mogla su uz pomoć torpeda prijetiti većim i jačim brodovima. Smatralo se je da bi ruska invazija preko Baltika mogla biti najveća moguća mornarička opasnost.

Katkad se tvrdi da su i vojni i mornarički časnici konzervativni i da ne žele vidjeti promjene u načinu na koji obavljaju stvari. Stoga se govori da su oprezni kad je riječ o uvođenju nove tehnologije i novih oružja u njihove organizacije. Kako su švedski mornarički časnici tog vremena gledali na torpeda i torpedne čamce? Jesu li raspravljali o novom oružju ili su se suprotstavljali njegovu uvođenju u Švedsku mornaricu? Je li uvođenje torpeda i torpednih čamaca utjecalo na švedsku mornaričku strategiju? Ovaj rad analizira opću švedsku vojnu strategiju u to vrijeme, stajališta mornaričkih časnika o tada aktualnim i poželjnim budućim zadacima mornarice. Cilj je pokušati objasniti zašto su mornarički časnici mislili i djelovali tako kako jesu kada su torpeda i torpedni čamci uvedeni u Švedsku mornaricu.

Rad se zasniva na proučenim dokumentima iz arhiva Švedske mornarice, kao i esejima objavljenim u dva ugledna vojna časopisa koja su u to vrijeme čitali mornarički časnici.

Ključne riječi: *Švedska, torpeda, torpedni čamci, vojna tehnologija, strategija*

THE MUTATIONS OF THE WHITEHEAD TORPEDO (1864 – 1918)

Promjene u Whiteheadovu torpedu (1864. – 1918.)

Helmut W. Malnig*

SUMMARY

Though the Whitehead Torpedo has only slightly differed in shape within decades, it has undergone many changes on component- and systems level, affecting / enhancing overall performance and efficacy. Not only because the requirements in competition with the Big Gun had been raised, but it had steadily advanced with the progress of science and technology, thus always representing an up-to-date state or even beyond. Due to its modular construction and potential for adaptation current science and technology could continuously be applied for its metallurgy, engine development, internal power transfer, propulsion, navigational control and explosive train, etc.
Speed and range are interdependent on the tank volume and on the internal energy of the propellant (pressure, heat), while stealth and the lethal subaquatic explosion constitute the real asset of the torpedo. Due to the easy and cheap application of the launching system it turned into a naval force equalizer also up-rating minor navies.
This paper, meant as an introduction, wants to present the major changes, starting with the mutation of Luppi's explosive boat into Whitehead's submarine weapon and its further development. All that was facilitated by the international branches of the Whitehead Company, as local modifications and improvements were instantly communicated within the company, leading to the first international military-scientific collaboration and achieving the most complex technical system of the 19th century.

Keywords: *introductive paper, explosive boat, Stealth naval weapon, subaquatic explosion, modular design, development with technical progress, force equalizer for minor powers, tribute to: Luppis – Whitehead – Obry – Gesztesy, most complex weaponry system of 19th century*

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1. INTRODUCTION

1.1. The torpedo – a subaquatic missile

The torpedo, considered at first only as secondary armament of capital ships, soon found a new carrier in the torpedo-boat and especially in the submarine, the stealth approach of which was ideal for delivery of its missile.

While big gunnery was mainly intended to destroy the upper-structure of ships, the torpedo produced a lethal underwater effect at stealth approach, though its initial disadvantage lay in the comparatively slow transition towards its target.

Due to the simplicity in its usage and of its launching system, it became a force equalizer even for minor naval powers, revolutionizing naval warfare.

The Torpedo is a technical marvel, which employed all the technical and scientific know-how of its time, thus constantly improving in precision and lethality.

Its significance in the 19th century is comparable to that of the space rocket of our time.

For description of the torpedo as a missile it may be simply sub-divided into 3 major units, all of which comprising the relevant cover-shell, tubing and valves, accessories and actuating elements:

– Warhead (payload)

– Propulsive-unit (mid- and tail-plane section)

– Navigational-control (stabilization)

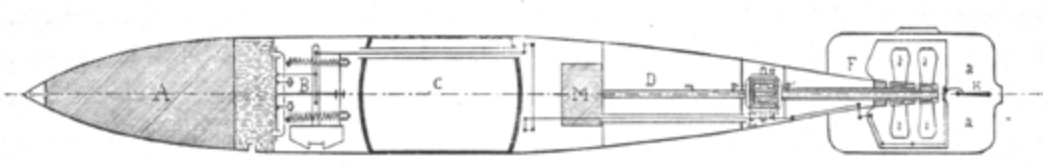


Fig. 95. — Coupe schématique d'une torpille Whitehead, montrant les divers compartiments.

A, cône de charge. — B, compartiments des régulateurs. — C, réservoir d'air. — D, flotteur. — E, emplacement des engrenages. — F, queue. — H. gouvernail. — M, machine. — *tttt*, hélice. — *aaa*, ailerons.

Figure 1.

2. WHITEHEAD TORPEDO: REASONS OF CHANGE

2.1. Military Requirements

In the course of technical progress in shipbuilding, tooling and metallurgy since the first appearance of the torpedo, the military requirements for this weapon had to be raised. This led to improvement in components- and systems level, very much facilitated by an inherent modular design, which allowed replacement of obsolete parts / components and related systems adaptation.

Here, I want to distinguish between changes which did not carry any significant improvement in performance, and those I shall not cite, as f.i. internal power transfer:

via rods and levers > Pneumatic / hydrodynamic drive > electrical actuators,

and changes directly affecting performance increase through shape, weight, war-load, propulsion and stability.

2.2. Basic Mutation from Explosive Boat to Sub-aquatic Missile

1866 The basic mutation occurred when Whithead transformed Luppi's "Salva Coste" explosive boat from 1864, into a sub-aquatic missile, which it has remained ever since. That date has become the origin of the torpedo.

The Torpedo has been derived from Luppis' remotely-controlled explosive boat (a surface vessel) of 2-dimensional scope, into a sub-aquatic, stealth missile of 3- dimensions. (Table 1)

Table 1. *Table of Comparison Explosive Boat vs. Torpedo*

TABLE OF COMPARISON

	Luppis' Explosive Boat – "salva coste"	Whitehead's "Fish-Torpedo"
Dimensions:		
Length	6 m	3.4 m
Width	--	cal Ø 35 cm
Displacement	--	136 kg
Explosive charge	boat filled with explosives (?)	8 kg
Design:	conservative surface vessel	revolutionary submarine craft
Hull:	tarpaulin covered boat wood	spindle-shaped with endcones steel sheet
Specifications:		
Speed	6 kn	6 – 8 kn
Range	500 m / rope length	300 m
Propulsion:	clockwork (or steam)	compressed air, 2-cyl.engine
	2 – bladed propeller	3 – bladed propeller
Deployment:	littoral, boat launch	on the high seas, tube launched
Perturbations:	exposed to wind and sea	undisturbed
Operations:	vessel and operator are vulnerably exposed	no further contact, stealth target approach
Target acquisition:	2- dimensional	3- dimensional
Guidance:	2 lines on rudders	launch-tube guided
	adjustable course	preset course > autonomous
Detonation:	4 spars for percussion fuzes at waterline	pistol fuze at tip subaquatic





3. MAJOR CHANGES

3.1. General: Changes of Dimensions

The most important changes affected size and shape > calibre, length and weight due to increased performance requirements and components internal lay-out. The torpedo was thus enabled to carry a greater war-load for lethal effect at higher speed and precision for longer ranges. (Figure 2)

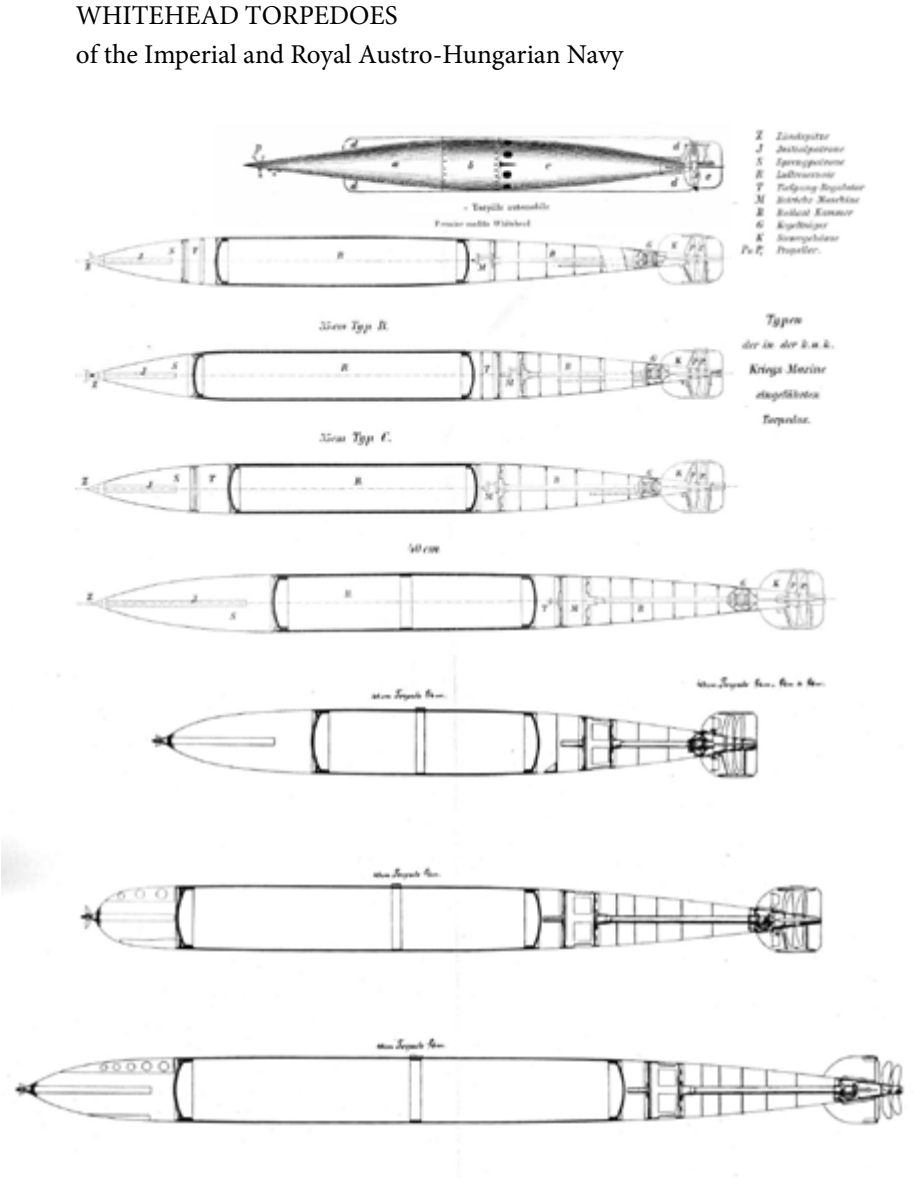


Figure 2. *Whitehead Torpedoes of the Austro-Hungarian Navy*

3.2. The Warhead

The warhead comprises the fuse, ignition chain, explosive charge and the safe-and arm (S.&A.) devise. As can be distinguished from Figure 2 the pointed tip of the torpedo was changed to a blunt ogival form in 1883 by Dr. Froude, accommodating a larger explosive charge, improving hydrodynamics and the possible contact area at impact.

Otherwise the lay-out of the entire explosive train remained unchanged starting with the mechanical safe-and-arm device, the contact fuse, the primer cartridge, transfer and main explosive charge.

The total charge amounted originally to 8 kg of wet gun-cotton while the new torpedo carried 100 - 150 kg explosives – either poured in directly or put in in slices from compressed gun-cotton fitting the available front space.

At target contact the grapple hook sets the percussion bolt free and hits the percussion cap, transmitting via ignition chain and amplifying charge, which are both centrally located inside the main charge, the explosion of the entire warhead.

3.3. The Propulsive Unit – Afterbody and Tail

3.3.1. The Pressurized Air Reservoir

The air tank represents the most dominant part of the torpedo, as its capacity is equivalent with the potential of the torpedo, i.e. it allowing stronger engines, improving the operational range, speed and precision at augmented war-load. Modern technology in material sciences and in manufacture allowed Robert Whitehead the storage of pressurized air from originally 25 atm up to 90 atm and beyond to 175 atm.

While the first vessels were made of standard riveted iron boiler plates, they were seamlessly produced later of 6 % Cr-Ni- steel, which eventually allowed an operational pressure of above 175 atm at 10 mm wall thickness. The end-bulkheads were attached air-tight to the reservoir flanges employing a special thread.

Under these considerations the air reservoir with its external surface and according to its inherent rigidity constitutes also a main element of the torpedo's rigid structure.

3.3.2. The Propulsion Unit

Thanks to the increased tank pressure stronger pneumatic engines could be employed instead of the two-cylinder engine, such as the compressed air driven three–cylinder Brotherhood radial motor delivering 70 hp (at close distance!) between 1871 – 1907, which towards the end of 1907 was furnished with an air-heater.

From 1908 onwards all torpedoes were powered by a 4-cylinder Brotherhood radial motor with standard equipped heater, resulting in a 15–20% increase in performance. (Figure 3)

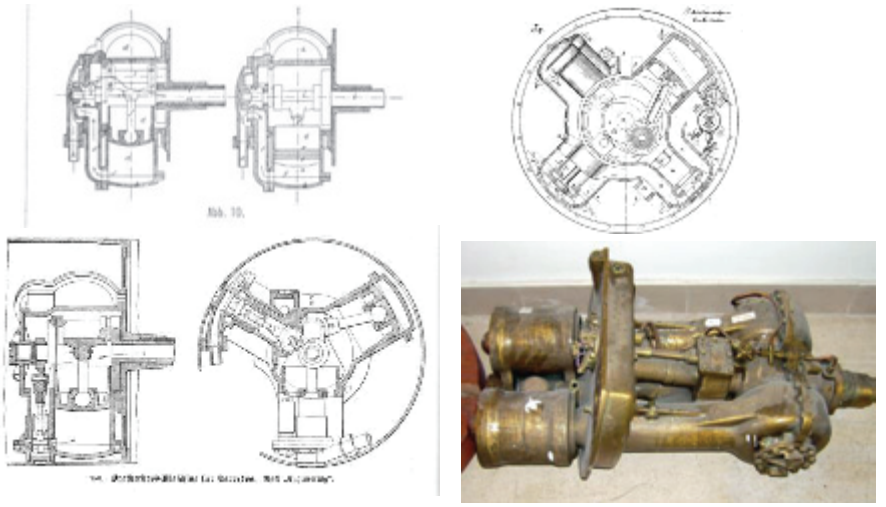


Figure 3. *Whitehead Changes of Power Source from 2 Cyl. to 3 Cyl. and to 4 Cyl. Radial to Axial 2 Cyl. Slanted Engine*

Between 1912 – 1916 75 Ø 53 cm torpedoes were furnished with a slanting 2-cylinder heat engine. The air entered the cylinders, where it actuated the pistons and escaped through the crank case and the hollow propeller shafts. The exhaust into the water produced an additional component of reaction for the propeller forward drive – and of course a treacherous trail of visible air bubbles mingled with traces of lubrication oil.

Some specifications of the 3-cylinder Brotherhood engine for various calibers:

– Ø 35 cm: 35 hp at 24 atm and 900 rpm

– Ø 45 cm: 50 hp at 34 atm and 900 rpm

3.3.3. Increase of the propellant's internal energy

K.u.k. Lt. Comdr. Gesztesy developed an air heater with water injection located between the air tank and the engine. Due to this new process a combustible liquid and the preheated operational air with their exhaust gases generated the new, more potent propellant / energy carrier, as pressure and volume of the exhaust gases were increased and herewith their internal energy. That system was also called wet pre-heating (steam-torpedo!) (Figure 4)

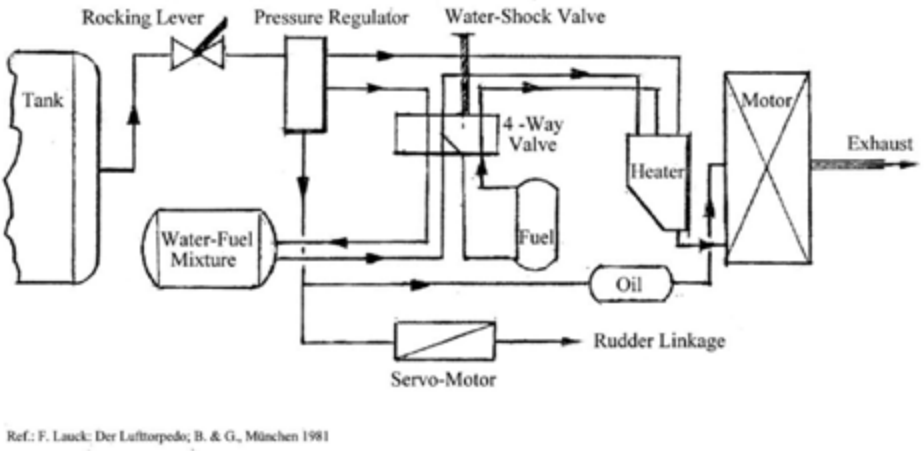


Figure 4. *Whitehead Torpedo Air Propulsion System with Fuel Injection and Heater, in 1907*

Steam-gas propulsion was generally introduced for torpedo manufacture in /after 1907.

The vessels of the combustion chamber (pre heater 10 kg), for the spirit-water mixture and the fuel were relatively small and of negligible weight and therefore easily accommodated later in the machine-chambers of earlier torpedo models.

In 1911 Gesztesy reduced the high combustion temperature by water injection also using a vaporized water-spirit mixture of lower heat content than that of petrol, which was heated before engine entry, at barely 220° C. This heating of the air brought an additional gain in performance of $\eta > 23\%$.

Test runs in 1908 resulted at 2 000 m distance in a remarkable speed of 33.2 kn and at 1 500 m in 36.6 kn. The resulting increase in performance – the torpedo had gained 5 – 7 kn in speed while doubling its range – signified a major success in torpedo design. The only disadvantage was a distinct bubble trace due to the steam-, fuel- and air mixture, which was otherwise compensated by the raised performance.

3.3.4. The Tunnel- and Afterbody

The Torpedo afterbody is its aft-section (stern), which consists of a reinforced conical shell containing the bevel gear, a lubrication device, two co-axial, counter rotating, hollow propeller-shafts driving each two 3 – 5 blades propellers. The afterbody carries also the rigid tail cross of the rudder, the propeller fairings, two horizontal and the originally fixed vertical fins, each adjustable by leverage.

Two possibilities of direct steering have resulted in two versions:

– Whitehead- or Fiume-rudder or -tail: the propeller in front of the rudder for better navigation control but inducing greater resistance

– Woolwich rudder or -tail: the aft arrangement of the propellers allows a generally simpler design of the rudder and transmission rods. It offers less resistance but is also less effective in steering.

The rudder-cross mounts the active depth- and lateral control, serves the stability in rough sea and against rolling, guidance inside the torpedo tube, and contains the bearings of the propeller axes.

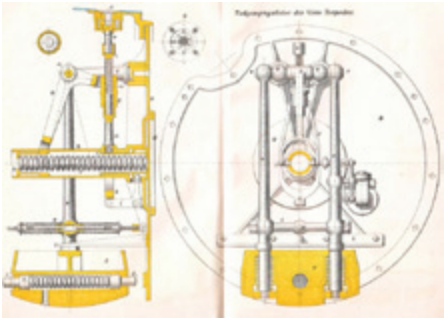
3.4. Stabilizing Systems

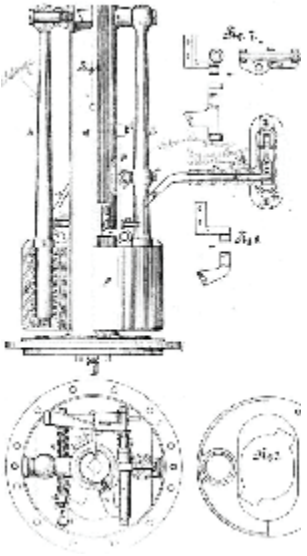
3.4.1. Counter-rotating Propellers

After 1873, the introduction of two counter-rotating propellers, featuring 2 or 3 blades, by the Woolwich Factory was a significant improvement, as the heeling effect due to one screw was compensated, and also providing a smoother run. Technically that was achieved by a bevel-gear box in the tail-section.

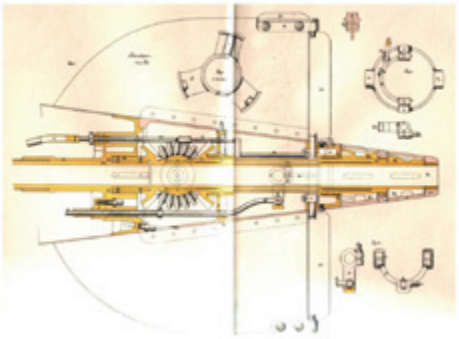
3.4.2. The Depth Control Device ("Whitehead's Secret")

The original depth control device worked on the principle of the hydrodynamic valve. Whitehead deployed in addition a heavy pendulum, which transmitted its effect via leverage – later through servo motors – unto the horizontal flaps of the tail plane. While the pressure-gauge sought the preset depth, the pendulum established the horizontal level.





■ **Figure 5.** *Depth Control*



During the course of development for the depth control regulator a hydraulic piston was employed, upon which the corresponding water pressure was exacted, against which on the inside for a preset depth the pre-tensioned spring counter acted. (Figure 5)

3.4.3. Installation of Depth Control in the Afterbody

In 1885 "Whitehead's Secret" was moved from stem to a position between tank and engine. This was a decisive move, as the penetration of the tank was avoided, releasing and shortening many mechanical links and joints, thereby reducing sealing and friction, and improving stability by positioning the C.G. in the afterbody.

A minor change slightly affecting speed and stealth was the ducting of the exhaust gases from athwart through the hollow propeller shaft and hub producing an additional jet repulse and a reduced trail of air bubbles.

3.4.4. The Gyroscope of Ludwig Obry

A final enhancement in stability was the introduction of the lateral steering control of the Triestine naval designer Ludwig Obry in the tail section after 1895 by Robert Whitehead.

That device was essentially a gyroscope, consisting of ca. 800 g heavy flywheel of diameter 7 – 8 cm, the axis of which had been gimbal-suspended parallel to the torpedo axis.

At torpedo launch the flywheel was spun at 2 400 rpm, and later far beyond that, initiating the system by a spiral spring drive. The free axle retained due to gyro motion its original position even when the torpedo changed its axial position. (Figure 6)

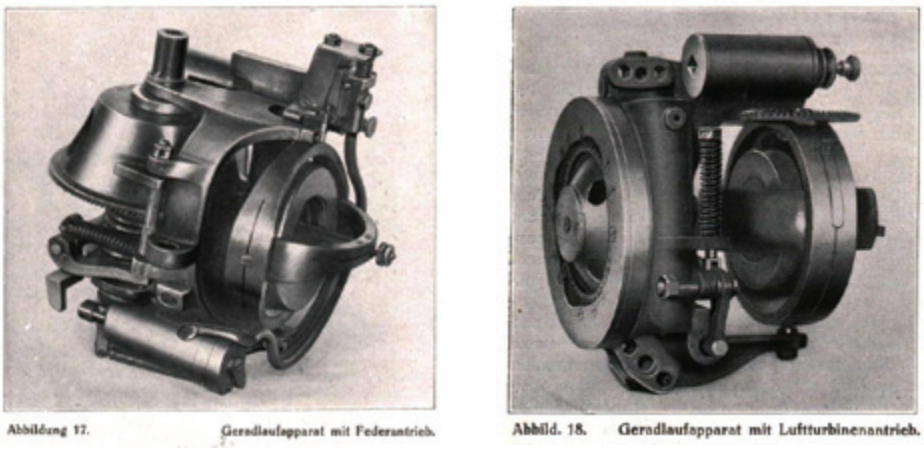


Figure 6. *Obry's Gyroscope: Spring with Rudder-flap, and later Air-Jet-Drive*

"Is the torpedo forced through external or internal reasons to a deviation in its course, then a change of the axial position of the gyroscope within the body of the torpedo occurs. The latter reacts on the servo engine, which accordingly and directly is applied to the lateral rudder, in order to set the torpedo on its initial course." (Ref.: Mitteilungen aus dem Gebiete des Seewesens; k.u.k. Hydrographisches Amt, Vol. XXIV, Nr. IX, Pola 1896.)

Before launch the gyroscope is generally retained, then at launch activated, whereby 10 000 rpm or with modern machines a multiple of this - are performed. This represents an indirect directional control, as the gyro only registers lateral deviations, but does not exact any corrective movement on the vertical rudder itself. The only disadvantage during that period was the diminishing number of rotations (rpm) of the spring driven gyro at greater distances and resulting in a fading effect on the swiveling of the lateral rudder fins – and with corresponding lack in stability. Only later, continuity of rotation could be obtained when an air turbine was used at 18 000 rpm or an electro motor, whereby the operative range of the weapon was accordingly increased, i.e. the dispersal dropped to 1% of the target distance.

Thanks to the lateral control device of Obry the Whitehead Torpedo achieved such an accuracy and reliability that surpassed already then heavy naval ordnance both in effectiveness and range.

4. A TRIBUTE TO THE ORIGINATORS OF THE ESSENTIAL CHANGES

4.1. The Originators

– **k.u.k. Lt. Comdr. Giovanni de Luppis,** Ritter von Rammersdorf
Italo-Austrian naval officer and inventor
28. 1.1818 born in Fiume (Rijeka)
11. 1.1875 died in Milan, a frustrated old man

– Lt.Cmdr. **Giovanni de Luppis** realized by model in 1865 an idea of the chemist / technician **Franz Pfeifer** for a surface craft, powered provisionally by a clock work, and with its twin-rudder remotely controlled by ropes. It was the first **remotely controlled explosive boat** with two-dimensional application!

– **Robert Whitehead,** Engineer and Industrialist;
English engineer in Austrian governmental services
3. 1.1823 born in Bolton-le-Moors, Lancashire
14.11. 1905 death in Becket, Berkshire, a wealthy personality in high repute

– The ingenious and versatile English engineer **Robert Whitehead**, collaborating with Luppis, developed from that the first **seaworthy, automotive**

torpedo, for which he devised a launching tube in 1867, and a reliable depth control in 1868. He recognized the "stealth"-factor of the subaquatic attack, employing the third dimension.

– **Ludwig (Luigi) Obry**, Naval Designer;

Austrian naval architect

22. 8. 1852 born in Trieste – no picture exists of that ingenious inventor!

2.11. 1942 death in Trieste, despite his ingenuity an unknown personality.

– But only the application of the **gyroscope** from **Ludwig Obry** in 1895 **stabilized the torpedo's course** to hit a target aimed at a proper distance even under adverse ambience.

– **k.u.k. Lt. Comdr. Johann Gesztesy**

Hungarian naval officer and inventor

Born on 24th Nov. 1865 in Güns, Hungary

1915 half-paralyzed and death in Vienna

– A **final increase in performance** due to augmented fuel energy brought the air pre-heater from **Johann Gesztesy** in 1907.

4.2. A Tribute

The combined effort of all those naval engineers had resulted in the most complex weapon's system of the 19th century. Even in the 20th century sea warfare was determined by the lethality of the torpedo, which in its significant components had remained unchanged.

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SAŽETAK

Iako se Whiteheadov torpedo oblikom tek neznatno mijenjao tijekom nekoliko desetljeća, doživio je mnoge promjene u komponenama i u sustavu, koje su utjecale ili poboljšavale stupanj izvršenja i učinkovitost. Unapređivan je ne samo zbog nametnutih zahtjeva u konkurenciji s teškim *topom, već usporedno s napretkom znanosti i tehnologije, pa je tako uvijek bio jako suvremen, ako ne i više od toga.*

Zahvaljujući svojoj modularnoj konstrukciji i mogućnosti prilagodbe, znanost i tehnologija neprestano su se mogle primjenjivati na njegovoj metalurgiji, razvoju motora, unutarnjem transferu energije, propulziji, kontroli navigacije, eksplozivnom lancu i slično.

Brzina i domet ovisni su o volumenu rezervoara i o unutarnjoj snazi pokretača (pritiska, topline), a potajna i letalna podvodna eksplozija istinska su vrijednost torpeda. Zbog lagane i jeftine primjene sustava lansiranja uspio je ojačati i manje ratne mornarice i učiniti ih ravnopravnima s onima većima.

Ovaj rad, zamišljen kao uvod, ima namjeru prikazati veće promjene, počevši od mijenjanja Luppijeva eksplozivnog čamca u Whiteheadovo podmorsko oružje, kao i njegov daljnji razvoj. Svemu tome išli su na ruku međunarodni ogranci Whiteheadove tvrtke jer su se lokalne promjene i poboljšanja mogli odmah proširiti tvrtkom, dovodeći tako do prve međunarodne vojno-znanstvene suradnje i ostvarujući najsloženiji tehnički sustav 19. stoljeća.

Ključne riječi: *uvodni rad, eksplozivni čamac,* stealth *pomorsko oruže, podvodna eksplozija, modularni dizajn, razvoj s tehničkim napretkom, izjednačivač sile za manje snage, odavanje priznanja: Luppis – Whitehead – Obry – Gesztesy, najsloženiji sustav naoružanja 19. stoljeća*

EUROPA NOSTRA'S INDUSTRIAL & ENGINEERING HERITAGE COMMITTEE (IEHC)

Odbor za industrijsku i tehničku baštinu *Europe Nostre*

David Morgan*

SUMMARY

Europa Nostra (EN) is recognised by the European Commission as the Voice of Cultural Heritage in Europe and seeks to support and promote interest in it throughout the continents if not the world.

IEHC was set up following EN's Annual Congress in Newcastle in 2008, whose theme was "Securing the future of Europe's Engineering Heritage". The committee seeks to promote the values of Europe's shared industrial and engineering heritage, by holding meetings twice a year in selected cities around Europe, preparing papers and presentations at seminars, and organising study tours of industrial heritage sites for delegates attending EN's annual congress.

IEHC also encourages industrial and engineering sites to participate in EN Award Schemes. Its members also serve on a number of panels and other Awards bodies as it seeks to collaborate with similar organisations such as TICCIH (The International Committee for the Conservation of Industrial Heritage) and FEDECRAIL (the European Federation of Museum & Tourist Railways). In particular, it supports research, dissertation and propagation of information on industrial and engineering history and developments, for example by participating in seminars and conferences such as TORPEDO HISTORY AND HERITAGE.

IECH comprises approximately ten volunteers from Belgium, France, Italy, Netherlands, Spain and the United Kingdom from a wide range of industrial and engineering specialism.

IEHC is also reviewing how it might best help the promoters, curators and directors of industrial and engineering heritage projects and sites on the ground.

Keywords: Europa Nostra*, IEHC – Industrial & Engeneering Heritage Committee,* Europa Nostra *Award,* Europa nostra *annual congress*

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SAŽETAK

Europu Nostru *(EN) priznaje Europska komisija kao glas kulturne baštine u Europi, kojim se želi podržati i promicati zanimanje za industrijsku i tehničku baštinu diljem svijeta.*
Industrial & engineering Heritage Committee *(IEHC) – Odbor za industrijsku i tehničku baštinu osnovan je nakon godišnje skupštine* Europe Nostre *u Newcastlu 2008., čija je tema bila* Kako osigurati budućnost europskoj tehničkoj baštini. *Odbor želi promicati vrijednosti europske industrijske i tehničke baštine održavajući sastanke dva puta na godinu u odabranim gradovima Europe, pripremati radove i prezentacije za seminare te organizirati znanstveno razgledavanje lokacija industrijske baštine za delegate koji sudjeluju na godišnjim konferencijama* Europe Nostre.
IEHC, isto tako, potiče predstavnike mjesta na kojima se nalazi industrijska i tehnička baština na sudjelovanje u programu dodjeljivanja nagrada EN-a. Njegovi članovi sudjeluju i u brojnim panelima i drugim tijelima koja dodjeljuju nagrade jer Odbor želi surađivati sa sličnim organizacijama kao što su TICCIH (The International Committee for the Conservation of Industrial Heritage – Međunarodni odbor za očuvanje industrijske baštine) i FEDECRAIL (The European Federation of Museum & Tourist Railways – Europska federacija muzeja i turističkih željeznica). Na poseban način podržava istraživanje, učene rasprave i širenje informacija o industrijskoj i tehničkoj povijesti i razvoju, primjerice sudjelovanjem na seminarima i konferencijama poput Torpedo – povijest i baština.
IEHC se sastoji od desetak volontera iz Belgije, Francuske, Italije, Nizozemske, Španjolske i Ujedinjenog Kraljevstva, koji pripadaju širem krugu industrijske i tehničke specijalizacije.
IEHC razmatra načine na koje može najbolje pomoći promicateljima, kustosima i voditeljima projekata industrijske i tehničke baštine, kao i samim lokacijama te baštine.

Ključne riječi: Europa Nostra*, IEHC – Odbor za industrijsku i inženjersku baštinu, Nagrada* Europa Nostra*, Godišnji kongres* Europa Nostra

MARITIME SAFETY – TORPEDO WEAPONS IN THE COLLECTIONS OF NAVY MUSEUM IN GDYNIA

Sigurnost na moru – torpedno oružje u zbirci Muzeja ratne mornarice u Gdyniji

Tomasz Neubauer*

SUMMARY

Torpedo weapons equipped battle ships of the Polish Navy appeared in the interwar period. In the years 1921-1939 Poland was exploited in the production of torpedoes French and English, which were supplied up until 1952 . After World War II Navy battle ships predominate, however, torpedoes Soviet production.
In the Polish museums we can see exhibits including torpedo weapons in the Polish Army Museum in Warsaw, Museum of Polish Arms in Kołobrzeg and Museum "Orzeł Biały" in Skarżysko-Kamienna. However, the largest such collection is housed in the Naval Museum, which was founded on June 28, 1953 in Gdynia. Many interesting exhibits from World War II and the postwar period, thanks to the hard work of several generations of historians and museum has survived from oblivion today. In Gdynia, visitors can admire the torpedo weapon inside the museum building, on the outside the museum, as well as a museum battle ship ORP "Błyskawica".

Keywords: *weapons torpedo, museum collections, the Navy Museum in Gdynia*

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1. INTRODUCTION

Before the construction of the torpedo battle ships began, the main focus was to improve the weapons, torpedoes, itself. Torpedoes, as well as all other kinds of weapons, had its moment of very dynamic development, which, from the very beginning, was technically challenging and demanding. Damaging of the underwater part of a battle ship's fuselage equaled its sinking or at least severe damage. In the beginning, metal underwater devices (cans) filled with gun powder, or other explosive materials, were attached either to the bottoms of sea routes or to the attacking battle ship's prow. At that time spar mines were called torpedoes. Long spar torpedoes had, along with the attachment, about nine meters of length. Their weight, along with the explosive material, was about 25-30 kilograms of piroxylin. Once the explosion took place and the spar torpedo would hit the battle ship's side at the depth of 2,5 meters, they pierced the side making a hole from a few to dozens of square meters big[1].

After year 1860 torpedoes were used during the American Civil War both as torpedoes defending the ports' entrance (which today we call mines) as well as torpedoes attached to the poles and used in direct battles[2].

In the second half of the 19th century, torpedoes were called self-propelled weapons. They were produced in Fiuma (today Rijeka), and the head of the production was engineer Robert Whitehead[3].

Torpedo weapon appeared in Poland around the end of the First World War. It was at that time when, due to war reparations, Poland was given six torpedo battle ships: OORP Krakowiak, Kujawiak, Kaszub, Mazur, Podhalanin and Ślązak. The torpedo weapons of the battle ship consisted of one double torpedo launcher, caliber 450 mm, made in France. Later on, double launchers were brought from France as well as triple launchers from Russia (all of the same caliber) 450 mm. In those different launchers, torpedoes made in France were used and those were obsolete torpedoes made in 1904, 1906 and 1911, which were modelled on Whitehead's torpedoes. In year 1932 English torpedoes caliber 450 mm type A were bought to be used by the underwater minelayers.

Between years 1926 – 1932 two Polish destroyers ORP "Wicher" and ORP "Burza" were built in France. They were equipped with six torpedo launchers, caliber 550 mm. The torpedoes used at that time by those battle ships were French, types 1923 D. Three underwater minelayers were also built at that time, OORP "Żbik", "Wilk", "Ryś", equipped with six torpedo launchers, also 550 mm.

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1 A. Komorowski, J. Kuliś, *Torpedy*, Warszawa 1977 r. s. 9, T. Neubauer, *Rola małych jednostek bojowych w zapewnieniu bezpieczeństwa morskiego państwa*, Gdynia 2016 r., s. 15-16.

2 J. Bloch, *Przyszła wojna*, Warszawa 1900, s. 77 i 98.

3 A. Komorowski, *Kierunki rozwoju broni torpedowej w Polskiej Marynarce Wojennej w latach 1921-1990*, Przegląd Morski, 1992, Nr 4, s. 26-27, T. Neubauer, *Rola małych jednostek…*, Wyd. Cyt., s. 18.

However, for those battle ships torpedoes type 1924 V were bought, and were characterized by bigger velocity[4].

Further battle ships – destroyers ORP "Grom" and ORP "Błyskawica" were ordered in shipyards in England and Holland between 1933 – 1936 and were equipped in six torpedo launchers, caliber 533 mm, English type. The torpedoes which were used were English AB 1937, caliber 533,4 mm. In Holland submarines ORP "Orzeł" and ORP "Sęp" were built. They were equipped with twelve torpedo launchers, caliber 550 mm, adapted to launch English torpedoes.

2. TORPEDO WEAPON AFTER WW II

After the end of World War II, the Navy exploited three types of torpedo weapons:

- Prewar torpedoes types 1924 V and AB,
- Post-German torpedoes, mostly aviation type, F 5b, F 5W and Japanese TR 91 – all caliber 450 mm,
- Soviet torpedoes – aviation type 45-36 caliber 450 mm and battle ship type 53-38 caliber 533,4 mm.

During the difficult economic situation of Poland, collected torpedoes were sufficient only for training, but weren't enough to be treated as combat force. In the 1950's and 1960's Poland bought equipment and weapon, along with torpedo weapon, from the Soviet Union. Among the equipment bought there were for example, torpedoes type 53-38 and type 53-59.

Gdynia's Polish Navy Museum is the oldest of such type of institutions which is entirely devoted to the Polish maritime weapons. The museum was established in June 28th 1953, from the initiative of the Polish Navy Commandment, as well as a number of fiends and historians.

Due to the specificity of the collection, quite untypical to other museums forms of exhibition, the outdoor one being the perfect example, is the oldest one among all of the museum's exhibitions. Naturally, as years went by, the exhibition underwent many changes, as it kept on becoming bigger and having more and more elements to display.

Systematic naval development and withdrawing of the used units allowed the museum to expand its offer of showpieces. The aim of that part of the museum is to present all types of maritime weapons, and the underwater weapons collection is certainly a very interesting one. Different types of mines, depth bombs launchers, torpedoes and missile depth bombs with launchers are displayed[5].

[4] A. Komorowski, *Broń torpedowa*, Warszawa 1995, s. 32-35, Muzeum Marynarki Wojennej sygn. 549, s.1.

[5] A. Kotecki, *Dział wystawienniczy Muzeum Marynarki Wojennej,* Biuletyn Historyczny nr 19, Gdynia 2004, s.39

Table 1. *Underwater/torpedo weapons in the Polish Navy Museum in Gdynia.*

No.	Year of when the showpiece was given to the museum	Museum section	Type of weaponry	Description	Source where it came from	Contractor
1	1954	UNDERWATER WEAPON	TORPEDO	MARITIME TORPEDO CALIBER 533,4; TORPEDO WITH PRACTICE WARHEAD PAINTED IN HORIZONTAL WHITE AND RED STRIPES, A WARHEAD EQUIPPED WITH AN EAR, TORPEDO'S PROPULSION, 2 PROPELLERS 4 - FEATHERY BACKWARD, FUMES MUZZLE, TORPEDO TAIL WITH STEERING MECHANISM	NO DATA	UNDERWATER WEAPONS FACTORY
2	1955	UNDERWATER WEAPON	TORPEDO	MARITIME TORPEDO C-84A, 1894. COMPLETE HULL WITH NO ENGINE, NUMBER ON THE MAIN BODY 790K, ON THE BODY OF THE PROPULSION AREA AND PROPELLERS NUMBER 499	NO DATA	MUSEUM OF THE WESTERN POMERANIA, SZCZECIN
3	1955	UNDERWATER WEAPON	TORPEDO	AVIATION TORPEDO TYPE F5B, CALIBER 450MM (SECTION), WARHEAD WITHOUT ANY LOAD, TORPEDO CONSISTS OF THREE MAIN PARTS: THE WARHEAD, THE PROPULSION MATERIALS CONTAINERS AND COMPRESSED AIR, IN THE PROPULSION PART THERE IS A 4-CYLINDER STAR ENGINE, A GYROSCOPE, PROPULSION SHAFTS, TORPEDO TAIL (4-ARM TYPE WITH TWO 4-FEATHER PROPELLERS AND STEERING AT THE END OF THE CONTAINTER OF THE COMPRESSED AIR. NUMBER ON THE CONTAINER IS 3772	NO DATA	MUSEUM OF THE WESTERN POMERANIA, SZCZECIN

No.	Year of when the showpiece was given to the museum	Museum section	Type of weaponry	Description	Source where it came from	Contractor
4	1955	UNDERWATER WEAPON	LAUNCHER	BATTLE SHIP LAUNCHER CALIBER 553,4 MM, MADE IN ENGLAND FOR ORP "BŁYSKAWICA"	ORP "BŁYSKAWICA"	UNDERWATER WEAPONS FACTORY
5	1962	UNDERWATER WEAPON	TORPEDO	GERMAN TORPEDO ENGINE FROM THE PERIOD OF THE WORLD WAR II – A PIECE OF IT		FOUND AT THE BOTTOM OF THE GDAŃSK BAY
6	1969	UNDERWATER WEAPON	TORPEDO	TORPEDO LAUNCHER HATCH FROM ORP "SĘP" FLAP WITH TORPEDO LAUNCHERS ORP "SĘP"	ORP "SĘP"	A FLEET BATTLE SHIP
7	1975	UNDERWATER WEAPON	TORPEDO	TORPEDO MACHINERY FROM ORP "SĘP" – BACK PART WITH A HATCH	ORP "SĘP"	A FLEET BATTLE SHIP
8	1975	UNDERWATER WEAPON	TORPEDO	TORPEDO MACHINERY 5-TUBES LAUNCHER, CALIBER 533,4MM, MADE IN THE USSR FOR THE ORP "WICHER" DESTROYER	ORP "WICHER"	NO DATA
9	1975	UNDERWATER WEAPON	TORPEDO	THERMAL ENGINE TORPEDO, CALIBER 533,4MM	NO DATA	NO DATA
10	2006	UNDERWATER WEAPON	TORPEDO	THERMAL ENGINE TORPEDO, CALIBER 533,4MM	NO DATA	NO DATA
11	2007	UNDERWATER WEAPON	TORPEDO	TORPEDO LAUNCHER 530	NO DATA	NO DATA
12	NO DATA	NO DATA	NO DATA	ELECTRIC ENGINE WITH PROPULSION SHAFT FROM A GERMAN TORPEDO TYPE G 7E FROM THE WORLD WAR II AREA	NO DATA	MARITIME OFFICE
13	2010	NO DATA	TORPEDO	AVIATION TORPEDO BODY	NO DATA	NO DATA
14	2010	NO DATA	TORPEDO	PARTS OF AVIATION TORPEDOES	NO DATA	NO DATA

No.	Year of when the showpiece was given to the museum	Museum section	Type of weaponry	Description	Source where it came from	Contractor
15	NO DATA	NO DATA	LAUNCHER	FIVE-TUBES LAUNCHER TORPEDO MECHANISM, CALIBER 533,4 MM, MADE IN THE USSR FOR ORP "WICHER", HATCHES WITH NUMBERS FROM 1 TO 5	NO DATA	NO DATA
16	NO DATA	NO DATA	LAUNCHER	DEPTH BOMBS LAUNCHER WRGB-2500, CALIBER 212 MM, 16 BARRELS, TWO-ROWED, 8 BARRELS EACH (FROM ORP "WARSZAWA")	NO DATA	NO DATA
17	2012	NO DATA	TORPEDO	GERMAN TORPEDO TYPE G-7	NO DATA	NO DATA
18	2012	NO DATA	TORPEDO	GERMAN TORPEDO TYPE G-7	NO DATA	NO DATA
19	2012	NO DATA	TORPEDO	GERMAN TORPEDO WITH AN ELECTRIC PROPULSION MECHANISM – THE WHOLE TORPEDO	NO DATA	NO DATA
20	2012	NO DATA	TORPEDO	GERMAN TORPEDO WITH AN ELECTRIC PROPULSION MECHANISM - WARHEAD	NO DATA	NO DATA
21	2015	NO DATA	TORPEDO	TORPEDO GYROSCOPE	NO DATA	NO DATA
22	2015	NO DATA	TORPEDO	PROBABLY A TORPEDO GYROSCOPE ATTACHED TO A WOODEN BASE, ORNAMENTED WITH A TORPEDO SHAPE. RUSSIAN ALPHABET ON THE BODY, ZSM GDYNIA 27.09.1983; DEDICATION "ON THE DAY OF BIRTRHDAY, CAPTAIN. MZ"	NO DATA	NO DATA

Source: Self-made on the basis of the museum's income book.

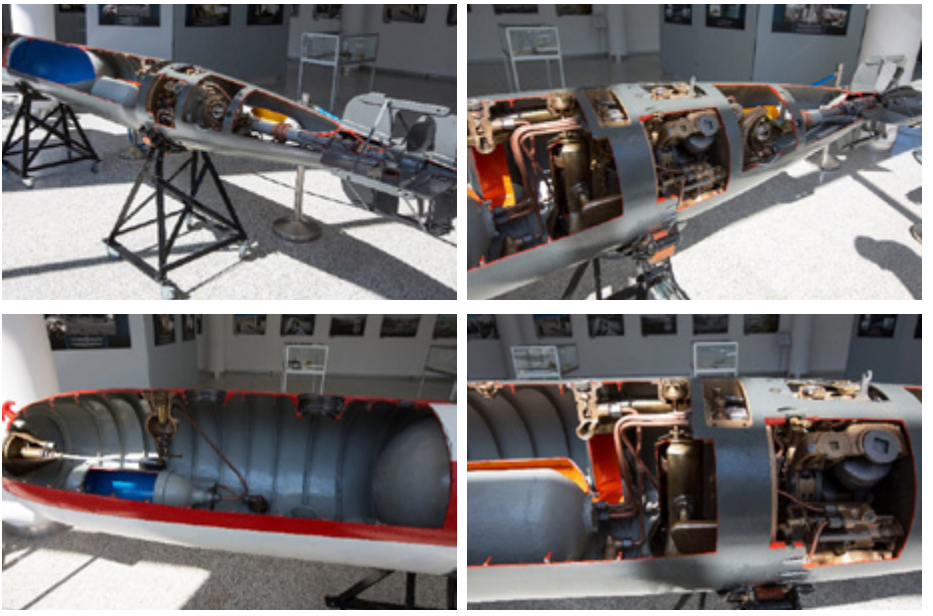


Figure 1. *German aviation torpedo section type F5B, Polish Navy Museum. (Source: Picture H. Nagrodzki)*

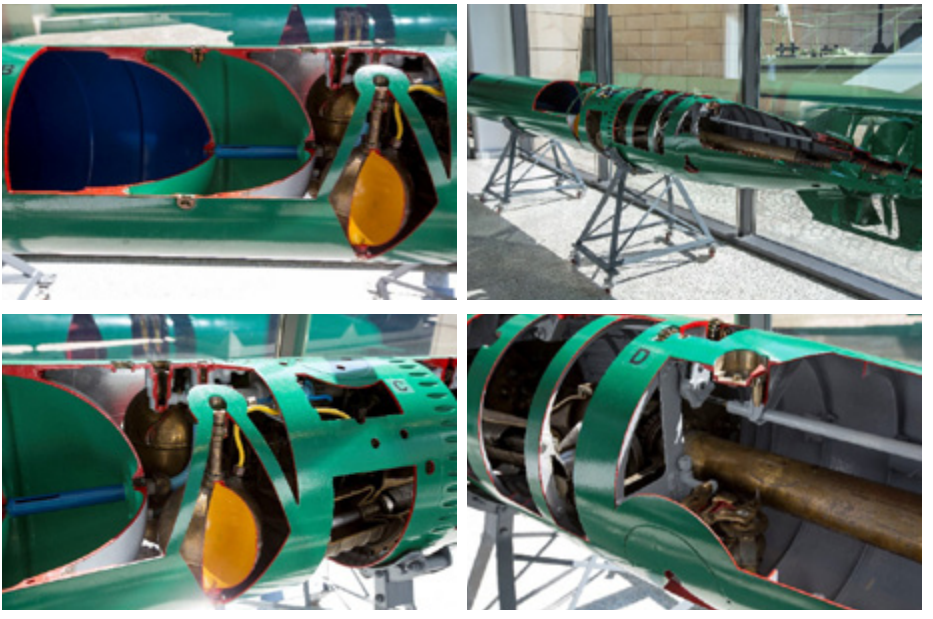


Figure 2. *Torpedo section type 53-38 with thermal engine. (Source: Picture H. Nagrodzki)*



Figure 3. *Torpedo caliber 533,4, Polish Navy Museum. (Source: Picture H. Nagrodzki)*



Figure 4. *Five-tubes launcher torpedo mechanism, caliber 533,4 mm, made in the USSR for ORP "Wicher". (Source: Picture H. Nagrodzki)*



Figure 5. *Torpedo C 84A from 1894. (Source: Picture H. Nagrodzki)*

Apart from the above-showed examples, one definitely needs to be mentioned. It is the oldest Polish destroyer which is still on duty – ORP "Błyskwica", a battle ship which during many years of its mission in museum was under the direct subordination to the Polish Navy Museum's manager. At this moment, even though the subordination has changed, one might say without a shadow of doubt, that the destroyer is an inseparable element of Gdynia's landscape and a true jewel in the museum's collection.

ORP "Błyskawica" throughout its entire time of duty as a museum-ship, is moored to the President's Dock by Kościuszko Square in Gdynia. During its museum duty, the battle ship has been visited by countless tourists, both Polish and foreign. Its unusual history as well as heavy artillery and underwater weapons are, up to now, an attractive element of the Polish coast's tourism and museum offer.

Bearing in mind the conference's main interest, ORP "Błyskawica's" torpedo weapon deserves a special attention. It is crucial to say that the biggest losses during sea battles in the time of World War II, when the battle ship was active, were caused by underwater weapons, especially torpedoes. The self-acting missiles were used even on such large distances as to 10 nautical miles. Among ORP "Błyskawica's" underwater weapon, during different time periods when the battle ship was active, apart from torpedoes were also torpedo launchers, depth bombs' thrower, depth bombs' airdrops, as well as sea mines. For example, in 1937, the battle ship was given two triple torpedo launchers caliber 550 mm with six reductors for torpedoes caliber 533,2 and four for torpedoes caliber 450 mm. They were all designed by Polish Navy engineers from Gdynia and were made by an English company, which belonged to Peter Brotherhood. What was characteristic for the launcher, its weight which was 9110 kilograms and length of 9030 mm. It was movable in a horizontal round-plane of 360 degrees. The torpedo launch had two options – from the launcher (compressed air or, in case of emergency, black powder load) and from the battle platform. The whole set of torpedoes consisted of 54 torpedoes types AB 1937, bought from Whitehead Torpedo Corp. Ltd in Weymouth and their characteristics were:

– length 7,2 m,

– explosive material weight 240 kg,

– maximum velocity 47 knots.

It's important to say that during the ORP "Błyskawica's" long-time service under the Polish flag, the battle ship underwent many modifications and modernizations[6].

[6] J. Łubkowski, Zmiany konstrukcyjne na ORP "Błyskawica" w latach 1937-2007 oraz jego aktualny stan techniczny, Biuletyn Historyczny nr 22, Suplement, Gdynia 2007, s. 57-70



■ **Figure 6 and 7.** *ORP "Błyskwica" torpedo launcher with a torpedo (top picture) (Source: Picture. A. Komorowski)*

Today, while visiting the battle ship, we can see a triple torpedo launcher type 1N-2 caliber 533,4 mm which weighs 12 tons with a torpedo as well as a thermal propulsion torpedo and its section[7].

3. CONCLUSIONS

Polish Navy Museum in Gdynia has been showing its rich and impressive exhibition to the visitors for dozens of years. The weapons which can be found there can be seen both inside and outside the building. The inside exhibition displays mostly technical sections of different types of torpedoes, showing how their construction has been changing for decades. The outside exhibition displays torpedo weapons as well as large elements of the Polish Navy's battle ship. It is the biggest exhibition of such kind in Polish museology, so guests can get to explore a truly wide spectrum of the torpedo weapons as well as find out a lot about the Polish Navy's history.

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[7] W. Pater, ORP "Błyskawica" jako obiekt muzealny, Biuletyn Historyczny nr 22, Suplement, Gdynia 2007, s. 71-75.

SAŽETAK

Torpednim oružjem opremljeni brodovi Poljske ratne mornarice pojavili su se u razdoblju između dva rata. Od 1921. do 1939. Poljsku su iskorištavali francuski i engleski proizvođači torpeda, koji su ih isporučivali sve do 1952. Nakon Drugoga svjetskog rata prevladavaju ratni brodovi, međutim torpeda su sovjetske proizvodnje. Torpedno oružje može se vidjeti u poljskim muzejima kao što su Vojni muzej u Varšavi, Muzej poljske vojske u Kolobrzegu te muzeju Bijeli orao u gradu Skarżysko-Kamienna. Međutim, najveća takva zbirka nalazi se u Muzeju ratne mornarice koji je utemeljen u Gdyniji 28. lipnja 1953. Zahvaljujući napornom radu nekoliko generacija povjesničara i kustosa mnogi zanimljivi izlošci iz Drugoga svjetskog rata i poslijeratnog razdoblja sačuvani su od zaborava sve do danas. U muzeju u Gdyniji posjetitelji se mogu diviti torpednom oružju u muzejskoj zgradi i izvan nje te na muzejskom brodu ORP Błyskawica.

Ključne riječi: *torpedno oružje, muzejske zbirke, Muzej ratne mornarice u Gdyniji*

OBITELJ LUPIS – PODRIJETLO I NJIHOV DOLAZAK U RIJEKU

The Luppis family – origins and arrival to Rijeka

Ivan Pamić*

SAŽETAK

Obitelj Lupis, iz koje dolazi izumitelj torpeda, potječe iz malog sela Nakovana koje se smjestilo na samom zapadu poluotoka Pelješca u južnoj Dalmaciji. Prema legendi, rodonačelnik Lupisa bio je Cvitko po kojemu se naziva središnji, ujedno i najstariji dio Donje Nakovane – Cvitkovi dvori. Budući da se u ta vremena prezimena nisu ustalila, teško je pratiti obiteljski slijed te povezati nakovanske Lupise s drugim Lupisima koji se već u 12. stoljeću spominju u Dubrovniku i okolici. Sa sigurnošću se jedino može ustvrditi da se u Nakovani spominje Vukić Petrov (1575. – 1665.) i da od njega potječu svi nakovanski Lupisi i ogranci koji su se razvili u drugim mjestima nakon doseljavanja pojedinih članova obitelji. Tako Lupise nalazimo po cijelom svijetu – bili su prvi Hrvati koji su naselili Novi Zeland, a prisutni su i u Australiji, Americi, Peruu, Argentini i dr. Jedan ogranak doselio se sredinom 18. stoljeća u Rijeku.

Nakon što se Luka Lupis doselio iz Nakovane u Viganj, njegov sin Jakov Lupis preselio se iz Vignja u Rijeku 1761. gdje se oženio i imao sinove Frana Maksimilijana Saveria (1784. – 1874.) i Ferdinanda Karla Ermenegilda koji se oženio Ivanom Perić iz Dubrovnika i s njom imao sina Ivana Blaža Lupisa Vukića.

Ključne riječi: *Lupis, Nakovana, Pelješac, Vukić Petrov, izumitelj torpeda, Ivan Lupis Vukić*

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OBITELJ LUPIS – PODRIJETLO I NJIHOV DOLAZAK U RIJEKU

Obitelj Lupis, iz koje dolazi Ivan Lupis Vukić, potječe iz malog sela Nakovana koje se smjestilo na samom zapadu poluotoka Pelješca u južnoj Dalmaciji.



Slika 1. *Ilirska gradina Grad u Nakovani*

Zbog sigurnosti koju pružaju visoka brda koja je uokružuju te izvora pitke vode, Nakovana je ljudima tisućama godinama bila savršeno mjesto za život. To je ujedno jedno od najstarijih stalno naseljenih mjesta na Pelješcu, u kojemu se neprekinutost života može pratiti više od 8000 godina!

Tragovi prvih ljudi iz najranijeg neolita potječu iz Spile iznad samog sela. U toj je špilji, u skrivenoj dvorani, pronađeno i netaknuto ilirsko svetište iz vremena kada su ovim područjima vladali kralj Agron i kraljica Teuta, koji su svoje sjedište imali na gradinskom brdu iznad Donje Nakovane koji i danas nosi ime Grad.

Nakovana u srednjem vijeku potpada pod Zahumlje, a od 14. stoljeća postaje, kao i ostatak Pelješca, dijelom Dubrovačke Republike. Tada se razvija ne samo kao zemljoradničko i stočarsko već i kao ribarsko naselje. Vješti ribari i mornari, Nakovjani se ukrcavaju na dubrovačke brodove tako da su već od 17. stoljeću gotovo svi muškarci pomorci koji plove svim morima svijeta. Služenjem na dubrovačkim brodovima ne samo da su postajali slobodni građani već su bili i imućniji te se sele u okolna mjesta Viganj i Kućište, u kojima na obali grade

kuće. Propast Dubrovačke Republike i ekonomska situacija tjeraju Nakovjane polovicom, a osobito krajem 19. stoljeća na iseljavanje u okolna mjesta, ali i u najudaljenije krajeve svijeta. Sredinom 19. stoljeća u Nakovani je svega nekoliko desetaka ljudi, a početkom 21. stoljeća, nakon više od 8000 godina, ostaje gotovo bez ijednog stanovnika.

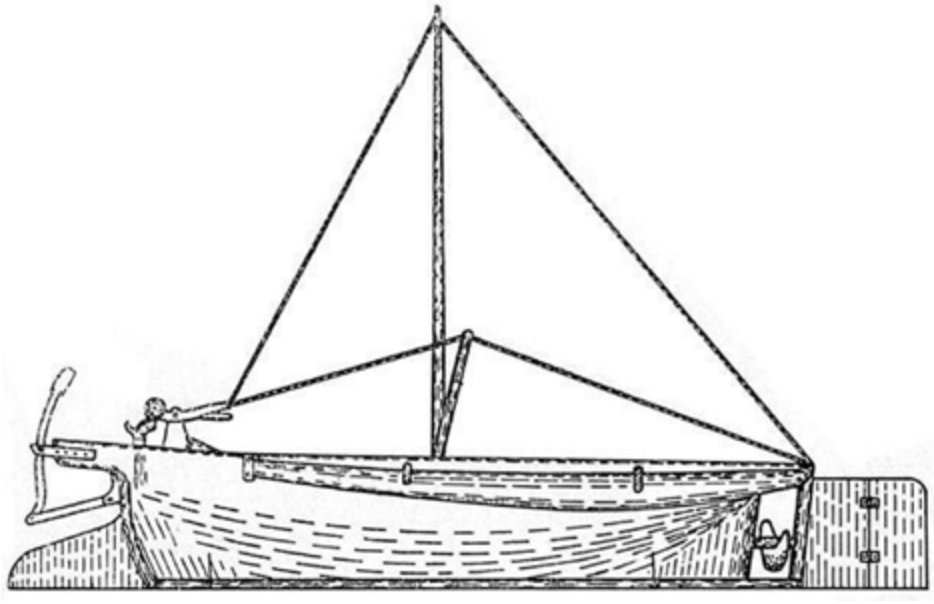


Slika 2. *Nakovana, 1901.*

Jedna od najznačajnijih i najstarijih nakovanskih obitelji bili su Lupisi. Prema legendi, rodonačelnik Lupisa bio je Cvitko po kojem se naziva središnji, ujedno i najstariji dio Donje Nakovane – Cvitkovi dvori. Budući da se u ta vremena prezimena nisu ustalila, teško je pratiti obiteljski slijed. Sa sigurnošću se jedino može ustvrditi da se u Nakovani spominje Vukić Petrov (1575. – 1665.) i da od njega potječu svi nakovanski Lupisi, a među njima i Ivan Blaž Lupis Vukić, izumitelj torpeda.



Slika 3. *Ivan Lupis Vukić*



Slika 4. *„Čuvar obale“ – preteča torpeda Ivana Lupisa Vukića*

U Dubrovniku se nešto prije spominje Tomas Lupis koji je tamo umro 1590., a mogao bi biti otac Petru, odnosno djed Vukić Petrovu, ali to su tek pretpostavke, kao i ona da nakovanski Lupisi potječu od obitelji Vuk, Vukić ili Vukasinović, koji se spominju u Dubrovniku ili okolici u 13. i 14. stoljeću. U Dubrovniku se, jednako tako, spominju državni notar Manfredi de Lupis 1291. te Pietro de Lupis arhiđakon 1360. godine Teško je uspostaviti i vezu nakovanskih Lupisa s onima koji se spominju na Hvaru i Visu, odnosno u Italiji kao plemići.

Vjerojatno nećemo nikad saznati odakle su Lupisi stigli u Nakovani jer prezimena u ta vremena nisu bila ustaljena, a često su se iz generacije u generaciju mijenjala, pa ćemo se posvetiti samo Vukić Petrovu i njegovim potomcima. Od njega su, kao što smo već spomenuli, potekli svi nakovanski Lupisi koji su najvećma bili, kao i ostali sumještani, pomorci. Pomorstvo u udaljenijim dijelovima Dubrovačke Republike doživljava procvat nakon što je sam Dubrovnik zadesio razoran potres 1667. godine. Zbog toga su vlasti dopustile da i građani, uz plemiće, budu vlasnici brodova. Tu su pogodnost posebno iskoristili stanovnici Vignja, Kućišta i Orebića, koji su se do 19. stoljeća obogatili i posjedovali vlastite flote. Sredinom 19. stoljeća pelješka flota imala je oko 90 brodova koji su plovili svim morima svijeta. Na njima su bili angažirani gotovo svi muški Nakovjani. Odlaskom na brodove upoznavali su nove svjetove, a nerijetko su i ostajali u dalekim zemljama koje su im pružale bolje mogućnosti nego što bi im pružila domovina.

Lupisi su navigavali ne samo na dubrovačkim već i na španjolskim, ruskim i britanskim brodovima. Tako je Pavao Lupis služio na britanskim ratnim brodovima koji su prevozili kažnjenike u Australiju. Dolaskom u Australiju, Pavao Lupis saznao je za novootkrivenu zemlju – Novi Zeland te se tamo uputio u potrazi za zlatom. Stupivši na tlo Novog Zelanda 1858., postao je prvi Hrvat koji je stigao u tu zemlju. Vrativši se u domovinu, povukao je svoju braću, rođake i prijatelje nazad, postavši tako i pokretač migracije u tu daleku zemlju. Uspostavio je i dobre veze s tamošnjim domorocima Maorima započevši tako stoljetno prijateljstvo Dalmatinaca i Maora. Godine 2015. izaslanstvo Maora stiglo je iz Novog Zelanda u Nakovani odati počast Pavlu Lupisu. Tom su prigodom u tradicionalnom koplju prenijeli njegovu dušu iz njegova groba u Novom Zelandu u rodno selo.

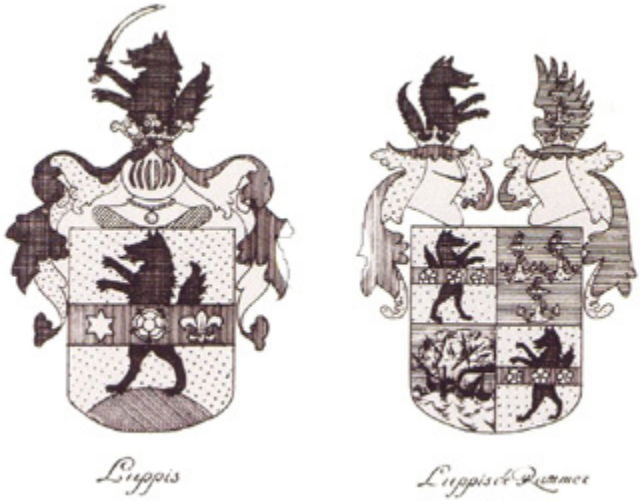
Njegov imenjak i rođak Pavle (Pablo) Lupis odselio se 1890. u Limu, Peru. Od drugih Lupisa spomenimo Balda Lupisa koji se odselio u Mahdiju, Tunis, a njegov brat Božo u New Orleans, SAD. Vincenzo Lupis (1820. – ?) odselio se sredinom 19. stoljeća u Argentinu, a jedan od njegovih potomaka, Enrique Florencio Lupiz Cordoba (1922. –2003.), postao je argentinski ambasador u Grčkoj i Siriji. Drugi članovi obitelji Lupis odselili su se u Kanadu i Australiju.

Ivan Lupis Vukić, rođak i imenjak izumitelja torpeda, rođen u Vignju 1876., doselio se u SAD 1891. Postao je poznati iseljenički novinar, a povratkom u domovinu značajan član hrvatskoga preporoda i najmlađi zastupnik Dalmatinskoga sabora u Zadru. U rodnome mjestu osnovao je prosvjetiteljsko društvo *Hrvatski dom Viganj* koji kao udruga djeluje i danas. Bio je neko vrijeme politički proganjan i zatvoren od austrijske vlade, a potom se vratio u SAD gdje je pokrenuo *Hrvatski glasnik* (1921. – 1926.).



Slika 5. *Ivan Lupis Vukić*

Osim kao pomorci, Lupisi su se istaknuli i kao svećenici. Ivan Lupis osnovao je 1761. župu i podignuo crkvu sv. Mihovila u Vignju 1740., a Bartolomeo Lupis je 1794. postao dubrovački plemić stonskoga plemstva.



Slika 6. *Stari i novi grb Lupisovih*

DOLAZAK U RIJEKU

Luka Lupis doselio se iz Nakovane u Viganj, a njegov sin Jakov Lupis preselio se iz Vignja u Rijeku 1761. gdje se oženio i imao sinove Frana Maksimilijana Saverija (1784. – 1874.) i Ferdinanda Karla Ermenegilda, kapetana koji je imao vlastitu flotu brodova i dvije velebne kuće u Rijeci. Oženio se Ivanom Perić iz Dubrovnika i s njom dobio sina Ivana Lupisa Vukića – izumitelja torpeda.

Frano Maksimilijan imao je sina Antonija Francesca Luppisa (1829. – 1910) koji je bio prvi rođak Ivana Lupisa Vukića. Bio je pomorski kapetan, brodovlasnik, posjednik i slikar amater (slika *Rijeka noću,* 1888.), predsjednik riječkoga kazališta i počasni konzul Švedske i Norveške. Za svoje zasluge odlikovan je plemstvom s pridjevkom „de Tihovac".



Slika 7. Rijeka noću *Antonija Lupisa*



Slika 8. *Kuća na Tihovcu Antonija Lupisa*



■ **Slika 9.** *Grob Antonija Lupisa*

SUMMARY

The Lupis family, which the inventor of the Torpedo comes from, originates from the small village of Nakovana that is situated in the western part of the peninsula Pelješac in the south of Croatia. According to the legend, the family progenitor was Cvitko, who the central and the oldest part of Donja Nakovana takes its name after, namely, Cvitkovi dvori. *As in those times surnames were still not established, it is hard to follow the family succession and connect the Lupis family from Nakovana with other Lupis families that already in the twelfth century are mentioned in Dubrovnik and its surroundings*

What can be established is that Vukić Petrov (1575–1665) is mentioned in Nakovana, also that it is from him that all the Nakovana Lupis family members originate, as well as family branches that developed in other places after some family members had moved. Thus, it is all over the world that we can find the Lupis family members; they were first Croats that settled in New Zealand, present also in Australia, America, Peru, Argentina, etc. One of the family branches moved to Rijeka in the middle of the eighteenth century.

After Luka Lupis had moved from Nakovana to Viganj, his son Jakov Lupis moved from Viganj to Rijeka in 1761, married there and had sons, namely, Fran Maksimilijan Saveri (1784–1874) and Ferdinand Karl Ermenegild. Ferdinand married Ivana Perić from Dubrovnik and they had the son Ivan Blaž Lupis-Vukić.

Keywords: *Lupis, Nakovana, Pelješac, Vukić Petrov, torpedo inventor, Ivan Lupis Vukić*

RISE INTO RUIN: DECAY OF INDUSTRIAL LANDSCAPES BY THE PORTS IN SOUTHERN BRAZIL

Uzdizanje u uništenje: propadanje industrijskog pejzaža u lukama južnog Brazila

Juliana Regina Pereira*

SUMMARY

Port areas represent a privileged arena of socio-economic interactions, technical development and symbolical appropriations that offer several possibilities to the study of industrial heritage. As material representations of technologycal and economical achievements of past times, abandoned port structures or emptied function find themselves assigned a remembrance value that is attached, not to it's original state, but to the representation of time elapsed since its establishment as marks on the buildings façade and structure denounce its age.

In light of the above, this reserarch intends to ponder peculiarities that decay and destruction, understood as similar kinds of processes, imprints themselves to an enthropic dimension of the port heritage, as we take as object of the analysis an industrial building complex that belonged to Indústrias Matarazzo in the coastal town Antonina, located in Brazilian southern state of Paraná, which, despite being inscripted in Brazilian national heritage list since 2012, experiences a severe state of decay since its deactivation back in 1972. As a theoretical instrument this reseach intends to mobilize concepts of preservation and ruin that are relevant to the study of multiple dimensions of the industrial heritage in southern Brazil, as well to develop a concrete documental series that allows us to criticize decay and the inevitability of ruin as well as emphasize the importance of establishing typological series with the intent to nuance industrial and port landscapes in heritage imagery.

Keywords: *port heritage, port industry, industrial landscape, Brazil, ruins, industrial imagery*

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SAŽETAK

Područja u kojima su luke povlaštena su arena društveno-ekonomskih interakcija, tehničkog razvoja i simboličkog prisvajanja, nudeći nekoliko mogućnosti za istraživanje industrijske baštine. Kao materijalnom prikazu tehnoloških i ekonomskih postignuća prošlih vremena, napuštenim lučkim strukturama ili napuštenim funkcijama dodjeljuje se vrijednost sjećanja, ne njihovu izvornom stanju, već prikazu vremena koje je prošlo od njihova osnivanja jer znakovi na pročeljima zgrada i struktura otkrivaju njihovu dob.

U tom svjetlu ovo istraživanje namjerava razmatrati posebnosti koje propadanja i razaranja, shvaćeni kao slične vrste procesa, ucrtavaju u devastirajuću dimenziju lučke baštine. Predmet je istraživanja industrijski kompleks zgrada koji je pripadao tvrtki Indústrias Matarazzo *u obalnom gradu Antonina, u brazilskoj južnoj državi Paraná, koji ozbiljno propada još otkad je prestao biti u funkciji 1972., unatoč tome što je upisan u brazilski popis baštine još 2012. Teoretski, ovo istraživanje ima namjeru mobilizirati koncepte očuvanja i uništenja važnih za proučavanje višestrukih dimenzija industrijske baštine u južnom Brazilu te dati konkretan niz dokumentacije koja nam dopušta da kritiziramo propadanje i neizbježivost uništenja te ističemo značenje utvrđivanja tipoloških serija da bismo nijansirali industrijske i lučke pejzaže u predodžbama nasljeđa.*

Ključne riječi: *lučka baština, lučka industrija, industrijski pejzaž, Brazil, ruševine, industrijske predodžbe*

ALFA ROMEO 6C 2300 AERODINAMICA SPIDER

Alfa Romeo 6C 2300 Aerodinamica Spider

Zoran Petrović – Bebe*

SAŽETAK

U Rijeci je između dva svjetska rata, od 1934. do 1938., konstruiran Alfa Romeo 6C 2300 Aerodinamica Spider *ili* Alfa Jankovits*, remek-djelo autoindustrije toga doba, a konstruktori i autori automobila su Riječani, braća Oscar i Gino Jankovits. Braća su bila sinovi Mattea Jankovitsa, službenog koncesionara* Alfa Romea *u Rijeci, te vlasnici polovnog automobila* 6C Turismo Berlina *iz 1934., broja šasije 700316. Od 1934. do 1937. konstruirana je trkaća šasija Alfe Jankovits i automobil je registriran u Rijeci registarskim pločicama 2757 FM. Jankovitsi su motor smjestili iza sjedišta automobila, a prvi nađeni nacrti upućuju na to da su braća konstruirala karoseriju koja je izvanserijsko remek-djelo aerodinamike. Cijeli je automobil vrlo lagan, ukupna masa iznosi 1150 kilograma, a postizao je brzinu od 225 km/h sa središnjim sjedalom za vozača. Mentor braće Jankovits bio je Vittorio Jano, proslavljeni talijanski dizajner automobila koji je tada već vrsnim studentima Politehničkog fakulteta u Torinu ustupio projekt za koji su braća Jankovitsi bili iznimno zainteresirani. Hvalevrijedno je spomenuti da je Oscar Jankovits u to vrijeme surađivao s najpriznatijim dizajnerima i konstruktorima automobila – Josefom Micklom, stručnjakom za aerodinamiku iz* Porshea*, Belom Barenyjem, dizajnerom* Volkswagena Beetlea *iz 1925., te Paulom Jarayem, priznatim stručnjakom i pionirom za aerodinamiku automobila. Aerodinamičnu čeličnu karoseriju* Alfe Jankovits *konstruirali su radnici i sami autori u garaži u Rijeci između 1936. i 1937.* Alfa Jankovits *je svojevrsna skulptura autodizajna, aerodinamično tijelo i kompletna tajnovitost projekta Vittorija Jana i braće Jankovits koji uzdižu* Alfa Romeo *do unikatnog modela u povijesti automobilske industrije i automobilizma. Početkom Drugoga svjetskog rata automobil je spremljen na sigurno, do dolaska narodne vlasti u Rijeku. Konstruktori automobila braća Jankovits za narodnu su vlast bili buržoazija. Braća Jankovits prebjegli su u Italiju. Oscar i Gino Jankovits krenuli su* Aerospiderom *na Božić 1946., punim su gasom prošli granicu prema Trstu, što je izazvalo klasičnu reakciju vojnika narodne vlasti na prijelazu – pucanje. Uspjeli su*

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proći, ali s rupama od metaka u karoseriji. Budući da nisu imali ništa i jedva spasili živu glavu, Alfu Aerospider *su uskoro prodali časniku američke vojske i potom joj se gubi svaki trag. Pojavila se 1967. u New Yorku gdje ju je kupio stanoviti Colin Crabbe, sakupljač neobičnih automobila. Crabbe nije znao o kojem je autu riječ, ali ga je očaravao njegov oblik i napredna tehnička rješenja. Automobil je prepoznao Luigi Fusi, vrstan poznavatelj* Alfi*, koji ga je dva puta pokušao kupiti. Prvi put za braću Jankovits, drugi put za muzej* Alfa Romea*. Oba puta bez uspjeha. Auto je kasnih devedesetih došao u ruke talijanskog kolekcionara, a potom kod aktualnog vlasnika Georgea Gerbharda koji ga je prije dvije godine restaurirao. Danas je prava ikona među legendarnim automobilima.*

Slijed konstrukcije automobila Alfa Romeo 6C 2300 Aerodinamica Spider*:*

1934. – 6C 2300 motor nadograđen trima Weberovim karburatorima, riješena transmisija i usavršen sustav kočnica

1935. – izrađena i usavršena prva verzija trkaće šasije automobila za brzine do 225 km/h

1936. – razdoblje testiranja i prilagodbe šasije, dizajniranje karoserije automobila

1937. – objedinjavanje šasije i karoserije automobila prilagođenog za automobilistička natjecanja

1938. – prilagodba automobila za cestovnu vožnju.

Ključne riječi: *braća Jankovits,* Alfa Romeo 6C 2300 Aerodinamica Spider

SUMMARY

In 1934, the chief engineer of Alfa Romeo, Vittorio Jano, of Hungarian descent, was in contact with two other men, also of Hungarian descent, Fiuman brothers Gino and Oscar Jankovits. They were brilliant students at the Polytechnic University in Jano's home town of Torino – Italy, where Fiat and Alfa Romeo recruited their technical staff. The brothers became Alfa Romeo concessionaires and owned the biggest garage in region, in Fiume, today called Rijeka. With their passion for race cars and the background of wealth, technical talent and the garage, they were excited at being able to participate in this project, and they financed it entirely. In 1934, Jano gave them a powerful, naturally-aspirated 6C 2300 engine upgraded with three Weber carburettors. This would be the engine for the sports car project. Jankovits also got the transmission system, and a basic frame suitable for the 12C engine, to be modified for a mid-engined racing car. Other mechanical systems such as suspensions and brakes were designed by the development team and built at Portello. Each mechanical part produced for the new car was marked with a description and date of production, and with the position where it was to be mounted. The parts were then taken to Fiume, and between 1935 and 1936 were installed and tested by the Jankovits in a "running chassis". Depending on test results, improvements were made, regardless of cost, until the systems worked to their satisfaction. All parts of the chassis were constructed very solid with view to high speed trials over 250 km/h. The Aerospider's chassis was the most advanced of its time and anticipated later designs by Mercedes and Auto Union. It was the first car with a suspension designed with wishbones, hydraulic dampers, transverse leaf springs, radius arms and torsion bars. Other pioneering features were devices to eliminate overbraking and a sophisticated system of gear change with pre-selection.

The breathtaking aerodynamic shape of the car also anticipated the later high speed designs of Auto Union by 4 years. It was designed by Oscar Jankovits, who was probably in contact with Josef Mickl, Porsche's specialist of aerodynamics, and others of the former Habsburg Empire as Paul Jaray, the inventor of streamlined cars, and Bela Barenyi, the inventor of the "Volkswagen". The exceptional streamlined steel body was built by workers at the Jankovits Garage in Fiume between 1936 and 1937. The Aerospider was the first mid-engined and low drag racing car of modern design. The car had all the features of a high speed racing car together with a stunning appearance. The Aerospider was to have been fitted with the newly developed V12 engine (430 hp) of Alfa Romeo – a "12C Aerodinamica Spider" – which would have made it a serious competitor to Auto Union and Mercedes Benz. But in 1937, when the car was ready to make its public appearance, the project was abruptly stopped when Vittorio Jano was dismissed by Alfa Romeo. Jankovits could no longer get the 12 C engine. They mounted the 6C 2300 which they had got for the sports car project, and they made the prototype suitable for use on the road by adding user-friendly components such as a bigger windscreen, a heating system and bumpers. The car still has its original licence plate and documents of registration. Any public appearance of the futuristic looking Aerospider would have caused a sensation, but because of the secrecy surrounding the project, and then the onset of the war, the prototype remained hidden in the Jankovits' garage in Fiume, and was not seen by anyone from outside the garage. On Christmas Eve 1946, Gino Jankovits drove the Aerospider at full speed under the toll-bar of the closed communist controlled border into Italy. Border guards fired volleys of shots after him, but the low, streamlined body saved Gino's life. Only the rear tyres were destroyed by the bullets, which also caused some dents in the rear of the car's bodywork. To get money they had to sell their car to an Anglo-American officer. Then the Alfa disappeared for about 20 years until it was rediscovered in England. In 1978 the Aerospider was recognized by the

well-known Alfa Romeo historian Luigi Fusi, who had worked with Vittorio Jano at the time of the Aerospider project. He wanted to acquire the car for the Alfa Romeo museum. The acquisition failed, but the prototype did eventually return to Italy, 30 years after its birth, to be restored at last to its original condition as a racing car.

Time frame of construction of the Aerospider:

1934 – construction of engine, transmission and frame

1935 – completion of first version of chassis

1936 – testing period, modifications of chassis, start of body making

1937 – completion of chassis and body for race car

1938 – modification into street car.

Keywords: *Jankovits brothers, Alfa Romeo 6C 2300 Aerodinamica Spider, Alfa Jankovits*

GERMAN TEST STATIONS AND TORPEDO TRIALS IN THE PUCK BAY – NOW AND THEN

Njemačke stanice za testiranje i probno ispitivanje torpeda u zaljevu Puck – sad i nekad

Iwona Pietkiewicz*

SUMMARY

Developed production and scientific research concerning torpedoes (533 mm) with the acoustic self-guide systems used by submarines, required countless prototype tests at sea. One of the test centers used for those particular reasons was brought to life in Oksywie region – which is nowadays one of the north districts in Gdynia. Torpedoversuchanstalt (TVA) Oxhoft was a branch of a scientific center of the same name, located in Eckernförde (Germany). A lot of new equipment and mechanisms used for the purposes of torpedo battleships which marked new standards and trends in that particular field, were developed there.

Another research and production center, this time connected with the development of aviation torpedoes, was Torpedowaffenplatz Gotenhafen – Hexengrund (TWP), located, in the area of today's Gdynia as well. The center was also situated by the Bay of Puck near the one mentioned above. Works concerning the improvement of small-caliber torpedoes (450 mm) and making them useful for the purposes of throwing them down from the aircrafts, took place there.

After the World War II war actions were over, the equipment used in both test centers was carried away to the East, and there wasn't more than walls of torpedo platform at the Bay of Puck left as well as land base of the two centers.

In the given work what has been left of the test centers as well as their post-war use was described, as well as some of the modern ideas to make them useful again.

The base of the analysis were the archive materials taken from the German archives as well as other scientific works.

Keywords: *torpedo trials, research centers, post war development problems*

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1. INTRODUCTION

Soon after the beginning of World War II, Hitler's production and research weaponry facilities became the main Allies' targets which were being regularly bombed. Such situation caused problems in the carrying out of the development tasks, particularly the ones concerning new weapons. It was thus decided to relocate those facilities, along with the production lines, to safer places.

As far as torpedo weapon was concerned it all pertained the facility placed near Eckenförde. The decision was made to move the submarine torpedoes' research and production center away from the Allies 'planes' range. The Gdańsk and Puck Bays as well as Gdynia port were chosen to become their new localization. Here, in the northern part of the harbour, a complex of buildings, workshops and laboratories were built between 1940-1941 and their main Focus was developing modern torpedoes for the submarine to use. On the territory of the Puck Bay a test station, often called a torpedo-platform[1], was built. It was a place where new weaponry was being tested by shooting them and controlling their parameters.

The area of the Puck Bay served also as a building ground for a test station, often called torpedo-platform, where new torpedoes were tested by being fired and having their parameters controlled. The building was called Torpedoversuchanstalt (TVA) Gotenhafen[2]. In this building, during the war period were held intense works to develop an electronic torpedo with an acoustic cruise-missile system.

[1] Torpedo-platform is a complex of various posts built to perform torpedoes' tests and adjustments. It is equipped with suitable stands, measurement devices, compressors, torpedo launchers, devices used to tow and lift practice torpedoes, as well as training marine ranges. Praca zbiorowa, *Encyklopedia techniki wojskowej.* PWN, Warszawa 1987, s. 740.

[2] Gotenhafen – Gdynia's German name used during the World War II period.

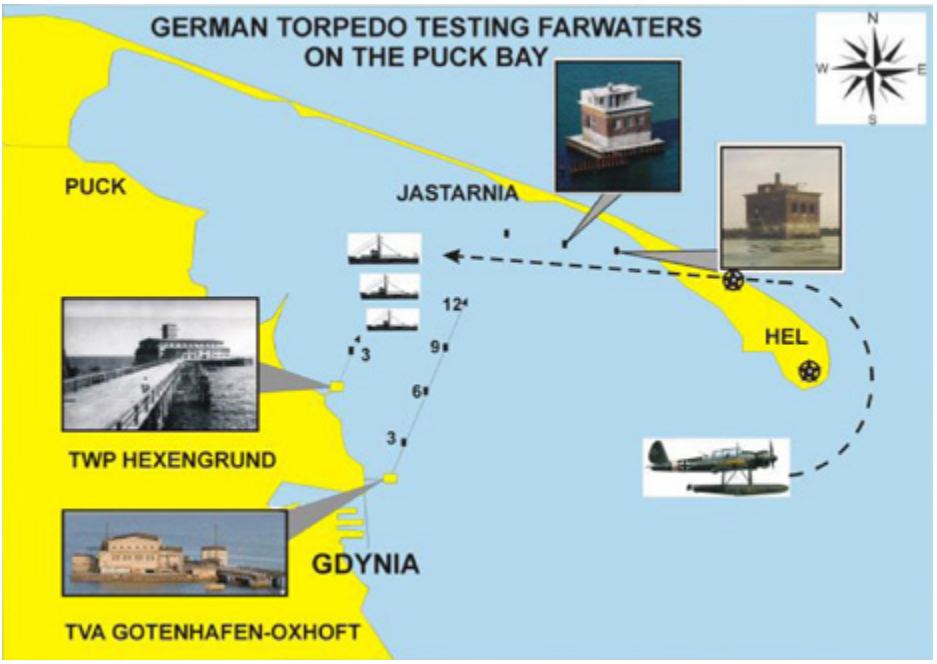


Figure 1. *Map depicting where the torpedo-platforms were settled along the Puck Bay. (Source: Draw: A. Szulczewski)*

The very first torpedoes of such kind were the type T IV *Falke*, then later on, after countless tests, type T V *Zaunkönig* (G7es). The main difference between the two models were the types of their cruise-missile systems. The TVA research and production facilities were also working on magnetic fuse and other torpedo proximity fuses. A magnetic fuse required special regulations (called balancing) to be performer in the field test far away from the facilities' buildings. Acoustic torpedoes equipped with acoustic cruise-missile systems were introduced as U-Boots' elements of weaponry already in 1943. Apart from working on electric torpedoes types T IV and T V, research was also held to improve thermal torpedoes type G7a[3].

[3] E. Rössler, Die Torpedos der deutsche U-Boote. Hamburg, Berlin, Bonn 2005, s. 133-149.



Figure 2. *The Gotenhafen-Oxhoft Torpedo-platform (TVA) and Hexengrund torpedo-platform (TWP) – modern look (Source: A. Komorowski collection)*

In a close proximity from the described TVA facility, where warships torpedoes caliber 533,4mm were developed, a second facility of similar sort was built named Torpedowaffenplatz Gotenhafen – Hexengrund TWP (Polish name of the area is Babie Doły). It was located on the north from TVA and the new facility was used for research conducted on German aerial torpedoes of a smaller, 450mm, caliber. After the warfare had begun the Germans had no aerial torpedoes so Norwegian torpedoes type Horten (LFT5) and Italian torpedoes type F5W were bought. As the construction work was moving forward, the research and tests conducted, a German aerial torpedo was constructed, type F5b[4]. The tests took part in two places – the Puck Bay

[4] F. Lauck, Der Lufttorpedo. München 1981.

torpedo-platform, TWP, and on the training ground located near the Hel Peninsula, in the area of Jurata and Jastarnia towns. Three observational buildings (Fig. 3) were built there, where the torpedoes' routes, dropped from the aircrafts, were observed. The research was to determine the optimum height of the torpedoes' drop from the aircrafts as well as to minimize the depth of the torpedoes' first stage of the underwater course.

There was also one more torpedo research facility during the World War II period, in the area which now belongs to Poland. It was a torpedo-platform built on the waters of Lake Miedwie along with a whole set of workshops and buildings.

2. BACKGROUND & ANALYSIS

Intense research and development works concerning the German torpedoes caliber 533,4mm were conducted in Torpedoversuschanstalt Gotenhafen[4] facilities built near the naval harbour area. One of the projects developed there was an electric torpedo G7e with a magnetic proximity fuse. Its various versions were tested in TVA. Not all ideas were effective during maritime actions. Electric torpedo, used as early as in the beginning of the war, proved to be useful as a weapon attacking stealthily and leaving no visible water stream behind it[5]. The research conducted on the German torpedoes debris allowed the Americans to quickly and successfully design and manufacture similar weaponry (type Mk-18). Soon the Brits and the Soviets had similar torpedoes (types Mark IX and ET-46 respectively). As it was mentioned above, acoustic cruise-missile systems were also designed, developed and improved. Their main element – the receiver of acoustic signals sent by the attacked ships – was tested (its various types were) in a special measurement pool built specifically for that purpose. After many attempts, a receiver based on magnetostrictive element, with similar way of working as a ship echo sounder receiver. Its receiving characteristics had a shape of two elongated and crossing leaves, set up at the angel of 24^0 towards the torpedo's longitudinal axis. The usage of electric cruise-missile torpedoes type G7es, *Zaunkönig* in 1943 had its impact on sinking of numerous ships and warships[6]. The stealth and leaving-no-trace torpedoes were a big surprise for the Allies. The new weapon was immediately incorporated into U-Boots' weaponry and would constitute up to 25% of the submarines' torpedoes taken on board.

[5] The very first attacks on English warships were performer by U-47 and resulted in sinking the *Royal Oak* ship.

[6] Those torpedoes were used for the first time during the ONS-18 and ONS -202 convoys attacks between 18-22.08 1943, where a Canadian destroyer and two corvettes securing the convoys were sunk. A. Komorowski, *Broń torpedowa*. Wyd. Bellona, Warszawa 1995, s. 26.

As it is stated above, the tests and research which were conducted in the TVA facilities brought quite surprising results. It was the effect of many scientists' and companies' work. The torpedo-platform built in the area of the Puck Bay, in the northern area of the war harbour was used very intensely, as the archive research depict. Nobody knows for certain how many test torpedoes were launched there during the war, but the number is bound to be impressive. Until this day many German torpedoes are often located in the Bay bottom around the buildings and are destroyed by the sappers. There were months during which as many as dozens of torpedoes were found and destroyed on a regular basis. It shows that the tests procedures during the World War II period was far from perfect and was often hasty.

If one is to evaluate the effects of works and research performed in the area of second facility built in the area of the Puck Bay, Torpedowaffenplatz Gotenhafen Hexengrund TWP, one can say for sure that the archive documents and the literature available indicate similar achievements. The works there brought new construction of a German aerial torpedo caliber 450mm – F5b – which was based on Norwegian and Italian torpedoes. In order to make those works possible in 1940, a research facility and aerial torpedoes test field was moved from Trawemünde to the area if Babie Doły. During two years the whole base of the test field was built, including the workshop, social buildings for one thousand and fifty Ukraine workers and a torpedo assembly line. The torpedo launch stand, torpedo-platform, was built three hundred meters away from the shore, where the water depth was about seven meters, and it was connected with the shore by a wooden pier. In the middle of the pier, from the South area, there was a marina settled, built for small ships and torpedo-sweepers. There were stationary launchers, both inside and outside of the torpedo-platform, which were used to launch torpedoes and test their velocity, range and departures from the wanted course.

The Hexengrund and Oxhoft torpedo-platforms were combined by a railway narrow-gauge train, which operated along the shore between the torpedo paths situated between the stilts rammed to the sea bottom. The train was used to transport both torpedoes and heavier elements as well as the TWP workers. Some people called it „The Kashubian Express"[7].

In order to exam and develop the aerial torpedoes, as it was already mentioned above, another test field was used, the one which was built near Bor and Jurata. Until 1943 the planes which base was in Rumia aviation club were used to test the torpedoes, but from June 1943 the Hexengrund airport runway was used.

[7] Ibidem, s. 55-56.



Figure 3. *Observation point of the aerial torpedo test field near Jurata. (Source: A. Komorowski collection)*

During research concerning the angel and the height of where the torpedoes dropped from planes reach water registering facilities were used which would allow to record the torpedoes' course which was later on analyzed in laboratories. During the Hexengrund torpedoes tests the measurements were made by observing the angels and cruise changes from the anchored boats and from the pier. Because during those tests and drills there was complete radio silence, the semaphores were used to communicate between the boats and the torpedo-platform. The improved elements of the aerial torpedoes were manufactured by facilities located in Germany. The Germans would also co-operate with the Italian navy and would build similar training facilities in Lucrino, near Napoli.

3. RESULTS

Thanks to the mentioned research and tests the more perfect aerial torpedoes types F5W and F5b were born. Both types became part of the German weaponry used regularly by the German air forces throughout the whole period of the World War II. What is more, ship torpedoes type G7e were also used, by German U-Boots. One does not need to forget that due to the intensity and the rush the research and tests were performer, a lot of the torpedoes were lost and left somewhere at the bottom of the Bay. After the World War II had finished, almost every year, around of few dozens of torpedoes are being found and neutralized which also proves the research of the Gdańsk and Puck Bay has been very thorough.

If one compares the wartime activity of Poland and Germany, once can spot that the Germans, after the war had finished, destroyed some of their torpedo test fields. The confirmation of such thesis is the fact that the torpedo-platform Neubrandenburg located in Lake Tollensee area (Die Torpedo-Versuch-Anstalt Eckernforde Abtailung Neubrandenburg) was completely destroyed. As for Poland and the torpedo facilities left in its borders, they can still be found in the area of the Puck Bay. The Oxhoft torpedo-platform nowadays, serves military purposes and is being kept in relatively good condition. The Hexengrund torpedo-platform and the concrete buildings in the area of the Hel Peninsula (Bor, Jurata) are degrading and serve as attractions for filmmakers, tourists, fishermen, divers, and people who like exploring interesting historical buildings. Until today, the torpedo-platform, despite the devastation processes it has been facing, is in a relatively good condition. Its foundation made of caisson and ferroconcrete is intact as well as the majority of the outside walls and the semaphore signalization tower. What has been destroyed is a part of the assembly line as well as a wooden pier connecting the torpedo-platform with the shore.

The existing structure of the building allows it to be arranged from the torpedo-platform remains and on the its basis a modern construction can be built, suitable for the needs of the 21st century. One of such designs is the one from 2001, prepared by the engineer Bartosz Felski. The design concerned the idea of modernization and expansion of the torpedo-platform that would serve as a NATO Conference Center called HEXENGRUND II. The author of the design proposed to incorporate into the already-existing building into a torpedo-shaped lump in order to underscore the construction's original purpose. Felski, in order to avoid too intrusive and too aggressive changes and save the historical shape of the Hexengrund torpedo-platform, proposed an idea of implementing a wall of glass onto the outside walls of the structure, and leaving the side walls of the building intact. Such resolution would enable to mix the historical construction with modern elements. The proposed complex was to include a conference room with a cliff and bay view and some smaller drill rooms and spaces. The space

available for the general public would consist of a multi-functioning atrium, halls, and roof terraces, which could be easily changed into exhibition areas. In the western part of the torpedo-platform Felski proposed a hotel and a bar. There would also be a marina allowing boats and yachts to moor. The tower would regain its basic function as it would become a view point with two panoramic elevators and terraces at the top. From the shore, it would be possible for people to reach the torpedo-platform by walking along the pier[8].

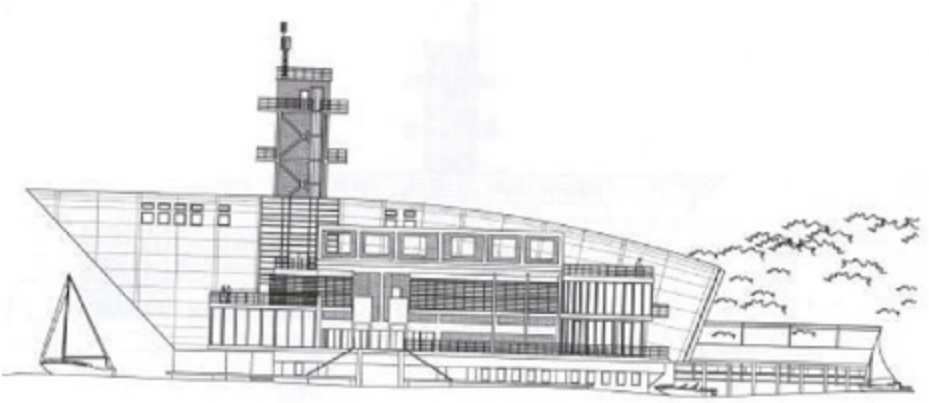


Figure 4. *The Hexengrund conference center – design*
(Source: Naval University of Gdynia collection)

Another idea of how to revive what's left of the Hexengrund torpedo-platform was presented by D. Kunicka – Pawlicka, a graduate from the Gdańsk Academy of Fine Arts, who was inspired to prepare her design (which was also her graduation work) by the fact that the city of Gdynia, back in 2005, tried to gain European Union funds to modernize the torpedo-platform and later on use it for tourism purposes only. As Kunicka-Pawlicka was doing her research, she interviewed the people living in the Babie Doły (Hexengrund) area and asked them what were their expectations and ideas. The majority of people replied that the platform should be redesigned in such was as not to lose its function as a symbol of the warfare and war actions, that it ought to remain to be a historical place and a witness to what was happening there decades ago. Kunica-Pawlicka's idea was then to redesign the platform in such way to make it a branch of World War II Museum.

A quite different project than the first idea showed linking the torpedo-platform with the shore by an underwater tunnel. Its entrance would be located on the beach and it would also serve as the entrance to the Museum. Thanks to such a solution, the platform, seen from the shore, would seem to be completely disconnected with it.

[8] Design document enitled. *Projekt modernizacji i rozbudowy torpedowni*, by engineer B. Felski, Gdynia 2001, s. 1-3.

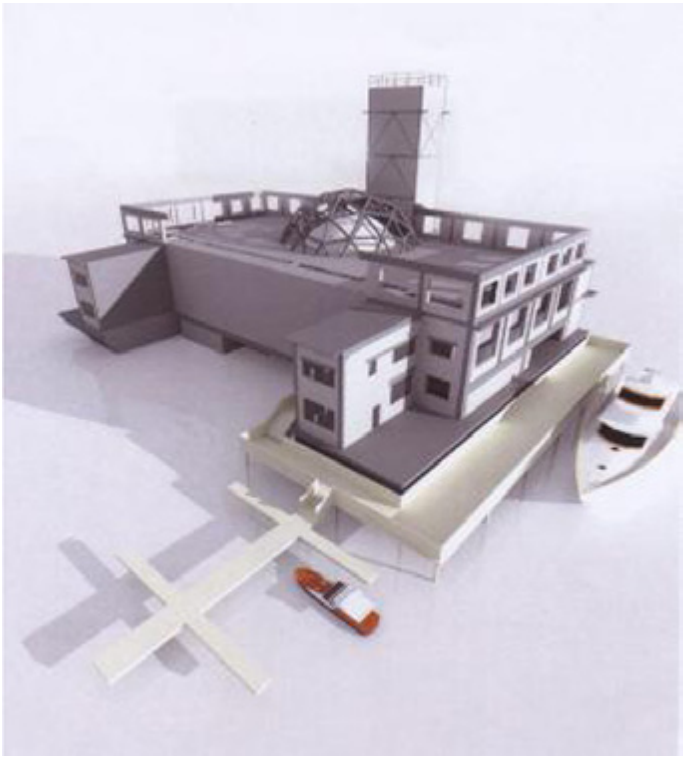


Figure 5. *World War II Museum in Hexengrund torpedo-platform, design (Source: Naval University of Gdynia collection)*

On the shore there would be a building with cloakrooms and ticket offices as well as escalators linking the building with the tunnel. The tunnel walls would have holes in them so that the guests could see and admire the underwater world. Near the museum building there would also be a marina for yachts and small cruise ships. On the ground floor there would be exhibition areas, a coffee place, a restaurant, and a pub; all of them would have seats facing windows so that guests might enjoy the view. On the ground level there would also be museum offices and toilets. The first floor would contain of, apart from the exhibition area, two conference-lecture rooms, half-round cinema with a spherical screen displaying historical pictures and six multimedia capsules, in which pictures from World War II would be shown. In the platform there would also be designed viewpoints, just as in the first concept, so the visitors might see the cliff and the bay. Kunicka-Pawlicka proposed very smooth combination of the original, old parts of the torpedo-platform with its new, planned parts in such way so that the museum visitors would experience various esthetical sensations.[9]

[9] D. Kunicka-Pawlicka, *Torpedownia Babie Doły problemy adaptacji na potrzeby współczesnego użytkownika*. ASP Gdańsk 2009, s. 1-31.

The designer's main idea was for the torpedo-platform to be an attraction not only for the people who love history, but also for tourists who would have another thing to see in Poland.

4. CONCLUSIONS

Torpedo weaponry had crucial impact on the maritime battles during the time of the World War II. Their battle worth was so high, they were used on a massive scale. Improved and developed they quickly became one of the most dangerous weapon against all possible vessels. The beginning of the World War II was a time of intense torpedo development, first for the submarine usage, then for the aviation. In order to fulfill the Nazi Germany's needs, country was intensely developing facility buildings that served to improve and test the newer and the more advance types of torpedoes.

Placing the German torpedo-platforms in Gdynia's harbour (TVA) and at the Puck Bay (TWP) allowed the Nazis to uneventfully conduct the torpedo research and testing. The intensety of such work led to quick development of both submarine and aerial torpedoes which were later on used during the whole period of the World War II. After the war had ended, the remains of the facilities left by the Germans on the Puck Bay and the Gdańsk Bay were used for military purposes. Later on only the Gdynia harbour torpedo-platform was used for military purposes and serves as such until this day. The remains of the Babie Doły torpedo-platform have been a signature spot for the Puck Bay landscape. People living in Gdynia find it fascinating and the object has been often visited by divers and tourist as well as photographers. In recent years there have been a few ideas of how to redesign the building to change it into a museum or a conference place, however none of them has been carried out so far, mostly due to economic reasons. One can only hope that perhaps one day an investor will show up willing to spend the money on one of the projects and thus will save the torpedo-platform for future generations.

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SAŽETAK

Za razvijenu proizvodnju i znanstveno istraživanje torpeda (533 mm) s akustičnim sustavom za samovođenje, kakvim se koriste podmornice, potrebna su bezbrojna testiranja prototipa na moru. Jedan od centara za takvo testiranje bio je otvoren u regiji Oksywie koja danas pripada sjevernom dijelu grada Gdynia. Torpedoversuchanstalt (TVA) Oxhoft *bio je ogranak istoimenoga znanstvenog centra sa središtem u gradu Eckernförde, u Njemačkoj. U tome znanstvenom centru razvili su velik broj nove opreme i mehanizama za torpedne ratne čamce koji su značili nove standarde i trendove u tom polju.*

Torpedowaffenplatz Gotenhafen – Hexengrund (TWP) *još je jedan centar za istraživanje i proizvodnju koji se nalazio u području današnjega grada Gdynia. I taj je centar bio smješten u Zaljevu Puck. Tamo se radilo na usavršavanju torpeda malog kalibra (450 mm) i na njihovoj prilagodbi za ispuštanje iz letjelica.*

Nakon što je završen Drugi svjetski rat, oprema koja se koristila u oba centra prenesena je dalje na istok tako da su ostali samo zidovi platforme za torpedo u Zaljevu Puck, kao i njihovo zemljište.

U ovom je radu opisano ono što je ostalo od tih dvaju centara za testiranje, njihova poslijeratna upotreba te neke od novih ideja i kako ih ponovno iskoristiti.

Osnova za analizu bio je arhivski materijal iz njemačkih arhiva i drugi znanstveni radovi.

Ključne riječi: *probno ispitivanje torpeda, centri za istraživanje, poslijeratni razvojni problemi*

BRITISH DEVELOPMENTS IN THE DELIVERY OF ANTI-SHIP TORPEDOES 1880 – 1950

Britanski razvoj u isporuci protubrodskih torpeda 1880. – 1950.

John Robinson*

SUMMARY

The earliest torpedo-men needed exceptional courage and disregard for their own safety if they were to succeed in delivering their weapons close enough to their targets to disable them. Ships sunk by torpedoes during the Anglo-American War of 1812 were the victims of attacks propelled by the wind or even manually. Not many of those who successfully operated these weapons survived to tell the tale. Half a century later the first self-propelled torpedoes appeared, typically capable of a speed barely above 5 knots. The invention of the steam turbine and its application to marine propulsion by Charles Parsons in 1897 was significant for torpedo development in providing a delivery platform capable of surprise attacks on enemy warships and of rapid escape to safety as their larger opponents retaliated.

Another British engineer, Sir John Thornycroft, established a small shipyard on the River Thames west of London 1866 for the construction of steam launches. He rapidly foresaw the possibilities offered by lightweight steam vessels as attack vessels. From Thornycroft's Chiswick factory, a large variety of small high-speed warships were delivered to the Norwegian and other foreign navies as well as to Britain's own Royal Navy. Their design varied according to the local conditions in which they were expected to operate.

The paper will offer an account of some notable innovations in the development of the vessels that brought the names of British marine engineers and naval constructors to the attention of navies throughout the world, and which exercised a decisive influence on the outcome of sea battles in both World Wars.

Keywords: *early torpedoes, platform for deliverieas of torpedoes, John Tornycroft, high spead warships, Britiain's Royal Navy*

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SAŽETAK

Najranijim torpedima upravljali su iznimno hrabri ljudi koji su morali zanemariti vlastitu sigurnost ako su svoja oružja željeli dovesti dovoljno blizu cilja kako bi ga onesposobili. Torpeda koja su potopila brodove za vrijeme Anglo-američkog rata 1812. pokretala su se uz pomoć vjetra, pa čak i ručno. Nije preživjelo mnogo onih koji su uspješno rukovali tim oružjem, da bi o tome mogli govoriti. Pola stoljeća poslije pojavila su se prva torpeda na vlastiti pogon koja su postizala brzinu jedva iznad 5 čvorova. Za razvoj torpeda kao platforme koja bi se u obliku iznenadnih napada mogla poslati na neprijateljske ratne brodove te nakon toga brzo pobjeći u sigurnost prije protunapada, zaslužan je izum parne turbine Charlesa Parsonsa 1897. i njezina primjena na plovila.

Jedan drugi britanski inženjer, Sir *John Thornycroft, utemeljio je 1866. malo brodogradilište na rijeci Temzi, zapadno od Londona, namijenjeno izgradnji parnih brodica. Brzo je predvidio mogućnosti koje lagane brodice na paru nude kao napadačka plovila. Iz njegove tvornice u Chiswicku isporučivao se cijeli niz malih ratnih brodica velike brzine Norveškoj mornarici, ali i drugim stranim mornaricama, kao i vlastitoj, Britanskoj kraljevskoj ratnoj mornarici. Njihova je konstrukcija varirala ovisno o uvjetima u kojima su trebali djelovati.*

Ovaj rad ponudit će prikaz nekih značajnih inovacija u razvoju plovila koja su mornaricama diljem svijeta skrenula pozornost na imena britanskih inženjera brodogradnje i brodograditelja te imala odlučujući utjecaj na ishod pomorskih bitaka u oba svjetska rata.

Ključne riječi: *najranija torpeda, platforma za lansiranje torpeda, John Tornycroft, brzi ratni brodovi, Britanska kraljevska mornarica*

SUCCESS BY A DEADLY WEAPON – THE USE OF TORPEDO BY THE *K.U.K. KRIEGSMARINE* IN THE FIRST WORLD WAR

Uspjeh uz pomoć smrtonosnog oružja – primjena torpeda u Carskoj i kraljevskoj ratnoj mornarici u Prvome svjetskom ratu

Nikolaus A. Sifferlinger*

SUMMARY

This paper deals with the weapon, which was invented, perfected and manufactured in Rijeka, and its use by the Austrian-Hungarian navy during the First World War. Torpedo boats, destroyers and submarines used the torpedo with good success in the Mediterranean Sea. In the first year of the war in the Adriatic Sea, the small submarine force of the K.u.K. Kriegsmarine *sunk or damaged several warships of France, Italy and Great Britain. So this kept the bigger warships of the Allies away from the Dalmatian coast and out of the Adriatic Sea for most of the war. The sinking of the French armoured cruiser* Leon Gambetta *on 27 April 1915 by the submarine U5 in the Ionian Sea with the loss of 681 sailors was a disaster for the French Navy and kept the battleships and armoured cruisers out of the Adriatic waters. But it is also important to get the victims of the new deadly torpedo out of the dark and name a few of them in this paper.*

A list of the successes of the use of torpedoes by the K.u.K. Kriegsmarine *will be given, taking into account the equipment destroyed but also the number of people killed as far as known.*

Rijeka itself, because of its torpedo factory, which was actually transferred from the city during the war, became the target of allied air raids.

And in the last twelve months of the war, the Austro-Hungarian Empire also suffered hard by losses of warships and merchant ships caused by the torpedoes from Allied vessels. On June 10, 1918, the sinking of the battleship SZENT ISTVAN, built in Rijeka, stopped the last big naval action of the K.u.K. Kriegsmarine*, claimed the life of 89 sailors, and damaged the moral of the Austro-Hungarian Navy.*

Keywords: *torpedo, World War I, ships sunk/damaged, cost of human live, victims of torpedo, Mediterranean, Austro-Hungary, Italy*

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SAŽETAK

Rad se bavi oružjem koje je izumljeno, usavršeno i proizvedeno u Rijeci te njegovom primjenom u Austrougarskoj mornarici u Prvome svjetskom ratu. Torpedni čamci, razarači i podmornice uspješno su se koristili torpedom na moru Mediterana. U prvoj godini rata u Jadranskom moru mala jedinica podmornica K.u.K. ratne mornarice potopila je ili uništila nekoliko ratnih brodova Francuske, Italije i Velike Britanije, što je većim dijelom rata držalo veće ratne brodove podalje od Dalmacije i Jadranskog mora. Nakon što je podmornica U5 *potopila francusku oklopnu krstaricu* Leon Gambetta *27. u travnju 1915. u Jonskom moru, kada je živote izgubio 681 mornar, to je veliko stradanje za francusku mornaricu držalo njezine ratne brodove i oklopne krstarice izvan Jadranskih voda. Važno je, jednako tako, izvući na svjetlo dana žrtve novoga smrtonosnog torpeda i imenovati nekolicinu u ovom radu.*

Dat će se i popis uspjeha K.u.K. ratne mornarice u korištenju torpeda, uzimajući u obzir uništenu opremu, ali i broj ubijenih ljudi, koliko se zna. Sama je Rijeka zbog svoje tvornice torpeda, koja je izmještena iz grada za vrijeme rata, postala ciljem zračnih napada Saveznika.

U posljednjih dvanaest mjeseci rata Austro-Ugarsko Carstvo pretrpjelo je gubitke i ratnih i trgovačkih brodova zbog torpeda sa savezničkih plovila. Potapanje ratnog broda Szent István*, inače sagrađenog u Rijeci, 10. lipnja 1918. zaustavilo je posljednje veliko djelovanje* K.u.K. *ratne mornarice, pri čemu je živote izgubilo 89 mornara i uništen moral Austrougarske mornarice.*

Ključne riječi: *torpedo, Prvi svjetski rat, potopljeni/oštećeni brodovi, cijena ljudskog života, žrtve torpeda, Mediteran, Austro-Ugarska, Italija*

OD *SPASIOCA OBALE* I LUPPIS-WHITEHEADOVA TORPEDA DO WHITEHEADOVA TORPEDA

From *Coast saver* (*kustenretter, salvacoste*) and Luppis-Whitehead torpedo to Whitehead torpedo

Miljenko Smokvina*

SAŽETAK

Primarni izvori o nastanku Luppisova (I. B. Vukić, J. B. Luppis) izuma Spasioca obale *(Kustenretter, Salvacoste) vrlo su oskudni. Jedini izvorni materijalni trag tog izuma, drveni model veličine otprilike metar, nalazi se u Ratnome muzeju u Beču. Rekonstrukcijom tragova u sekundarnim pisanim izvorima doznajemo da je G. B. Luppis na ideju o novome pomorskom oružju došao oko 1860. Tijekom mornaričkog školovanja te u službi časnika Austrijske ratne mornarice bio je upoznat s uporabom „požarnih brodova" (Brander, brulotto) prema kojima je razvio svoj izum nazvavši ga je* Spasilac obale *(Kustenretter, Salvacoste). Nakon odlaska u mirovinu 1861., uporno ga je više godina pokušavao prodati Austrijskoj mornarici. Inženjerijska komisija austrijskoga Ministarstva rata razmotrila je njegov prijedlog i odgovorila mu da je ideje dobra, ali zahtijeva tehničku doradu.*

Svojim skromnim novčanim sredstvima i oskudnim tehničkim znanjem G. B. Luppis nije bio u stanju svoj izum razviti u uspješno pomorsko oružje. Uz pomoć istaknutoga Riječanina G. Ciotte došao je u kontakt s direktorom Riječkoga tehničkog zavoda (Stabilimento Tecnico di Fiume) *R. Whiteheadom koji je svojim radom i sredstvima usavršio njegovu ideju. Nakon dvije godine rada i mnogobrojnih pokusa u moru razvijeno je novo podmorsko oružje* (Minenboot, fish torpedo).

Ugovorom skopljenim između G. B. Luppisa, R. Whiteheada i G. Ciotte utvrđeno je da se to novo oružje nazove Luppis-Whiteheadov torpedo *i da sve buduće isporuke ove konstrukcije torpeda nose to ime. Idućih nekoliko godina u ugovorima o isporukama torpeda iz riječke tvornice, kao i u onodobnim novinama i u literaturi redovito nailazimo na naziv* Luppis-Whiteheadov torpedo.

Tek kada je R. Whitehead razvio nove modele torpeda te njih počeo isporučivati raznim ratnim mornaricama, naziv Luppis-Whiteheadov torpedo *mijenja se u*

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Whiteheadov torpedo. *Malo poslije sva torpeda proizvedena u Rijeci ili u drugim tvornicama širom svijeta prema riječkoj ideji, nosila su samo naziv* Whitehead *i svima je bilo jasno da je riječ o riječkom torpedu.*

Ključne riječi: *G. B. Luppis, R. Whitehead,* Kustenretter, Luppis-Whiteheadov torpedo, Whiteheadov torpedo, *torpedo*

SUMMARY

The original sources on how Luppis (I. B. Vukić, J. B. Luppis) invented the Coast Rescuer *(*Kustenretter, Salvacoste*) are few. The only original material trace of that invention is a wooden model about a meter long in the War Museum in Vienna. By reconstructing traces of secondary written sources we find out that G. B. Luppis came upon the idea of the new naval weapon around the year 1860. During his naval education and afterwards as Austrian Navy officer, he became acquainted with the use of* fire-ships *(*Brander, brulotto*) and developed his invention naming it* Coast Rescuer *(*Kustenretter, Salvacoste*). Having retired in 1861, he kept trying to sell it to the Austrian Navy. The Engineering Committee of the Austrian Ministry of War considered his proposal and replied they thought it to be a good idea, though needing technical improvements.*

*Of meagre financial resources and insufficient technical knowledge, G. B. Luppis was not able to develop his invention into a successful naval weapon. With the help of G. Ciotta, a distinguished citizen of Rijeka, he was introduced to the director of Rijeka Technical Institute (Stabilimento Tecnico di Fiume) R. Whitehead, who, owing to his work and sources, succeeded in improving Luppis' invention. After a two-year work and numerous experiments in the sea, a new underwater weapon was invented (*Mineboot, fish torpedo*).*

The contract signed by G.B. Luppis, R. Whitehead and G. Ciotta set out that the new weapon be called Luppis-Whitehead Torpedo and that all future supplies of this torpedo were to bear this name. In the following few years, we regularly find the name of Luppis-Whitehead Torpedo, be it in the Rijeka factory torpedo supply contracts or in the newspapers or literature of that time.

Only when R. Whitehead had developed new models of torpedoes and began delivering them to different navies, was the name of Luppis-Whitehead Torpedo changed into Whitehead Torpedo. A little afterwards, all the torpedoes produced in Rijeka or other world factories after the idea from Rijeka bore the name of Whitehead *only, everyone aware of the fact that it was the Rijeka torpedo.*

Keywords: *G. B. Luppis, R. Whitehead, Kustenretter, Luppis-Whitehead torpedo, Whitehead torpedo, torpedo*

REPRESENTATION OF RIJEKA'S TORPEDO HERITAGE IN ENCYCLOPAEDIC EDITIONS

Zastupljenost riječke torpedne baštine u enciklopedičkim izdanjima

Ivan Smolčić, Nataša Jermen, Zdenko Jecić

SUMMARY

According to contemporary historiographical insights, the contribution of Ivan Blaž Luppis and Rijeka to torpedo's development is unquestionable. However, this contribution was not always adequately evaluated and presented in the past hundred years or so. Encyclopaedic works are good indicators of experts' and the public's relation toward a topic as their declared objectivity is unavoidably subject to national, ideological and other biases. This paper presents the results of comparative analyses and an epistemological evaluation of articles published in world encyclopaedias that deal with the torpedo's history, with emphasis on presenting the contribution of I. B. Luppis from very beginnings. The authors analysed older and newer editions of great world encyclopaedias (Encyclopaedia Britannica, Brockhaus Enzyklopädie, Enciclopedia Italiana di Scienze, Lettere ed Arti, Grand Larousse enciclopédique, Boljšoja sovjetskaja enciklopedija), the national, general and specialised ones. The analysed encyclopaedias, be they general or specialised, have to a degree taken part in the process of expanding and organising knowledge regarding technical heritage and in its dissemination to users. The observed differences in these encyclopaedic interpretations of Rijeka's torpedo heritage are in correlation with national and ideological affiliation and the period in which each encyclopaedia emerged. Also, special attention was devoted to the role of digital technologies in the dissemination of knowledge on Rijeka's torpedo heritage. Digital technologies have made impact on the gradual transformation of traditional encyclopaedias into collaborative online editions of open access, enabling in this way the breakthrough of lesser known or uncovered topics. The insight into the valorisation of Luppis's work in the newly started project of the Croatian encyclopaedia of technology is also presented. Owing to innovations in the field of knowledge networking, this encyclopaedia enables the surpassing of shortcomings of traditional encyclopaedias regarding the objectivity and comprehensiveness of analysis.

Keywords: *Ivan Blaž Luppis, Rijeka's torpedo heritage, encyclopaedia, Croatian encyclopaedia of technology*

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1. INTRODUCTION

Encyclopaedia is a reference work that contains a comprehensive summary of information on all branches of knowledge (general encyclopaedias) or on a particular branch of knowledge (specialised encyclopaedias). Throughout the centuries, encyclopaedias have represented a means by which the users could easily and quickly obtain objective and accurate information on any topic. The appearance of digital encyclopaedias 30 years ago have facilitated the distribution and usage of encyclopaedic knowledge. However, the true revolution in encyclopaedic science occurred with expansion of the Internet and open access online encyclopaedias that are based on free and collaborative editorial concept, such as Wikipedia. Wikipedia has extended the range of covered topics and the ways in which information is presented to an immeasurable extent and as such has become the most comprehensive and most used encyclopaedia in history. In such a way, Wikipedia, as well as traditional professionally edited online encyclopaedias, are becoming means to deal with information overload.

The role of both professionally edited encyclopaedias and of Wikipedia is to offer reliable and generally agreed upon information. Therefore, every encyclopaedia should adhere to the basic encyclopaedic principles: accuracy and objectivity.[1] Accuracy refers to the given facts and numerical data. Objectivity implies that information and facts should be treated equally, without religious, national, ideological, racial or sexual prejudices, both conscious and subconscious. Although encyclopaedias aim to be as accurate and as objective as possible, the treatment of certain topics can sometimes reveal the deviation from these two principles. Inaccuracy (erroneous facts and data) can occur on account of inadequately thorough elaboration of a topic. Bias could be the consequence of prejudices or even deliberate distortion of the truth, but it could also reflect the perception of the topic in certain national, ideological or cultural surroundings.

2. SCOPE AND METHODOLOGY OF RESEARCH

The scope of the research was to analyse perception of the contribution of Ivan Blaž Luppis and Rijeka to torpedo's development, based on the representation and the definition in various encyclopaedic editions. As encyclopaedias are a representative indicator of experts' and the public's opinion toward a certain topic, the hypothesis is that elaboration and presentation of topics regarding Rijeka's

[1] Encyclopaedic principles are essential for encyclopaedic work, and for the characterisation of encyclopaedic editions. Some of the main characteristics are comprehensiveness, accuracy, objectivity, credibility, relevance, conciseness, structure, keeping up to date, etc. More in: Jecić, Z: *Enciklopedički koncept u mrežnom okruženju*. Studia Lexicographica, 7(2014) 2(13), pg. 99–115.

torpedo heritage will reflect social perception in a given area (geographically) and the period of history in which they originated. As consequence, they would inevitably contain deviations in accuracy and objectivity of given facts and data. Forty-one encyclopaedias that have taken part in organisation and dissemination of knowledge regarding technical heritage were chosen. These encyclopaedias contain *torpedo* as an encyclopaedic entry, with few exceptions where torpedo is discussed as a part of a larger review article. These entries were analysed in terms of representation and interpretation of topics relevant to Rijeka's torpedo heritage: *Giovanni Biagio Luppis or Ivan Blaž Vukić (Luppis), Robert Whitehead, Rijeka, Rijeka torpedo factory.*

The selected encyclopaedias cover a broad time period of publishing and have a large geographical distribution, so after initial analysis the study material consisted of encyclopaedias written in 11 different languages and published over a 125 year timespan. Using comparative analysis encyclopaedic texts on Rijeka's torpedo heritage were examined against the findings of contemporary historiography (Table 1), noting deviations in accuracy (based on verification of the data) and objectivity (based on references to the relevant protagonists and events).

■ **Table 1.** *The chronology of events in Rijeka based on contemporary historiographical findings*

Year	Event
1860	Luppis demonstrated the model of the *coastsaver* (*Kustenretter)* to Austrian authorities, but his request to support further development of the idea was rejected.
1864	Luppis became partners with an engineer and a politician, Whitehead and Ciotto, in attempt to develop his idea, which soon proved to be impractical. Whitehead continued to work on the idea on his own.
1866	Whitehead and his collaborators built the first successful prototype called *Minenschiff* and presented it to Austrian military authorities.
1867	Austrian government contracted Whitehead and Luppis for a test production of the torpedo.
1868	First delivery of Whitehead-Luppis torpedo produced in Rijeka's factory Stabilimento tecnico fiumano.
1870	In cooperation with Whitehead, British Navy started their own torpedo production in Woolwich arsenal.
1875	Whitehead took possession of Stabilimento tecnico fiumano.
1890–1891	Whitehead opened a new factory in Weymouth.
1912–1914	Whitehead torpedo production started in Italy (La Spezia and Naples), France (Saint Tropez), USA (Newport) and Russian Empire (Odessa).

3. RESULTS OF THE COMPARATIVE ANALYSES

3.1. Encyclopaedias published in English-speaking countries

Several editions of the *Encyclopaedia Britannica* were analysed, from 1911 until the present day *online* edition. In its article *torpedo,* published in 1911, several decades after the torpedo invention, there is no mention of Luppis, whereas Whitehead is denoted as the torpedo's inventor. The factory in Rijeka is also mentioned: "*...A great improvement in the torpedo devised by* ***Mr Whitehead...*** *The* ***Whitehead torpedo*** *is a steel fish-shaped body....The efficiency of such a torpedo compared with all previous types was clearly manifest when it was brought before the maritime states by the inventor, Whitehead, and it was almost universally adopted****...Messrs Whitehead & Co., of Fiume,*** *then acquired the invention, and after exhaustive experiments produced the apparatus which is now fitted to every torpedo made*".

In the 1947 edition, however, the contribution from Luppis is recognised, albeit with the incorrect date: "*...In* ***1862 Captain Luppis of the Austrian Navy*** *sought the assistance of* ***Robert Whitehead****, a Scotsman (then manager of an* ***engineering factory at Fiume****) to perfect a self-propelling floating torpedo which he had designed. Mr. Whitehead modified this first invention and* ***after two years*** *of incessant labour the first* ***Luppis-Whitehead torpedo*** *was produced. To preserve secrecy it was done by Mr. Whitehead himself, his son and one trusted workman...As the Austrian government were not prepared to purchase the exclusive rights of this invention it was offered to other powers...*"

In micropaedia and macropaedia of *Encyclopaedia Britannica* from 1974, Luppis is not mentioned and credit for the torpedo's invention goes to Whitehead, but it is stated that Austrian Navy encouraged this invention. Additionally, the micropaedia article gives the description of Luppis' *coastaver*: »*...The modern torpedo was developed by* ***Robert Whitehead,*** *a British engineer. In* ***1864*** *the* ***Austrian navy asked*** *him to work out an idea for an* ***explosive-carrying, self-propelled boat that could be steered from its launching site by long yoke lines.*** *After building a model of the device, Whitehead rejected the scheme as impracticable and began work on an idea of his own. By* ***1866*** *he had a successful torpedo...«.* Almost identical articles, that have no reference to Luppis whatsoever, can be found in the subsequent printed and digital editions of *Britannica*, as well as in current edition of *Britannica Online.*

Among other printed encyclopaedias in English that were published between 1960's and 1990's, *World Book, Chambers's Encyclopaedia* and *Academic American Encyclopedia* mention Luppis as the person with the first idea for a torpedo. All encyclopaedias, however, recognise Whitehead as the key person in the creation of a modern torpedo. Rijeka and its torpedo factory regularly do not appear in analysed articles.

■ **Table 2.** *Representation of Rijeka's torpedo heritage in Encyclopaedias published in English-speaking countries*

Encyclopaedia (publication year)	Topics relevant to Rijeka's torpedo heritage				Error
	Luppis	Whitehead	Rijeka	Rijeka torpedo factory	
Encyclopaedia Britannica (1911)[2]	-	✓	✓	✓	-
Encyclopaedia Britannica (1947)[3]	✓	✓	✓	✓	✓
Collier's Encyclopedia (1960)[4]	-	✓	-	-	✓
Encyclopedia International (1963)[5]	-	✓	-	-	-
Encyclopedia Americana (1964)[6]	-	✓	✓	✓	-
Chambers's Encyclopaedia (1973)[7]	✓	✓	✓	-	-
Encyclopaedia Britannica Micropaedia (1974)[8]	-	✓	-	-	-
World Book (1979)[9]	✓	✓	-	-	✓
Academic American Encyclopedia (1988)[10]	-	✓			-
World Book (1994)[11]	✓	✓	-	-	✓
Encyclopaedia Britannica (2002)[12]	-	✓	-	-	-
Encyclopaedia Britannica digital (2008)[13]	-	✓	-	-	-
Encyclopaedia Britannica online (2016)[14]	-	✓	-	-	-

[2] *Torpedo*. Encyclopaedia Britannica, vol. 27, 1911, pg. 53–58.

[3] *Torpedo*. Encyclopaedia Britannica, vol. 22, 1947, pg. 300–302.

[4] *Torpedo*. Collier's Encyclopedia, vol. 18, 1960, pg. 410–411.

[5] *Torpedo*. Encyclopedia International, vol. 18, 1963, pg. 165–166.

[6] *Torpedoes*. The Encyclopeia Americana. International edition, vol. 26, 1964, pg. 705–707.

[7] *Torpedo*. Chambers's Encyclopaedia. New revised edition, vol. 13, 1973, pg. 698–700.

[8] *Torpedo*. Encyclopaedia Britannica, vol. 10, 1974, pg. 53–54.; *The Technology of War*. Encyclopaedia Britannica, vol. 19, 1974, pg. 529–627.

[9] *Torpedo*. The World Book Encyclopedia, vol. 19, 1979, pg. 264–265.

[10] *Torpedo*. Academic American Encyclopedia, vol. 19, 1988, pg. 242–243.

[11] *Torpedo*. The World Book Encyclopedia, vol. 19, 1994, pg. 340–341.

[12] The New Encyclopaedia Britannica, 15th ed. (2002).

[13] Encyclopædia Britannica. Encyclopaedia Britannica 2008 Ultimate Reference Suite. Chicago: Encyclopædia Britannica, 2008.

[14] Encyclopædia Britannica. Encyclopædia Britannica Online. Encyclopædia Britannica Inc., 2016. URL http://www.britannica.com (accessed on Dec 12th 2018).

3.2. German encyclopaedias

Analysed German encyclopaedias were published over the course of more than a hundred years. The most extensive torpedo article among general encyclopaedias is given in the earliest one, *Meyers Konversations Lexikon*, which was published only two decades after the invention of torpedo. The article mentions both Luppis and Whitehead, as well as Rijeka, but uses the incorrect date: »*...All these and other offensive torpedoes are surpassed by the fish torpedo, invented by* ***Austrian Captain Luppis*** *and engineer* ***Whitehead*** *in* ***Fiume*** *in* ***1867****, which was introduced by almost all navies for its excellent performances. A Whiteheadian fish torpedo...*«.

The next edition of the lexicon from 1909 supplemented the text with the incorrect statement that the Luppis-Whitehead torpedo was significantly improved by a German industrialist Robert Schwartzkopff, who in fact only produced the copy of the mentioned torpedo in another material. The biggest German encyclopaedia, *Brockhaus,* from 1934 names Luppis as no lesser than the father of the modern torpedo. It mentions Whitehead and Rijeka, but on the other hand gives the incorrect date and states a significant improvement of torpedo by Schwartzkopff in Berlin: »*The father of today's fish or machine torpedo is the* ***Austrian Captain Luppius****. His thoughts were taken up by the machine manufacturer* ***Robert Whitehead*** *in* ***Fiume****, who then created the first usable T (Whitehead torpedo,* ***1872****)... Significant upgrades continued to create the torpedo workshop of Schwarzkopff in Berlin*«. Fortunately, in the following editions, the incorrect information concerning Schwarzkopff has been removed.

Among specialised technical encyclopaedias, *Das Buch der Erfindungen Gewerbe und Industrien* offers the review article *torpedo arms* which only briefly mentions Luppis and Whitehead, with no specification on who they were and where they worked, while the *Lugers Lexikon der gesamten Technik* mentions Whitehead and Schwartzkopff but not Luppis.

■ **Table 3.** *Representation of Rijeka's torpedo heritage in Encyclopaedias published in German-speaking countries*

Encyclopaedia (publication year)	Topics relevant to Rijeka's torpedo heritage				Error
	Luppis	Whitehead	Rijeka	Rijeka torpedo factory	
Meyers Konversations Lexikon (1890)[15]	✓	✓	✓	-	✓
Das Buch der Erfindungen Gewerbe und Industrien (1901)[16]	✓	✓	-	-	-
Meyers Großes Konversations-Lexikon (1909)[17]	✓	✓	✓	-	✓
Lugers Lexicon (1929)[18]	-	✓	-	-	✓
Der Grosse Brockhaus (1934)[19]	✓	✓	✓	-	✓
Brockhaus Enzyklopädie (1973)[20]	✓	✓	✓	-	✓
Meyers Neues Lexikon (1976)[21]	-	✓	✓	✓	-
Brockhaus die Enzyklopädie (1999)[22]	✓	✓	✓	-	✓

3.3. Italian encyclopaedias

Enciclopedia Italiana di Scienze, Lettere ed Arti, the renowned encyclopaedia of the Treccani Institute, in 1936 edition reviews the torpedo in a comprehensive review article *underwater arms,* which provides an elaborated review of the torpedo's historical development in Rijeka. The article states both the Italian Luppis, the officer of the Austro-Hungarian Navy, and the engineer Whitehead as torpedo's inventors. In the detailed description of the emergence and characteristics of original torpedoes, this encyclopaedia primarily gives data on Luppis' coastsaver. The information on Luppis' partnership with Whitehead, as the founder of the *Stabilimento meccanico* in Rijeka is mention but not entirely correctly: *»Other experiments and similar attempts were made elsewhere, until around 1860 the **Luppis** built and experimented in **Fiume** at first the coast guard, a sort of self-propelled barrel, driven by a clockwork machine... But the attempts of*

[15] *Torpedo*. Meyers Konversations Lexikon, vol. 15, 1890, pg. 764–768.

[16] *Torpedowefen*. Das Buch der Erfindungen Gewerbe und Industrien, vol. 9, 1901, pg. 731–744.

[17] *Torpedo*. Meyers Großes Konversations-Lexikon, vol. 19, 1909, pg. 625–627.

[18] *Torpedo*. Luegers Lexikon der Gesamten Technik, vol. 6, 1929, pg. 611–612.

[19] *Torpedo*. Der Grosse Brockhaus, vol. 18, 1934, pg. 766.

[20] *Torpedo*. Brockhaus Enzyklopädie, vol. 18, 1973, pg. 769–770.

[21] *Torpedo*. Meyers Neues Lexikon, vol. 13, 1976, pg. 640–641.

[22] *Torpedo*. Brockhaus die Enzyklopädie, vol. 22, 1999, pg. 196–197.

***Luppis** did not produce a practical result, so that in **1864** he associated **Whitehead**, founder of the mechanical plant of **Fiume**, who modified the idea of **Luppis** in the sense of making the projectile underwater and independent from the device of launch. It was thus that, in an attempt to try, the **Luppis and Whitehead** came to an end in October **1868**, the first torpedo driven by compressed air and completely independent of the earth.«.*

La Piccola Treccani-Dizionario Enciclopedico, encyclopaedia published by the Insitut Treccani around 1990, in the *torpedo* article provides a short review of its historical development, mentioning that it was thought out by Luppis around 1860 and improved by Whitehead from Rijeka. The article from Enciclopedie online doesn't provide details on the historical development of torpedo, but unlike other professional encyclopaedias, it does contain articles on Luppis and the coastsaver.

It is quite interesting to point out that in one of the additional volumes of *Enciclopedia Italiana* from 2013 *(Cronologia 1420-2013 – Il Contributo italiano alla Storia del Pensiero: Tecnica*), which is available online as well, Luppis's and Whitehead's invention is located in Trieste and its *stabilimento tecnico*: *»In **Trieste**, **Giovanni Biagio Luppis** joins the company with the English engineer **Robert Whitehead** (1823–1905), and the two establish the **Trieste technical plant**, in whose workshop they design an underwater weapon that, from the name of the fish Silurus glanis, will call torpedo; his first truly effective example – operated by compressed air and completely independent of the earth – will be manufactured in October **1868**.«.*

■ **Table 4.** *Representation of Rijeka's torpedo heritage in Encyclopaedias published in Italian-speaking countries*

Encyclopaedia (publication year)	Topics relevant to Rijeka's torpedo heritage				Error
	Luppis	Whitehead	Rijeka	Rijeka torpedo factory	
Enciclopedia Italiana (1936)[23]	✓	✓	✓	✓	✓
La Piccola Treccani - Dizionario Enciclopedico (1997)[24]	✓	✓	✓	-	-
Enciclopedie online (2016)[25]	-	-	-	-	-

[23] *Subacquee, armi*. Enciclopedia Italiana di Scienze, Lettere ed Arti, vol. 32, 1936, pg. 907–911.

[24] *Siluro*. La Piccola Treccani-Dizionario Enciclopedico, vol. 11, 1997, pg. 158–159.

[25] *Siluro*. Enciclopedie on line. URL http://www.treccani.it/enciclopedia/siluro/ (accessed on Dec. 12th 2018).

3.4. Encyclopaedias in other languages

Among other encyclopaedias, only the Czech encyclopaedias Ottův Slovník Naučný from 1906 and Technickỳ Slovnik Naučnỳ from 1937 bring the information on all the analysed topics. There is a major inaccuracy in *Great Soviet Encyclopaedia* as it locates the torpedo invention in England.

■ **Table 5.** *Representation of Rijeka's torpedo heritage in Encyclopaedias published in countries speaking languages other than English, German and Italian*

Encyclopaedia (publication year)	Topics relevant to Rijeka's torpedo heritage				Error
	Luppis	Whitehead	Rijeka	Rijeka torpedo factory	
Ottův Slovník Naučný (1906)[26]	✓	✓	✓	✓	-
Technickỳ Slovnik Naučnỳ (1937)[27]	✓	✓	✓	✓	✓
Boljšaja Sovetskaja Enciklopedija (1949)[28]	✓	✓	-	-	✓
Svensk Uppslagsbok (1954)[29]	-	✓	-	-	-
Wielka Encyklopedia Powszechna Pwn (1968)[30]	-	✓	-	-	✓
La Grande Encyclopèdie (1975)[31]	-	✓	-	-	-
Gran Enciclopèdia Catalana (1995)[32]	✓	✓	-	-	-

[26] *Torpedo*. Ottův Slovník Naučný, vol. 25, 1906, pg. 589–594.

[27] *Torpedo*. Technickỳ Slovnik Naučnỳ, vol. 13, 1937, pg. 1012–15.

[28] *Torpeda*. Boljšaja Sovetskaja Enciklopedija, vol. 43, 1949, pg. 40.

[29] *Torped*. Svensk Uppslagsbok, vol. 29, 1954, pg. 672–674.

[30] *Torpeda*. Wielka Encyklopedia Powszechna Pwn, vol. 11, 1968, pg. 589.

[31] *Marine*. La Grande Encyclopèdie, vol. 13, 1975, pg. 7630–46.

[32] *Torpede*. Gran Enciclopèdia Catalana, vol. 22, 1995, pg. 442–443.

3.5. Encyclopaedias of The Miroslav Krleža Institute of Lexicography

Editions published by The Miroslav Krleža Institute of Lexicography contain all relevant information connected to the Rijeka's torpedo heritage, successfully avoiding inaccuracies and biased information. *Croatian encyclopaedia,* a general encyclopaedia with special emphasis on national content, points out Luppis as the Croatian inventor who thought of the torpedo prototype and was responsible for its initial development. Both editions of the *Maritime encyclopaedia* bring comprehensive articles on torpedo using the Croatian variant of Luppis' surname.

Fairly recently, in 2014, the Institute initiated the *Croatian encyclopaedia of technology* project. It is carried out in collaboration with the Croatian Academy of Science and the Croatian Academy of Engineering. As a national specialised (technical) encyclopaedia, which will be published in four volumes as well as online, its main purpose is to describe historical development as well as the current state of technology in Croatia. Therefore, the relevant topics that this encyclopaedia will cover will be related to both technology and Croatia, i.e. persons born in Croatia or those of Croatian origin, or persons whose achievement marked technological development in Croatia, and the same regarding companies, institutions, etc., as well as general facts connected to technology development in Croatia. In spite of the fact that those topics will take major part of encyclopaedia, it will strive to keep objectivity and neutrality by bringing correct and historiographically verified facts and data. Consequently, the article *torpedo* pays the most attention to Rijeka's torpedo heritage, starting from the Luppis' invention all the way to the ceased production in Rijeka's factory Torpedo in 1960s, giving correct and unbiased statements: »*The predecessor of the self-propelled torpedo was created by the officer of the Austrian Navy* ***Giovanni Biagio Luppis*** *(Ivan Blaž Vukić).* ***Luppis*** *has constructed a model of a ship without a crew that could attack the enemy ship at a greater distance, and called it a rescuer of the coast (the Küstenretter). The idea on two occasions (1860 and 1864) was presented to the Austrian military top, but with no results. Through the mediation of Rijeka's Mayor Giovanni Ciotte (1824-1903), he was adored in* ***1864*** *with* ***Robert Whitehead****, an engineer and manager of the Rijeka factory Stabilimento tecnico fiumano. Shortly afterwards, Whitehead left the idea of* ***Luppis*** *on a new basis, with the help of a son John and mechanic Annibale Plöch constructed the first torpedo of today, which called mineschiff. The invention was presented on* ***21 December 1866*** *to the Technical Commission of the Naval Department of the Austrian Ministry of War... In 1867, the Austrian Government signed the torpedo production test and in* ***1868*** *delivered the first specimens of the name* ***Whitehead-Luppis torpedo****«.* Thanks to innovations in the field of knowledge networking, authors believe that the encyclopaedia's online version will be beneficial for the organisation and dissemination of knowledge connected to Croatian technology heritage.

■ **Table 6.** *Representation of Rijeka's torpedo heritage published by the encyclopaedias in other speaking countries*

Encyclopaedia (publication year)	Topics relevant to Rijeka's torpedo heritage				Error
	Luppis	Whitehead	Rijeka	Rijeka torpedo factory	
Maritime encyclopaedia (1961)[33]	✓	✓	✓	✓	-
Maritime encyclopaedia (1989)[34]	✓	✓	✓	✓	-
Croatian encyclopaedia (2008)[35]	✓	✓	✓	✓	-
Croatian encyclopaedia of technology (2018)[36]	✓	✓	✓	✓	-

3.6. Wikipedia

At present, there are in total 282 language editions of Wikipedia. The *torpedo* articles in Croatian, English, German, Italian and Russian Wikipedia were analysed. All those articles, except for the Russian one, mention all the relevant data on the Rijeka's torpedo heritage. Croatian Wikipedia offers a rather concise and inadequately elaborated article on torpedo, which carries the biased statement that Croatian Luppis was the inventor of the modern torpedo. On the other hand, English Wikipedia carries the most extensive article, which brings factual information on the torpedo's historical development in Rijeka in an elaborate manner. The German and Italian Wikipaedias show similar properties. German Wikipedia for instance gives the Croatian variant of Luppis's name. Russian Wikipedia mentions Whitehead's invention in Rijeka only sporadically, and partly gives credit for this invention to the Russian inventor Aleksandrovski: *»The first self-propelled mine ("self-propelled torpedo") was created in **1865** by the Russian inventor **I. F. Aleksandrovsky** ... The first samples of torpedoes (torpedoes Whitehead) were developed by Englishman **Robert Whitehead (1866)**.«.*

[33] *Torpedo*. Maritime encyclopaedia, vol. 7, 1961, pg. 560–567.

[34] *Torpedo*. Maritime encyclopaedia, vol. 8, 1989, vol. 171–181.

[35] *Torpedo*. Croatian encyclopaedia, vol. 10, 2008, pg. 820. URL: http://www.enciklopedija.hr/Natuknica.aspx?ID=61863 (accesed on Dec. 12th 2018).

[36] *Torpedo*. Croatian encyclopaedia of technology, vol. 1, 2018, pg. 664–667. URL: http://tehnika.lzmk.hr/torpedo/ (accesed on Dec. 12th 2018).

■ **Table 7.** *Representation of Rijeka's torpedo heritage published by several language-versions of Wikipedia*

Encyclopaedia (publication year)	Topics relevant to Rijeka's torpedo heritage				Error
	Luppis	Whitehead	Rijeka	Rijeka torpedo factory	
hr.wikipedia.org (2016)[37]	✓	✓	✓	✓	✓
en.wikipedia.org (2016)[38]	✓	✓	✓	✓	-
de.wikipedia.org (2016)[39]	✓	✓	✓	✓	-
it.wikipedia.org (2016)[40]	✓	✓	✓	✓	-
ru.wikipedia.org (2016)[41]	-	✓	-	-	✓

4. CONCLUSION

Through comparative analysis of articles entitled *torpedo* published in a large number of great world and national encyclopaedias, general and specialised ones, the contribution of Ivan Blaž Luppis and Rijeka to the development of torpedo has not always been adequately evaluated and presented. The authors took notice of inaccuracies, which in most cases referred to the erroneous dates of relevant events, as well as of bias. For example, encyclopaedias published in English-speaking countries neglect Luppis more frequently, not recognising him as the man behind the torpedo, while the contribution of the English engineer Whitehead to the torpedo development is seen as a given. In general, German encyclopaedias contain the information on Luppis and on his contribution to the torpedo invention, since he was the captain in Austro-Hungarian Navy. They also state Rijeka as the town where torpedo was invented, since Rijeka was a part of the Austro-Hungarian Empire in that period. Some of those encyclopaedias, however, outline the biased information that torpedo was improved by Schwartzkopf. Among all these printed world encyclopaedias, the Italian Enciclopedia Italiana carries the most extensive review of torpedo devel-

[37] *Torpedo*. Wikipedia, Slobodna enciklopedija. URL https://hr.wikipedia.org/wiki/Torpedo (accesed on Dec. 12th 2018).

[38] *Torpedo*. Wikipedia, The Free Encyclopedia. URL https://en.wikipedia.org/wiki/Torpedo (accesed on Dec. 12th 2018).

[39] *Torpedo*. Wikipedia, Die freie Enzyklopädie. URL https://de.wikipedia.org/wiki/Torpedo (accesed on Dec. 12th 2018).

[40] *Torpedo*. Wikipedia, L'enciclopedia libera. URL https://it.wikipedia.org/wiki/Siluro (accesed on Dec. 12th 2018).

[41] *Torpedo*. Vikipedia, svobodnaja enciklopedija. URL https://ru.wikipedia.org/wiki/Торпеда (accesed on Dec. 12th 2018).

opment in Rijeka. The reason for this, besides the general comprehensiveness of this encyclopaedia, could be that Luppis is supposed to be an Italian and that Rijeka belonged to Italy in the period in which this encyclopaedia emerged (1929–1937). Surprisingly, in one of its recent additional volumes, the place for the invention of torpedo is transferred to Trieste. Encyclopaedias that cover other languages in most cases are unbiased, with the lack of some relevant data due to the condensed concept of encyclopaedias. As expected, *Croatian encyclopaedias* shows the greatest interest for the analysed topics and provides an elaborated review on the events in Rijeka. The given facts and data are generally compatible with the contemporary historiographical insights. It is concluded that the observed differences in the interpretation of Rijeka's torpedo heritage are correlated to national affiliations and the period in which each encyclopaedia emerged.

As for Wikipedia, previous analysis determined that it shows high level of accuracy and objectivity, but on the other hand in some cases it contains biases and inaccuracies that can hardly ever be found in traditional encyclopaedias. We found that English, German and Italian Wikipedia are almost impeccable with regard to their accuracy, objectivity and elaboration of analysed topics. On the other hand, encyclopaedic entry *torpedo* in Croatian Wikipedia is surprisingly short, inadequately informative, and inaccurate. Finally, we can conclude that the use of digital media brings focus on knowledge on Rijeka's torpedo heritage.

In this respect, we believe that the online *Croatian encyclopaedia of technology*[42], thanks to the innovations in the field of knowledge networking, will surpass the shortcomings of traditional encyclopaedias regarding their objectivity and comprehensiveness.

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SAŽETAK

*Doprinos Ivana Blaža Lupisa i Rijeke razvoju torpeda prema suvremenim je historiografskim spoznajama neupitan. U proteklih stotinjak godina, međutim, taj doprinos nije uvijek bio odgovarajuće vrednovan i prezentiran. Enciklopedička su djela dobri pokazatelji odnosa stručnjaka i javnosti prema nekoj temi budući da je njihova deklarirana objektivnost neizbježno podložna nacionalnim, ideološkim i drugim pristranostima. Ovaj će rad pokazati rezultate komparativne analize i epistemološke evaluacije članaka objavljenih u svjetskim enciklopedijama koje obrađuju povijest torpeda, s naglaskom na prikaz Lupisova doprinosa njegovu nastanku. Analizirali smo starija i novija izdanja velikih svjetskih enciklopedija (*Encyclopaedia Britannica, Brockhaus Enzyklopädie, Enciclopedia Italiana di Scienze, Lettere ed Arti, Grand Larousse enciclopédique, Boljšoja sovjetskaja enciklopedija*), nacionalnih, općih i strukovnih enciklopedija. Analizirane enciklopedije, i opće i specijalizirane, u određenoj su mjeri sudjelovale u procesu okrupnjavanja i organizacije znanja povezanoga s tehničkom baštinom, kao i u njegovoj diseminaciji korisnicima. Uočene razlike u obradi riječke torpedne baštine u korelaciji su s nacionalnom i ideološkom pripadnosti te razdobljem nastanka enciklopedija. Posebna će se pozornost posvetiti ulozi digitalnih tehnologija u diseminaciji znanja o riječkoj torpednoj baštini. Digitalne su tehnologije utjecale na postupnu pretvorbu tradicionalnih enciklopedija u kolaborativne* online *enciklopedije otvorenoga pristupa, omogućujući na taj način prodor manje poznatih ili neobrađenih tema. Donijet će se i uvid u valorizaciju Lupisova djela u novopokrenutom projektu* Hrvatska tehnička enciklopedija*. Zahvaljujući inovacijama na području umrežavanja znanja, ova će enciklopedija omogućiti nadilaženje nedostataka tradicionalnih enciklopedija u pogledu objektivnosti i sveobuhvatnosti obrade.*

Ključne riječi: *Ivan Blaž Lupis, riječka torpedna baština, enciklopedija, Hrvatska tehnička enciklopedija*

TRADING FLATBOAT ON THE SANA RIVER

Trgovačka dereglija na rijeci Sani

Emir Trožić, Edin Smajić

SUMMARY

From the middle stream of the Sana and Una River, trading flatboats floated over the Sava River all the way to Belgrade. It was different agricultural products that were transported by these small boats. With regard to local constructors, characteristic variations are possible in the constructing of these flatboats, i.e., according to the capacity and size of the boat, as quoted in the Proceedings of the Krajina Museums, I, 1962, pages 181-191, in the article entitled Traffic on the Sana and the Una. *These data differ depending on the period of construction and the client. Characteristic details were analyzed according to the original photographic records and sketches. Analysis results are presented in tables, thus leading to the conclusion. With regard to complying with basic construction proportions and the maximum permissible draught, there were differences in the capacity of these trading flatboats. What has also been noted is the use of fir-timber for the construction of proper boats.*

Keywords: *small boats, transportation, local construction, constructional proportions*

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SAŽETAK

Od središnjeg toka rijeke Sane, Une, Savom su do Beograda plovile dereglije (drvena riječna teglenica). Tim su malim brodicama prevoženi razni poljoprivredni proizvodi. S obzirom na lokalne graditelje, pri izradi dereglija moguća su karakteristična odstupanja. U Zborniku krajiških muzeja*, I., 1962., str. 181–191. pod naslovom* Saobraćaj na Sani i Uni *navodi se nosivost i dimenzije tih brodica. Podatci se razlikuju od vremena gradnje i naručitelja. Prema originalnim fotografskim zapisima i skicama analizirani su karakteristični detalji. Rezultati analize prikazuju se tabelarno, iz čega se raspravom dolazi do zaključka. Vezano uz pridržavanje osnovnih graditeljskih proporcija i maksimalno dopustiv gaz, postojale su razlike u nosivosti dereglija. Zabilježena je i upotreba jelove građe za gradnju vlastitih brodica.*

Ključne riječi: *mala brodica, prijevoz, lokalno graditeljstvo, konstrukcijske proporcije*

TRACES OF COMMERCIAL UNCLASSIFIED WATERWAY OF THE SANA RIVER

Tragovi trgovačkoga neklasificiranog vodnog puta rijeke Sane

Emir Trožić, Edin Smajić

SUMMARY

The study was conducted on 112 kilometres of watercourses, unclassified waterway (50 kilometres) of the Una River from the Croatian Dubica to Bosanski Novi and (62 kilometres) from the estuary of the Sana River into the Una River.

The study analyses the route of the waterway of the Sana River 100 years after the termination of river navigation.

The survey tracks commercial waterways on the Una and Sana (right tributaries of the Sava in Bosnia), leading us to the names of some small destinations such as "Popov brod" (Priest's Ship), "Delića brod" (Delić's Ship) and the name of "splavište" (Raft). Photographs and postcards which were created 100 years ago document the use of the route of the river as a commercial waterway.

*From galleys which were taken downstream by the river current while upstream dragged by strong galley-slaves, the first modern small wooden boats without decks were built before 1871, called Trading Flatboats (*dereglija*) and used for the transport down the Sana River. These boats are flat-bottomed while the bow and stern are slanted. Their load capacity is 60 tons and the length up to 20 m, the width up to 4.5 m, draught up to 1 m and without their own propulsion and upstream hauling or pulling.*

What is particularly interesting is the configuration of the terrain and landscapes along the route, also extremely clean river. With regard to the obligation of preserving the natural heritage of this ecological area, it is necessary to emphasise the need to protect the cultural property of the "commercial waterway of the Sana River" with the affirmation of all its tourism potential, that can be recognised here.

Keywords: *waterway, Trading Flatboat, capacity, launching, draught*

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SAŽETAK

Istraživanje je provedeno na 112 kilometara vodotoka, neklasificiranoga plovnog puta (50 kilometara) rijeke Une od Hrvatske Dubice do Bosanskog Novog i (62 kilometra) rijeke Sane od ušća u rijeku Unu.
U radu je analizirana trasa vodnog puta rijeke Sane nakon stotinu godina od prestanka plovidbe.
Istraživanje tragova trgovačkih vodnih putova na rijeci Uni i Sani (desnim pritokama Save u Bosni) dovode nas do naziva malih destinacija kao što su Popov brod, Delića brod te naziva „splavište". Fotografije i razglednice koje su nastale prije stotinu godina dokumentiraju korištenje trasa rijeka kao trgovačkih vodnih putova.
Od galija koje je nizvodno nosila riječna struja, a uzvodno vukli snažni galijoti, prva moderna, manja drvena plovila bez palube – dereglije – izgrađena su prije 1871. za potrebe transporta niz rijeku Sanu. To su plovila s ravnim dnom i zakošenim pramcem i krmom, nosivosti do 60 tona, duljine do 20 m, širine do 4,5 m, gaza do 1 m i bez vlastita pogona pa su se uzvodno teglila ili vukla.
Posebno je zanimljiva konfiguracija terena i pejzaži kojima prolazi trasa iznimno čiste rijeke. S obzirom na obvezu očuvanja prirodnog nasljeđa ovog ekološkog revira, nužno je istaknuti potrebu zaštite kulturnog dobra „trgovački vodni put rijeke Sane", s afirmacijom svih turističkih potencijala koji se tu mogu prepoznati.

Ključne riječi: *vodni put, dereglija, nosivost, porinuće, gaz*

FRANZ I SILVIUS MORIN – ČASNICI CARSKE I KRALJEVSKE RATNE MORNARICE

Franz and Silvius Morin, Austro-Hungarian Navy officers

Josip Vretenar*

SAŽETAK

U C. i kr. ratnoj mornarici bilo je više vrlo uspješne braće, ali su Franz i Silvius Morin jedni od rijetkih čiju se karijeru može povezati s torpedom.
Kraj Prvoga svjetskog rata Franz Morin dočekuje u zvanju kapetana fregate, zapovjednika II. flotile torpiljarki. Kao član "ratnoga štaba flote", jedan je od predstavnika C. i kr. ratne mornarice pri predaji flote Hrvatskome narodnom vijeću 31. listopada 1918.
Za razliku od svoga starijeg brata, Silvius Morin krenuo je sasvim drugim putem. Posvetio se tehničkim znanostima da bi završetkom školovanja pristupio ratnoj mornarici u struci brodograđevnog inženjera.
Prvi svjetski rat proveo je u Mornaričkom odjelu Ministarstva rata u Beču u zvanju Schifbau Ober ing 1. klase *(glavni brodograđevni inženjer 1. klase). Konstruirao je prototip torpednog čamca.*

Ključne riječi: *torpiljarka, brod, Pula, torpedni čamac, ratna mornarica*

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1. UVOD

Iz Malog Lošinja, tradicionalnog središta pomoraca sjevernoga Jadrana, dolaze i braća Morin koji su svoju karijeru ostvarili u C. i kr. ratnoj mornarici.

Još 1810. spominje se kapetan trgovačkog broda Giovanni Morin koji se u svibnju 1810., zajedno s kapetanom Matteom Vidulichem, nalazi na Malti. Pomorsku tradiciju nastavlja njegov sin Giovanni Ernesto, otac Francesca i Silviusa (Silvio).

Tradicija se prenosi na sinove, ali s malo drukčijom karijerom. Franz plovi morima na ratnim brodovima C. i kr. mornarice, a Silvius se posvećuje njihovoj izgradnji.

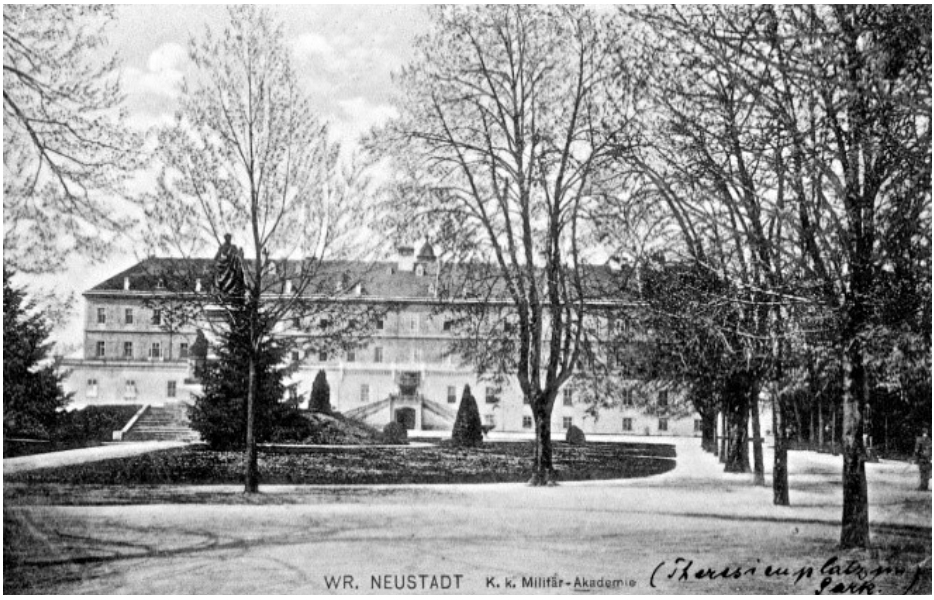


■ **Slika 1.** *Obitelj Morin:*
otac Giovani Ernesto (1842. – 1913.), majka Silvia Teomilla Stuparich (1848. – 1928.),
sinovi Silvio (1877. – 1928.) i Francesco (1874. – 1946.) te kći Maria (1875. – 1945.),
digitalna kolekcija autora

2. FRANZ I SILVIUS MORIN

2.1. Franz Morin

Rođen je 1874. godine. Osnovnu školu (*Scuola elementare*) započinje 1879., a 1884. upisuje Vojnu školu u Bečkome Novom Mjestu (*Scuola militare di Wiener Neustadt*). Nakon završetka i određenog vremena provedenog u pješaštvu, odlučuje se karijeru nastaviti u C. i kr. ratnoj mornarici.



Slika 2. *Vojna škola u Bečkome Novom Mjestu (*Wiener Neustadt, Militär- unterrealschulen*), digitalna kolekcija autora*

Prema propisima za to je morao ispunjavati opće uvjete – biti primljen kao kandidat-pripravnik (*eleven*) i uspješno završiti predviđenu obuku. Nakon završene obuke postaje kadet, kao i časnici koji su završili pomorsku akademiju. Godine 1891. na obuku je primljeno trideset pripravnika. Za usporedbu, iste je godine četvrtu godinu Pomorske akademije u Rijeci polazilo jednako toliko studenata.

- Od 1. listopada 1891. u službi kao pripravnik (*Seeaspiranten*)[1], 14. listopada 1891. započinje pripravnički kurs (*Seeaspiranten kurs*)[2] na SMS *Novara* stacioniranoj u Puli. Godine 1892. – 1893. na školskom putovanju do istočne Azije na SMS *Kaiserin Elisabeth* **(8. prosinca 1892. polazak iz Pule, povratak 19. prosinca 1893. u Pulu)**.
- 6. veljače 1893. – pomorski kadet (*See- Cadeten*)[3]
- 1. svibnja1897. – kadet (*Linienschiffs- Fährinche*)[4]
- 1. svibnja 1904. – poručnik bojnog broda 2. klase (*Linienschiffs- leutnant* 2. klase)[5]
- 1900. – 1901. na instrukcijskom putovanju do istočne Azije na torpiljarki SMS *Leopard* **(1. listopada 1900. polazak iz Pule, povratak 1. listopada 1901. u Pulu)**.
- 1905. (1. svibnja) ima završen *Offiziers torpedokurs*[6], a od 1. listopada 1907. do 15. travnja 1908. polazi artiljerijski tečaj za časnike (*Offiziers artillerie-kurs*)[7]
- 1907. – poručnik bojnog broda 1. klase (*Linienschiffs- leutnant* 1. klase)[8]
- od 14. prosinca 1908. zapovijeda torpiljarkom SMS *Boa*[9] u sastavu I. eskadre[10]. Opredijelio se za službu na torpednim brodovima. Stacioniran u svim centrima torpiljarki: Pula, Trst, Lošinj, Šibenik, Zadar, Kotor...
- 1909. unaprijeđen u poručnika bojnog broda (*Linienschiffsleutnant*)[11] prema novim zvanjima.

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1 *Almanach für die K und K Kriegsmarine*, 1892., str. 345.
Almanach für die K und K Kriegsmarine, 1893., str. 347.

2 *Jahrebericht pro 1891.* na str. 24. navodi podatak da je 10. rujna u Pomorskoj akademiji u Rijeci obavljen odabir kandidata-pripravnika za prijam u C. i kr. mornaricu. Prijavilo se 47 kandidata. Njih jedanaest nije ispinjavalo uvjete, četvorica nisu prošla liječnički pregled, a dvojica su kandidata odustala. Primljena su 22 pripravnika (*Aspiranten*) sa završenom civilnom školom i osam pripravnika sa završenom Vojnom nižom realnom školom (*Militär-unterrealschulen*). Među tih osmero bio je i Franz Morin.
Jahrebericht pro 1891. na str. 27. navodi podatak da je 14. listopada počeo tečaj za 16 pripravnika (aspiranata) koji su se kandidirali za aktivnu službu u C.i k. mornarici.

3 *Almanach für die K und K Kriegsmarine,*1897., str. 436.

4 *Almanach für die K und K Kriegsmarine,*1898., str. 455.

5 *Almanach für die K und K Kriegsmarine,*1905., str.585.

6 *Rangliste der K.U.K. Kriegsmarine,*1905., str. 13.

7 *Rang- und einteilungsliste der K.U.K. Kriegsmarine,*1907., str. 177.

8 *Rang- und einteilungsliste der K.U.K. Kriegsmarine,*1907., str.16. Uvršten je na popis *Linienschiffs-leutnant* 1. klase, ali očito nije ažuriran datum kada dobiva to zvanje. Rang-liste donose stanje od 6. rujna 1907. pa je u zvanje *Linienschiffs- leutnant* 1. klase unaprijeđen iste godine prije toga datuma.

9 *Rang- und einteilungsliste der K.U.K. Kriegsmarine,* 1909., str. 168.

10 *Einteilungsliste der K.U.K. Kriegsmarine,*1909., str. 168.

11 *Almanach für die K und K Kriegsmarine*, 1910., str. 578. Od 1909. na snazi su nova zvanja: *Linienschiffs- leutnant* 1. klase i *Linienschiffs- leutnant* 2. klase mijenjaju se u *Linienschiffs- leutnant* i *Fregaten- leutnant*.





■ **Slika 3.** *Posada torpiljarke* SMS Boa *(Franz na slici prvi zdesna), torpiljarka* SMS Boa *(lijevo), digitalna kolekcija autora*



■ **Slika 4.** *Braća Franz (lijevo) i Silvius (desno) fotografirani u Puli u starim mornaričkim odorama (prije 1907.), digitalna kolekcija autora*

2.2. Silvio – Silvius Morin (ing. brodogradnje)

Za prijam u ratnu mornaricu na mjesto jednogodišnjega dobrovoljca kandidat treba zadovoljiti ove uvjete: završena odgovarajuća visoka tehnička škola, državljanin Austro-Ugarske, poznavanje njemačkog jezika, liječnička svjedožba i ne smije biti stariji od 24 godine[12]. Nakon odrađenog staža u trajanju od jedne godine na odgovarajućem radnome mjestu, kandidati koji su zadovoljili, uvršteni su u pričuvni sastav C. i kr. mornarice, iz kojih se redova prema potrebi primalo u redovnu službu. Silvius Morin proveo je godinu dana u pričuvnom sastavu C. i kr. ratne mornarice.



Slika 5. *Silvius Morin, brodograđevni inženjer 2. klase (1. svibnja 1903. – 1. svibnja 1905.), digitalna kolekcija autora*

- U ratnu mornaricu stupa 1. listopada 1899. kao pripravnik, brodograđevni inženjer 3. klase (*provisorische schiffbau ing. 3. clase*)[13], u brodograđevnoj direkciji pomorskog arsenala u Puli gdje su započinjali svi brodograđevni inženjeri.
- 1. ožujka 1901. primljen u redovnu službu kao brodograđevni inženjer 3. klase (*schiffbau ing.* 3. klase)[14]
- 1. svibnja1903. – brodograđevni inženjer 2. klase (*schifbau ing. 2. klase*)[15]
- 1. svibnja 1905. – brodograđevni inženjer 1. klase (*schifbau ing. 1. klase*)[16]

[12] *Statut für das technische Wesen S.M. Kriegs-Marine,* prema članku 8.

[13] *Almanach für die K und K Kriegsmarine,*1901., str. 524.

[14] *Almanach für die K und K Kriegsmarine,*1903., str. 541.

[15] *Almanach für die K und K Kriegsmarine,*1905., str. 600.

[16] *Almanach für die K und K Kriegsmarine,*1906., str. 614.

2.2.1. *C. i kr. Pomorski arsenal (K.u.k. Marine Seearsenal)*

- ZAPOVJEDNIŠTVO ARSENALA (*SEEARSENALS KOMMANDO*)
- BRODOGRAĐEVNA DIREKCIJA (*SCHIFFBAU DIREKTION*)
- STROJARSKA DIREKCIJA *(MASCHINENBAU DIREKTION)*
- ARTILJERIJSKA DIREKCIJA *(ARTILLERIE DIREKTION)*
- ELEKTRODIREKCIJA *(ELEKTRO DIREKTION)*
- DIREKCIJA TORPILJARKI (*TORPEDO BOOTS DIREKTION)*
- DIREKCIJA OPREMANJA *(AUSRÜSTUNGS DIREKTION)*
- DIREKCIJA OPREME BRODA *(TAKEL DIREKTION)*
- KOMISIJA ARSENALA *(ARSENALS KOMMISION)*
- UPRAVLJANJE GRADNJE *(BAULEITUNGEN)*
  - Lansirna stanica torpeda *(Torpedolanzierstation)*
  - Kemijski laboratorij *(Chemischen Laboratorium)*
  - Odjel za municiju *(Marinem Unitions Etablissement)*
  - Centralno skladište *(Hauptmagazin)*
  - Škola za naučnike i radnike Arsenala *(Arsenals-Lehrlings- und Arbeiterschule)*
  - 27. srpnja 1905. premješten u Mornaričko-tehnički komitet[17] u Puli (u MTK-u su radili samo posebno istaknuti pojedinci)

2.2.2. *C. i kr. Mornaričko-tehnički odbor (K.u.k. Marine-technische Comité)*

C. i kr. Mornaričko-tehnički odbor *(K.u.k. Marine-technische Comité)*

ODJEL *(Abteilung)*	
I	Brodogradnja (*Schiffbau*)
II	Strojarstvo (*Maschinenwesen*)
III grupa A	Artiljerija (*Artillerie*)
III grupa B	Artiljerija (*Artillerie*)
IV	Torpedo (*Torpedowesen)*
V	Mine (*Seminenwesen)*
VI	Tehnologija i elektrotehnika (*Tehnologie und Elekrotechnik*)
VII	Hidrografija i navigacija (*Hydrographie und Navigation*)
VIII	Mornarička biblioteka (*Marine-Bibliothek)*

[17] *Rang- und einteilungsliste der K.U.K. Kriegsmarine,* 1907., str. 139.

- 12. listopada 1908. premješten u *Danubiuswerfte* u Rijeci kao nadzorni inženjer.[18] Naime, tvrtka je za C. i kr. ratnu mornaricu gradila torpedne brodove i torpeda.
- 9. kolovoza 1910. premješten u Beč, Ratno ministarstvo, Mornarički sektor (*Kriegsministerium Marinesektion*), u Odjel brodogradnje[19]. Na tome mjestu ostaje do kraja rata. Treba spomenuti da se u ratno ministarstvo raspoređuje samo odabrano osoblje.
- 1. studenoga 1910. – brodograđevni glavni inženjer 3. klase (*schifbau Ober ing.* 3. klase)[20]
- 1. siječnja 1914. – brodograđevni glavni inženjer 2. klase (*Schifbau Ober ing.* 2. klase)[21]
- 1. kolovoza 1917. brodograđevni glavni ing. 1. klase (*Schifbau Ober ing.* 1. klase)[22]



Slika 6. *Silvius Morin, brodograđevni glavni inženjer 1. klase (1917. – 1918.), digitalna kolekcija autora*

[18] *Rang- und einteilungsliste der K.U.K. Kriegsmarine,* 1909., str. 151.

[19] *Rang- und einteilungsliste der K.U.K. Kriegsmarine*, 1911., str. 140.

[20] *Almanach für die K und K Kriegsmarine,* 1912., str. 666.

[21] *Almanach für die K und K Kriegsmarine,*1915., str. 633.

[22] *Almanach für die K und K Kriegsmarine,* 1918., str. 547.

2.2.3. *Ministarstvo rata, sektor Mornarice u Beču (Kriegsministerium, Marinesektion in Wien)*

I. RADNA GRUPA: PERSONALNI POSLOVI

1/

2/

3/

II. RADNA GRUPA: TEHNIČKO-ADMINISTRATIVNI POSLOVI

4 / S Brodogradnja

4 / M Strojogradnja

4 / A Artiljerija

4 / E Elektro

5 / LW Gradnja na zemlji i vodi

6 / Administracija

7 ODJEL

8 ODJEL

S. Morin jedini se bavio teorijskim dizajnom brodova pa izdvajamo dva njegova projekta.

a) Projekt *Rapidkreuzer*

Istisnina: 4960 t, dužina: 151,2 m, širina: 13,8 m, gaz: 4,82 m

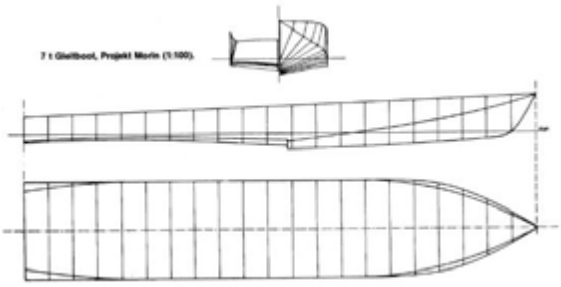
Pogon: 2X AEG 41000 KS Elise: 2X brzina: 30,2 milja, posada: 400

14. travnja 1914. komisija ocjenjuje projekte:

1. Schiffbau – Obering. 2. kl. Johann Fiala
2. Schiffbau – Obering. 3. kl. Silvius Morin

(projekt nije realiziran)

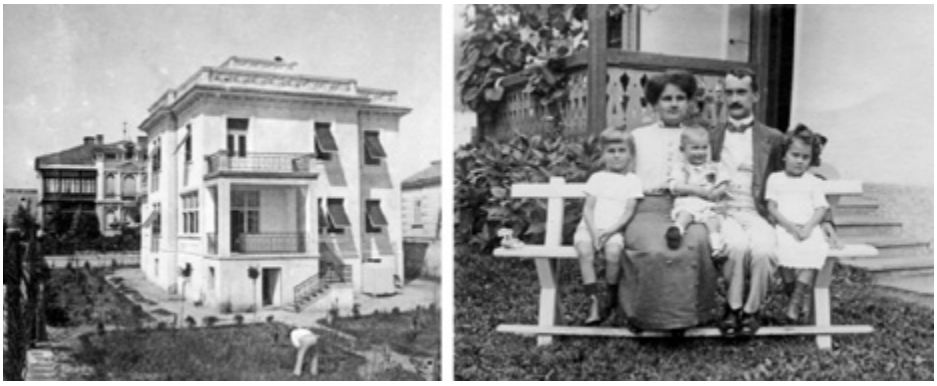
b) Torpedno-motorni čamac *Morin*



Slika 7. *Projekt završen 1917., istisnina: 7 t, dužina: 15,57 m, širina:3 m, brzina: 35 milja, pogon: 2 X Austro - Daimler 350 KS, realizacija: kolovoz 1918., 2X Fritz Eppel, Beč, 2X Danubius & Co., Budimpešta, digilana kolekcija autora*

Krajem rata zauzima rang 4. od 4 u zvanju, odnosno 5. u ukupnom poretku brodograđevnih inženjera. Dosegnuti rang 6 od 7 mogućih (7. rang ima samo jedna osoba).

2.3. Franz Morin *(nastavak)*



Slika 8. *Obitelj Franza Morina od 1910. živi u novosagrađenoj vili Morin, Via della milizia 21, današnja Ulica Pine Budićina 21(lijevo). U krugu obitelji: Franz, supruga Elly Fischer i djeca: Freddy, Hildegarde i Otto (desno), digitalna kolekcija autora*

- 15. rujna 1910. – Pomorski arsenal, Direkcija opremanja (*Konstruktors arsenal, ausrüstungs direkcija*)[23]
- 1. svibnja 1913. – kapetan korvete (*Korvetten- kapitän*)[24]

Mornarica je prije Prvoga svjetskog rata nabavila četiri moderna bojna broda koji su sačinjavali 1. diviziju.

	SMS *Viribus Unitis*[25]	SMS *Tegetthoff*[26]	SMS *Prinz Eugen*[27]	SMS *Szent István*[28]
u službi	5. 12. 1912. – 1. 11. 1918.	14. 7. 1913. – 1924.	8. 7. 1914. – 1922.	13. 12. 1915. – 10. 6. 1918.
glavni topovi L/45	12 x 305 mm	12 x 305 mm	12 x 305 mm	12 x 305 mm
časnici (stab + unter) – posada	(37+16) – 993	(37+16) – 993	(37+16) – 993	38 – 1056

[23] *Rang- und einteilungsliste der K.U.K. Kriegsmarine,*1911., str. 154.

[24] *Almanach für die K und K Kriegsmarine,*1914., str. 609.

[25] W. Aichelburg, *Register der k.(u.)k. Kriegsschiffe,* str. 523.

[26] Isto, str. 427.

[27] Isto, str. 362.

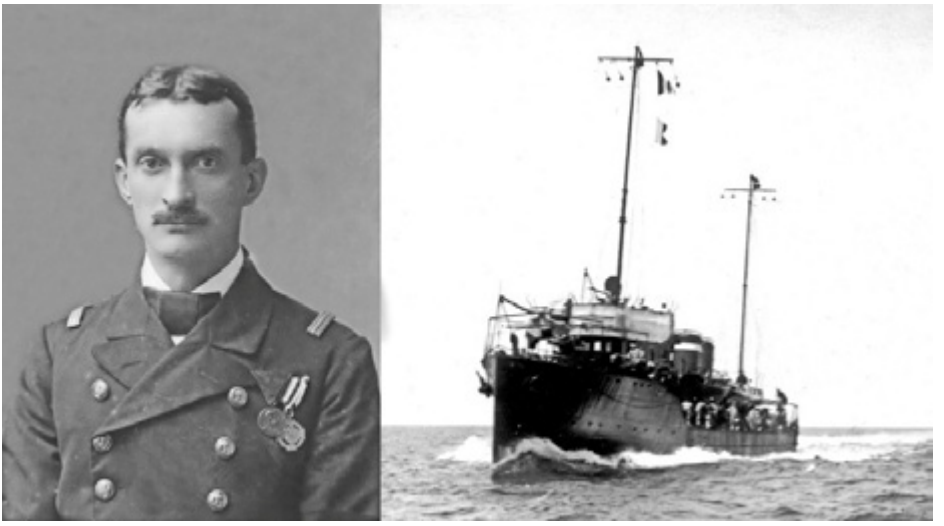
[28] Isto, str. 388.

Za nove brodove trebalo je osposobiti najkvalitetniji kadar (37 časnika, 16 podčasnika i oko 1000 mornara) za svaki brod.

- 20. lipnja 1913. – SMS *Radetzky,* na mjestu 2. časnika, odmah do zapovjednika broda.

Morin je dobio priliku, unaprijeđen je u kapetana korvete i postavljen za prvog časnika na brod SMS *Radetzky*[29], tada drugi brod u floti, odmah iza SMS *Viribus Unitisa* u sastavu 1. divizije (SMS *Radetzky* u floti od 15. siječnja 1911., istisnine 14.500 tona, s 4 topa kalibra 305 mm, posada 30 časnika + 860 mornara).

Mjesto prvog čanika modernoga bojnog broda SMS *Radetzky* najveći je dotadašnji doseg u karijeri Franza Morina.



Slika 9. *Franz Morin, zapovjednik na torpiljarki SMS* Balaton *(sagrađena u* Danubiusu *u Rijeci, 1911. – 1913., dužine 83,5 m, istisnine 1050 tona, dva turbinska motora od 20560 KS, posada 5 časnika i 100 mornara u službi od 1. kolovoza 1914.), digitalna kolekcija autora*

Zbog nekih razloga ne samo da nije uvršten u posade novih bojnih brodova već nije zadržao ni mjesto prvog časnika na SMS *Radetzky.* Postavljen je za zapovjednika SMS *Erzherzog Fridrich,* istisnine 10.600 tona, sagrađenog deset godina prije i već zastarjelog (topovi kalibra 204 mm), a s njega prebačen na torpedne brodove. U lipnju 1915. zapovjednik je na SMS *Reka,* a od 29. prosinca 1915**.** zapovjednik na SMS *Balaton.* Sudjeluje u više akcija na Otrantu, ali najvažniji je sukob **14. i 15. svibnja** 1917. kada SMS *Csepel* **i** *Balaton* **uspješno napadaju neprijateljski konvoj. Nakon dolaska pojačanja neprijateljskom konvoju,** *Csepel* **i** *Balaton* **su se, uza stalnu izmjenu topničke vatre i prilična oštećenja, uspjeli skloniti u Kotor.**

[29] *Entailungs liste -Kuk Kriegsmarine,* 1913., str. 56.

- Dana 1. kolovoza 1917. unaprijeđen u čin kapetana fregate[30], postavljen za zapovjednika 2. flotile torpiljarki, čime ujedno postaje i članom ratnog štaba flote.

Godine 1918. po rangu je 17. u klasi, ukupno u mornarici je negdje oko 80. mjesta, s pet postignutih zvanja od deset mogućih (u floti pet od šest). Treba uzeti u obzir da su časnici u floti bili relativno slabo rangirani, osobito u ratu, pa je npr. Podkpelski tada zapovjednik zastavnog broda SMS *Viribus Unitis* imao zvanje kapetana bojnog broda, znači svega jedan stupanj iznad Morina.

- Završetkom rata, umirovljen, preveden u pričuvni sastav u zvanju kapetana bojnog broda.



Tieferschüttert gibt die Familie die schmerzliche Nachricht vom Hinscheiden des

Linienschiffskapitäns d. R.

FRANZ MORIN

Inhaber des Leopoldordens, des Eisernen Kreuzes u. anderer Auszeichnungen

im Alter von 72 Jahren.

Sein Leben war nur Pflichterfüllung und äußerste Güte.

Die Beerdigung findet Mittwoch, den 28. August, um 4.40 Uhr statt.

Grün-Bozen, den 26. August 1941 - Via A. Diaz 8

■ **Slika 10.** *Osmrtnica, obavijest o smrti Franza Morina, digitalna kolekcija autora*

2.4. Primopredaja flote[31]

Predstavnici ratne mornarice (K. und K. Kriegsmarine)

K.A. Mikols Horthy de Nagybánya, zapovjednik flote

Kap. b.b. Adolfo Schmidt, komandant I. divizije

Kap. b.b. Commodoro Franz Lauffer, komandant II. divizije

Kap. b.b. Emilio Konek von Norwall, šef Štaba mornarice

Kap. fre. Franz Morin, komandant II. flotile torpiljarki

Predstavnici Narodnog vijeća

Iz Zagreba: Dr. Ante Tresić Pavičić, Vilim Bukšeg, dr. Ivan Maria Čok.

Iz Pule: Lacko Križ, dr. Lovro Škaljer, dr. Mirko Vratović, dr. Mario Krmpotić, kap. fre. Metod Koch.

[30] *Almanach für die K und K Kriegsmarine,* 1918., str. 519.

[31] M. Balota, *Puna je Pula,* Izdavački zavod Jugoslovenske akademije Zagreb, Zagreb,1960.str. 305.

Zapisnik o primopredaji ratne flote potpisan je na admiralskom brodu *Viribus Unitis* 31. listopada 1918. u 11 sati. Sam čin primopredaje završen je istoga dana u 16.45 spuštanjem austrougarske zastave i podizanjem zastave Hrvatskoga narodnog vijeća[32]. Flotu je predao kontraadmiral Mikols Horthy de Nagybánya predstavniku Narodnog vijeća, zapovjedniku flote, kap. bojnog broda Janku Vukoviću Podkapelskom.

2.5. Rang u C. i kr. mornarici

Rang	**POMORSKI ČASNICI** *(Seeoffiziere)* – Franz Morin	**ING. C. I KR. MORNARICE** *(Marineingenirur)* – Silvius Morin
	ZASTAVNI ČASNICI (*FLAGGENOFFIZIERE*)	
II.	Veliki admiral *(Grossadmiral)*	
III.	Admiral *(Admiral)*	
IV.	Viceadmiral *(Vizeadmiral)*	
V.	Kontraadmiral *(Kontra admiral)*	General-ing. *(Generalingenirur)*
	ŠTABNI ČASNICI *(STABSOFFIZIERE)*	
VI.	Kapetan bojnog broda *(Linienschiffs- kapitän)*	Vrhovni (*ObersterIng.)* **Glavni (*Obering.*) 1. kl.**
VII.	**Kapetan fregate *(Fregaten- kapitän)***	Glavni (*Obering.*) 2. kl.
VIII.	Kapetan korvete *(Korvetten- kapitän)*	Glavni (*Obering.*) 3. kl.
	VIŠI ČASNICI *(OBEROFFIZIERE)*	
IX.	Poručnik b.b. *(Linienschiffs- leutnant) (1909. Linienschiffs- leutnant I. clase)*	Ing. 1. kl.
X	Poručnik fre. *(Fregaten- leutnant) (1909. Linienschiffs- leutnant II. clase)*	Ing. 2. kl.
XI.	Pomorski kadet *(Fähnriche)*	Ing. 3. kl. Tehnički crtač (*Konstruktionszeichner*)
XII.	Pomorski kadet (*Seekadett),* Kandidat *(Seeaspiranten)*	Pripravnik (*Eleven*) Dobrovoljac (*Freiwillige*)

Završetkom rata glavni ing. (*Obering*) 1. kl. Silvius Morin bio je bolje rangiran od brata Franza, kapetana fregate *(Fregaten- kapitän).* Umirovljenjem i unapređenjem Franza Morina u zvanje kapetana bojnog broda *(Linienschiffs-kapitän),* braća su se našla u istom, šestom rangu.

[32] M. Balota, *Puna je Pula,* Izdavački zavod Jugoslovenske akademije Zagreb, Zagreb,1960., str. 306. i 307. Na *Viribus Unitisu* na dva su glavna jarbola podignute zastave crvene boje.

2.6. Prilozi

2.6.1. Flota 1918 (pojednostavnjen prikaz)

I.) I. divizija

II.) II. divizija

III.) III. divizija

a) flotila krstarica

b) 1. flotila torpiljarki

c) 2. flotila torpiljarki, komandant fre. kap. Morin Franz

IV.) "Pomoćni brodovi"

- Podmornička flotila
- Mornaričko zrakoplovstvo

Flotila torpiljarki

SMS *Admiral Spaun* – zapovjedni brod (*kap. fre.* Franz Morin)

SMS *Dinara* (*kap. kor.* Heinrich Pauer)

SMS *Reka* (*kap. kor.* Walter edel von Hayek)

SMS *Pandur* (*kap. kor.* Ernst Sauter)

SMS *Csikós* (*kap. kor.* Cozimus conte de Medici)

SMS *Scharfschütze* (*kap. kor.* Severin Brettner)

SMS *Velebit* (*kap. kor.* Moriz von Becker)

SMS *Turul* (*kap. kor.* Theodor Braun)

SMS *Uskokekap. kor.* Konstantin Zemplén)

SMS *Ulan* (*kap. kor*. Stanislaus Witkowki)

SMS *Huszár* (*kap. kor.* Oskar Dolezál)

SMS *Warasdiner* (*kap. kor.* Friedrich von Wimmer)

T 72 (*poručnik b.b.* Alexander Pitamić)

T 69 (*poručnik b.b.* Werner ritter von Stockert)

T 70 (*poručnik b.b.* Rafael von Hofmann)

T 55 (*poručnik b.b.* Franz Nejebsy)

T 68 (*poručnik b.b.* Franz Wallnoefer)

T 64 (*poručnik b.b.* Karl Meynier)

T 57 (*poručnik b.b.* Franz Dyrna)

T 60 (*poručnik b.b.* Moritz Vechiatto)

T 58 (*poručnik b.b.* Georg Jakčin)

T 62 (*poručnik b.b.* Gastone von Albert)

T 59 (*poručnik b.b.* August Kuster)
T 63 (*poručnik b.b.* Albert Huber)
T 52 (*poručnik b.b.* Heinrich Groll)
T 66 (*poručnik b.b.* Alfred Lerch)
T 65 (*poručnik b.b.* Otto Stoker)
T 61 (*poručnik b.b.* Maximus Ivancich)
T 71 (*poručnik b.b.* Rudolf Schlacht)
T 67 (*poručnik b.b.* Alberto von Attems)

2.6.2. Zapovjednici ratne mornarice

Zapovjednici ratne mornarice

- Admiral Maximilian Daublebsky von Sterneck (studeni 1883. – prosinac 1897.)
- Admiral Herman von Spaun (prosinac 1897. – listopad 1904.)
- Admiral Graf Rudolf Montecuccoli (listopad 1904. – veljača 1913.)
- Veliki admiral Antun Haus (veljača 1913. – veljača1917.)

Šef Mornaričkog sektora Ministarstva rata

- Viceadmiral Karl Kailer von Kaltenfels (veljača 1917. – travanj 1917.)
- Admiral Maximilian Njegovan (travanj 1917. – veljača 1918.)

Zapovjednik flote

- Viceadmiral Miklós Horthy (veljača 1918. – studeni1918.)

Šef Mornaričkog sektora Ministarstva rata

- Viceadmiral Franz von Holub (veljača 1918. – studeni 1918.)

3. ZAKLJUČAK

Analizirajući karijere braće Morin dolazi se do zaključka da su u C. i kr. ratnoj mornarici bili natprosječno uspješni.

Brodograđevni ing. Silvius Morin istaknuo se već na početku karijere kao iznimno nadaren u struci i za kratko vrijeme popeo se na sam vrh u struci te brzo napredovao u zvanju.

Pomorski časnik Franz Morin, za razliku od brata, imao je puno teži i sporiji put u karijeri. U pomorskoj je struci karijera za većinu bila unaprijed zacrtana i samo su pojedinci imali sreću posebno se istaknuti i ubrzati unapređenja. Franz Morin istaknuo se tijekom rata i ratnih sukoba s neprijateljskim brodovima pa je 1917. uvršten među najelitnije časnike C. i kr. mornarice unapređenjem u kapetana fregate, imenovan je zapovjednikom 2. flotile torpiljarki te uvršten u Ratni štab flote.

Braću Morin treba tretirati kao iznimno uspješne sinove našeg podneblja (nekadašnja Istra, danas Kvarner) i u skladu s tim trebali bi naći zasluženo mjesto u povijesti istaknutih pomoraca s istočnih obala Jadrana.

Zahvala

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SUMMARY

In the Austro-Hungarian Navy there were a number of brothers with successful careers, however, brothers Franz and Silvius Morin are the rare ones whose careers are connected with the torpedo.
At the end of World War I, Franz Morin is the Commander of the Second Flotilla of torpedo boats. As member of "the fleet war headquarters", he was one of the K.u.K Navy representatives who turned the fleet over to the Croatian National Committee on 31st October 1918.
The younger brother, Silvius Morin, followed another path, devoting himself to technical studies. Once he graduated he joined the navy as naval architect.
He spent World War I in the Navy Department of the War Ministry in Vienna as Schifbau Ober ing 1*, the main naval architect of class 1. He designed a prototype of the torpedo boat.*

Keywords: *torpedo boat, ship, Pula, Navy*

TORPEDNA ŠKOLA CARSKE (I) KRALJEVSKE RATNE MORNARICE

Austro-Hungarian torpedo school

Josip Vretenar*

SAŽETAK

Uvođenjem torpeda u C. kr. ratnu mornaricu 1869., brod See Hund *preuređuje se u torpedni brod.*
Torpedna škola otvara se 10. ožujka 1876. U početku škola djeluje na prvome torpednom brodu See Hund *da bi joj 1878. bio dodijeljen i brod* Velebich. *Godine 1888.* See Hund *briše se iz flotne liste i umjesto njega školi je dodijeljen brod* Alfa *koji je u službi do raspada mornarice, a od 1897. do 1912. i brod* Zara. *Prema potrebi angažiraju se i drugi brodovi, prvenstveno torpiljarke.*
Uređenjem uvale Fisella škola nastavlja s radom u sklopu minersko-torpedno--telegrafske škole u kojoj se održava teoretska nastava, a praktična se nastava održava u Fažanskom kanalu.
Škola se u pravilu održava dva puta godišnje, posebno za stožerne i niže časnike, a posebno za mornare rukovaoce i radnike za održavanje torpeda. Uz školi se prema potrebi organiziraju i razni tečajevi vezani za održavanje i upotrebu.
Važnost torpedne škole pokazuje se u Prvome svjetskom ratu kada osnovnu operativnu snagu C. i kr. ratne mornarice čine flotile torpiljarki i flotila podmornica. Plovilima čije je glavno naoružanje torpedo, zapovijedaju sposobni školovani časnici. U pulskome pomorskom arsenalu održavaju se i ispituju torpeda, izrađuju planovi i grade te održavaju torpiljarke. Sama ratna luka i Fažanski kanal prije početka rata zaštićeni su protutorpednim čeličnim mrežama, a na Malom Brijunu sagrađena je torpedna bitnica.

Ključne riječi*: škola, torpedo, brod, Pula, ratna mornarica*

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1. UVOD[1]

Torpedo kakva danas znamo izumio je 1860. časnik C. kr. ratne mornarice Ivan Blaž Lupis Vukić, nazvavši ga *spasilac obale.* Nakon višegodišnjega neuspješnog pokušaja da ostvari svoj izum, dolazi u vezu s tadašnjim direktorom Riječkoga tehničkog zavoda, engleskim industrijalcem Robertom Whiteheadom.

Dana 14. kolovoza 1864. Luppis, Whitehead i Giovanni de Ciotta potpisuju ugovor o tehničko-financijskoj suradnji. Nakon dvije godine rada uz pomoć tadašnjega šefa radionice Annibalea Ploecha i Whiteheadova sina Johna, 20. prosinca 1866. predstavljen je prvi model Whitehead-Luppisova torpeda. Tog je dana pred C. kr. mornaričkom komisijom izvedeno uspješno lansiranje torpeda iz za to pripremljenog čamca.



■ **Slika 1.** *Prva inačica torpeda, 1867. (Pomorski muzej Split, foto Franjo Zeljak)*

C. kr. ratna mornarica želi uvesti torpedo u upotrebu u ratnoj floti pa ga početkom 1867. dodatno testira pred drugom komisijom, stavljajući za potrebe testiranja na raspolaganje topovnjaču *Gemse* i jahtu *Fantazi.*

Najprije se izvodi bojno testiranje sa za to pripremljenim sandukom kao metom. Rezultat je odagnao svaku sumnju u efikasnost novog oružja.

Niz testiranja s topovnjačom *Gemse,* na kojoj je ugrađena lansirna torpedna cijev, i jahtom *Fantazi,* zaštićenom čeličnim mrežama, kao cilj, dalo je korisne podatke o nedostacima torpeda koji su u hodu otklonjeni, a napravljen je i novi

[1] M. Smokvina, *Ispitivanje torpeda i evolucija riječke torpedne lansirne stanice,* Zbornik *Rijeka i industrijsko graditeljsko nasljeđe,* Pro Torpedo, Rijeka, 2014., str. 315–336.

model. Pred ljeto 1868. komisija nakon ispitivanja donosi zaključak da je torpedo uspješno oružje te ga C. kr. ratna mornarica prva kupuje s namjerom da ga uvrsti u naoružanje ratne flote.

Razvije se suradnja između C. kr. ratne mornarice i proizvođača torpeda, a *See Hund* je određen da bude eksperimentalni brod C. kr. ratne mornarice (1867. – 1870.).

2. TORPEDNA ŠKOLA C. (I) KR. RATNE MORNARICE

Radnje vezane za korištenje torpeda u C. kr. mornarici odvijaju se dalje u sastavu Artiljerijske direkcije C. i kr. arsenala u Puli.[2]

Brod *See Hund* izvučen je na kopno (od 20. studenoga 1869. do 20. srpnja 1870.) kako bi se prilagodio novoj svrsi i bio obavljen opći popravak broda.[3]

- **Artiljerijska direkcija**[4]
  - Direktor: *Oberst L.* Franz Pichl
- **Stalna artiljerijska komisija 1870.**[5]
  - Predsjednik: *Lin. Sch. K.* Daublebsky Freihard v. Sterneck[6]
  - Članovi:
    - *L. Sch. L. 1. Cl.* Moriz Engelrnann
    - *L. Sch. L. 2. Cl.* Emil v. Wohlgemuth
    - *L. Sch. L. 2. Cl.* Allnoch v. Edelstädt, Victor v. Freih
    - *M. Art. Ober-Ing. 1. Cl.* Wilhelmi Wenzel
    - *M. Art. Ing. 1. Cl.* Carl Klöckner
    - *M. Art. Ing. 1. Cl.* Franz Scheid
    - *M. Art. Ing. 1. Cl.* Michael Sikič

[2] Artiljerijska direkcija C. kr. ratne mornarice osnovana je 1870. reorganizacijom mornarice koju je proveo tadašnji zapovjednik viceadmiral Wilhelm v. Tegetthoff.
U sastavu Artiljerijske direkcije djeluje i Stalna artiljerijska komisija. Direkcija je smještena u C. kr. pomorskom arsenalu u Puli.

[3] Jahrbucht der Kais. Kön. Kriegs-Marine, 1871., str. 78.

[4] Kais. Königl. Militär-Schematismus,1871., str. 890.

[5] Kais. Königl. Militär-Schematismus, 1871., str. 891.

[6] Admiral Daublebsky v. Sterneck (1829. – 1897.), komandant zastavnog broda *Ferdinand Maks* u bitci kod Visa, zapovjednik mornarice od 1883. do smrti1897. Pokopan je na Mornaričkom groblju u Puli, a posmrtni ostaci preneseni su u kriptu Mornaričke crkve u Puli, gdje se i danas nalaze.

2.1. Osnivanje osnovnih kadrovsko-tehničkih resursa

C. kr. ratna mornarica odlučuje se na dugoročan program uvođenja torpiljarki u sastav flote. U tu svrhu organizira prvi izvanredni tečaj za časnike koji bi dalje vodili program razvoja torpednih brodova i resursa vezanih za to područje.

- Izvanredni tečaj[7] za časnike, inženjere artiljerije i strojarske majstore organiziran je od 26. srpnja 1870. do 6. rujna 1870. Tečaj je organiziran u sklopu tečaja artiljerije, a uspješno ga je završilo 25 polaznika. Organiziran je na brodovima *Gemse* i *See Hund,* privezanima na otoku Sv. Petar.[8]
- Prvi tečaj za časnike[9] organiziran je u razdoblju od 1. siječnja do kraja ožujka 1872., a nazočilo mu je 12 polaznika.
- Drugi tečaj za 12 polaznika traje od 1. travnja do kraja srpnja 1872.
- *Seeaspiranten*-tečaj organiziran je od 15. studenoga 1871. do sredine travnja 1872.

Na drugom su tečaju kao učitelji radili šest pomorskih časnika, inženjeri artiljerije i strojarstva.

2.1.1. Torpedni odjel[10]

- Odjel je osnovala Stalna artiljerijska komisija odredbom C.K./M.S. Nr. 695 od 28. svibnja 1872.
- Zapovjednik odjela je kapetan broda *See Hund.*
- Odredbom C.K./M.S. Nr. 814 od 27. lipnja 1872. *See Hund* postaje eksperimentalni brod.
- ***Sastav Torpednog odjela***[11] (Torpedo-Abtheilung)
  - *Corv. K.* Weissenbach, Ernst v. Freih (od 31. svibnja 1872.)
  - *Corv. K.* Gustav Brudl (od 30. lipnja 1874.)
  - *L. Sch. F.* Otto Eurian (od 1. travnja 73.)
  - *L. Sch. F.* Friedrich Rupprecht v. Virtsolog (od 1. ožujka 1874.)
  - *Maschb. Ing. 1. Cl.* FerdinandHütner
  - *Mar. Art. Ober - Ing. 3. Cl.* Wilhelm Schwihlik

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7 Jahrbucht der Kais. Kön. Kriegs-Marine, 1871., str. 50.

8 Poluotok na kojem se danas nalazi tvornica cementa.

9 Jahrbucht der Kais. Kön. Kriegs-Marine. 1873., str. 54–55.

10 Jahrbucht der Kais. Kön. Kriegs-Marine, 1873., str. 66.

11 Rangsund Eintheilungs- liste der k. k. Kriegs-marine, 1876. (od 15. svibnja), str. 59.

- ***Testiranje lansiranja torpeda 1872***. s broda *See Hund.*[12]

U prvoj fazi obavljeno je 81 lansiranje i nakon reparature lansirke još sedam lansiranja. Rezultati i zapažanja prosljeđuju se u Rijeku proizvođaču torpeda, a artiljerijska komisija zaključuje da torpedo još nije dovoljno pouzdan za korištenje u ratne svrhe, odnosno da se može koristiti jedino kao pričuvno oružje.

2.1.2. Radionica Torpednog odjela 1873.[13]

Radionica za popravak i održavanje torpeda locira se unutar C. kr. pomorskog arsenala.

Izrađuju se planovi za novu radionicu, kompresor te glavni rezervoar sa spojnim kanalom između pumpe i rezervoara.

U ožujku 1873. nova radionica je u funkciji, ima šest zaposlenih radnika.

2.1.3. Ministarstvo rata – Mornarički sektor (Beč)[14]

Dana 15. rujna 1872. car odobrava novi statut Mornaričkog sektora. Prema Naredbi br. 25. od 28. rujna 1872., od 1. siječnja 1873. vrijedi nova organizacija Mornaričkog sektora. Prema novoj organizaciji (II. grupa – 4. odjel), nadležan za poslove artiljerije postaje nadležan i za pitanja torpeda (*M. Art. Ing. 1. Cl.* Scheid Franz[15]).

2.1.4. Torpiljarke, torpedni brodovi

U razdoblju 1874. – 1882. ukupno je sagrađeno deset torpiljarki.[16]

Prvih šest torpiljarki, T1, T2, T3, T4, T9 i T10, sagrađeno je u Londonu da bi se nakon toga torpiljarke počele graditi u C. kr. pomorskom arsenalu u Puli. Budući da raste potreba za novim torpiljarkama, a i same torpiljarke postaju sve veće, proizvodnja se organizira u *STT* Trstu, Monfalkoneu i *Danubiusu* u Rijeci, a u C. (i) kr. arsenalu u Puli obavlja se njihovo održavanje.

Broj torpednih cijevi povećava se od dvije na prvim torpiljarkama na četiri (Tb 100M), a plovni radijus sa 600 Nm (Tb1) na 1200 Nm (Tb 100M).

Na postojeće ratne brodove montiraju se lansirne torpedne cijevi; tako brodovi klase *Tegetthoff* imaju po četiri podvodne i dvije prijenosne torpedne cijevi.

Razvoj torpiljarki prema nekim osnovnim podacima dan je u tablici 1.[17]

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[12] Jahrbucht der Kais. Kön. Kriegs-Marine 1873., str. 75–76.

[13] Jahrbucht der Kais. Kön. Kriegs-Marine 1874., str. 102.

[14] W. Wagner Die Obersten Behörden der K.und K. Kriegsmarine, str. 73–74.

[15] Kais. Königl. Militär-Schematismus 1874., str. 680.

[16] W. Aichelburg Register der k. (u.) k. Kriegsschiffe, str. 433– 436.

[17] W. Aichelburg Register der k. (u.) k. Kriegsschiffe, str. 433–461.





Slika 2. *Torpiljarka* T1 *sagrađena u Londonu (lijevo), torpiljarka* T6 *sagrađena u pulskom arsenalu (desno). (Aichelburg Wladimir Register der k.(u.)k. Kriegsschiffe, sl. 267, 268.)*

Tablica 1. *Pregled razvoja torpiljarki C. (i) k. ratne mornarice prema osnovnim tehničkim svojstvima*

Oznaka	Mjesto gradnje	Godina	Motor (KS)	Istisnina (t)	Dužina (m)	Posada
T1	London	1875.	184	7,5	20,7	1 + 8
T2	London	1878.	300	28,4	26,5	1 + 9
T3, T4	London	1879.	430	26,9	26,4	1 + 9
T5 - T8	Pula	1882.	430	27,7	30	1 + 9
T9, T10	London	1881.	620	47,5	31,2	2 + 13
T11- T12	Pula	1885.	600	55	34,26	2 + 14
T13-T32	Pula	1883. – 1888	600 –762	55 – 55,8	34,26	2 + 14
T33-T39	Pula	1887. – 1891.	707 –750	70	36,88	2 + 14
Tb1-Tb6	Trst	1909. – 1910	2500	116	44,1	2 + 18
Tb7-Tb12	Rijeka	1910. – 1911.	2400	131	44,2	2 + 18
Tb13-Tb72F	London Rijeka	1899. – 1910.	2000 3000	135 210,7	46,5 56	2 + 20 3 + 22
Tb73F	Rijeka	1910.	3000	203,3	56	3 + 22
Tb74T-Tb81T	Trst	1914.	5700	267	57,84	3 + 38
Tb 82F-97F	Bakar	1916.	6000	267	58,76	3 + 38
Tb 98M-100M	Monfalcone	1916.	6000	256	60,36	3 + 38
Tb100M / T1	–	–	**32,6**	**34,1**	**3**	**4,5**

2.2. Stalna torpedna škola

Dolaskom prvih torpednih brodova pokazala se potreba za organiziranjem stalnih tečajeva za upotrebu i održavanje torpeda, a potom od 1897. i školama za osposobljavanje tehničkoga osoblje za upravljanje torpedima i njihovo održavanje.

Na *Fizelli* u uvali Val. S. Zeno počinje s radom stalna torpedna škola. Na istom lokalitetu djeluje i škola za mine te škola za telegrafiste. Škola je radila neprekidno do kraja Prvoga svjetskog rata.

- **1876. Torpedo-tečaj** (*Torpedo-curs*)[18] na brodu *See Hund*
  - Torpedo-tečaj za časnike (srpanj-kolovoz)
    Tečaj je završilo šest polaznika.
  - Torpedo-tečaj za poslužioce i posadu (22 polaznika). Tečaj su završila:
    – tri instruktora za torpedo
    – šest poslužioca torpeda 1. klase
    – osam poslužioca torpeda 2. klase.

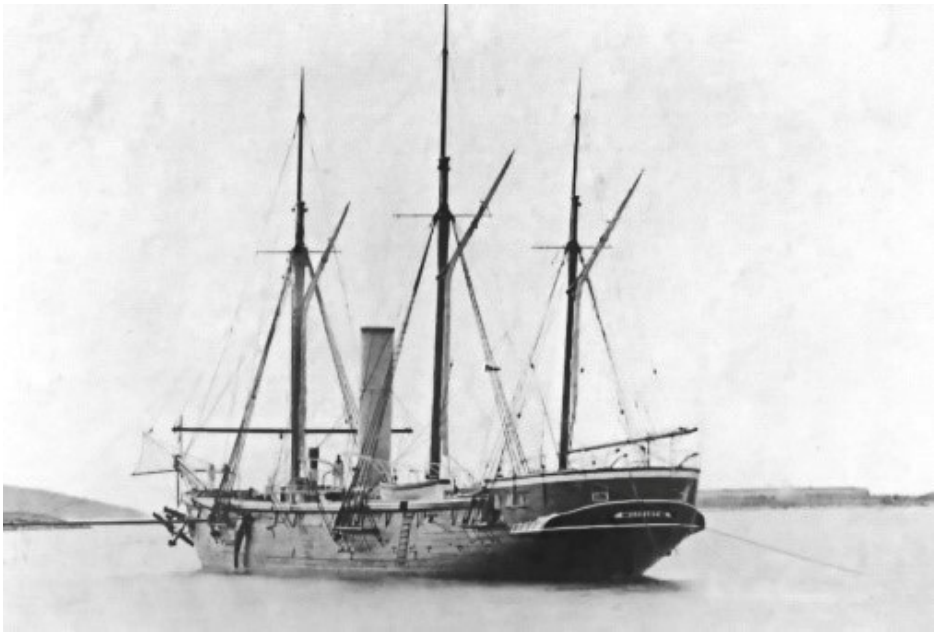
- ***See Hund,* brod Torpedne škole** (*Torpedoschulschiff*) ***1876.***[19], 900 T., 230 Pfk., 2 G.
  L. Sch. L. Carl v. Baritz (od 15. studenoga 1871.)
  Mar. Com. Adjet. 3.Cl. Johann Linhart
  Maschst. 2.CI. Wilhelm Beck (od 31. svibnja 1872.)

- ***Časnici, polaznici tečaja za mine i torpedo*** (*Seeminen- und Torpedo-curs*) ***1876.***[20]
  L. Sch. L. Wladimir Khittel (od 29. svibnja 1875.)
  L. Sch. L. Carl Edl. v. Bermann (od 2. srpnja 1875.)
  L. Sch. F. Franz Ritt. v. Wagenbauer (od 28. studenoga 1873.)
  L. Sch. F. August Roth (od 24. prosinca 1873.)
  Mar. Art. Ing. 1. Cl. Alexander Wilhelmi
    – Obuka se održavala u uvali Fizella – praktično rukovanje i lansiranje.
    – Polaznici tečaja trebali su imati završen artiljerijski tečaj.
    – Održavalo se na brodu *See Hund* u Fažanskom kanalu.
    – Dodatna teorijska nastava organizirana je u Tvornici torpeda u Rijeci.

[18] Jahresbericht der k. k. Kriegs-Marine, 1876., str. 14.

[19] Rangsund Eintheilungs- liste S. M.. Kriegs-marine, 1876. (od 15. svibnja), str. 88.

[20] Rangsund Eintheilungs- liste S. M.. Kriegs-marine, 1876. (od 15. svibnja), str. 59.



Slika 3. SeeHund*, 1876. – 1886. (W. Aichelburg Register der k.(u.)k. Kriegsschiffe, sl. 242.)*

- **1878. Torpedo-tečaj** (*Torpedo-curs*)[21] na brodu *See Hund*
  - Torpedo-tečaj za časnike: (1. travnja – 3. rujna 1878.)
    – završilo 36 od 42 polaznika
  - II. Torpedo-tečaj za poslužioce i posadu (40 polaznika)

  Tečaj su završila:
  – dva majstora za torpedo
  – šest instruktora za torpedo
  – četiri poslužioca torpeda (za Fisch torpedos)
  – četiri radnika za pripremu torpeda (za Fisch torpedos)
  – jedanaest poslužioca torpeda (za Schlepp- Spieren torpedo)
  – devet radnika za pripremu torpeda (za Schlepp- Spieren torpedo)
- ***See Hund*,[22] brod Torpedne škole** (*Torpedoschulschiff*), 900 T, 230 Pfk., 2 G.
  L. Sch. L. Alois Ritt v. Becker (od 26. siječnja 1877.)
  Mar. Com. Adjct. 3. Cl. Johann Bervar
  Maschst. 2. Cl. Johann Grössl (od 28. listopada 1876.)

[21] Jahresbericht der k.und k. Kriegs-Marine, 1878., str. 13–14.

[22] Rangsund Eintheilungs- liste der k. und k. Kriegs-marine, 1878. (od 15. kolovoza), str. 89.

- ***Časnici, polaznici Torpedo-tečaja*** (*Torpedo-curs*) ***1878.***[23]

  L. Sch. L. Josef Reznicek (od 17. siječnja 1877.)

  L. Sch. L. Carl Adamovic (od 29. ožujka 1876.)

  L. Sch. F. August Schweissgut (od 26. siječnja 1877.)

  L. Sch. F. Wenzel Ärleth (od 6. listopada 1875.)

  L. Sch. F. Edmund Hermann (od 19. veljače 1877.)

  L. Sch. F. Guido Couarde (od 19. veljače 1877.)

  L. Sch. F. Max Kutschera (od 9. kolovoza 1876.)

  Maschb. Ing. 3. Cl. Johann Ulm

U sklopu tečaja u lipnju-srpnju obuka se održavala u Tvornici torpeda *Whitehead* Rijeci.

Taktički dio obuke održan je od 1. do 21. kolovoza u Fažanskom kanalu. Dnevno su simulirana tri-četiri napada torpedom.

- **Inspekciju C. kr. mornarice obavilo Njegovo Veličanstvo 1882.**[24]

Popodne (16. rujna 1882.) S. M. torpedni brod Zara *i pet torpednih čamaca izveli su u vanjskoj dijelu pulske luke*[25] *nekoliko manevara napada i obrane, a Hulk* Aretuza *poslužio je kao meta, pogođen torpedom s torpednog čamca u vožnji.*[26] *Veličanstvo se udostojio prisustvovati demonstraciji upotrebe torpeda prateći manevre na parnoj jahti* Fantazia.

2.3. Mornaričko-tehnički odbor (osnovan 1885.)

Zadaća mu je bila istraživanje mogućnosti primjene tehničkih novosti u ratnoj mornarici, priprema raznih tečajeva, izrada tehničkih uputa, planova i nacrta za sva tehnička područja zastupljena u mornarici.[27] Sama organizacija postavljena je kompatibilno s organizacijom C. k. pomorskog arsenala i Mornaričkog sektora Ratnog ministarstva u Beču.

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[23] Rangsund Eintheilungs- liste derk. und k. Kriegs-marine, 1878. (od 15. kolovoza), str. 64.

[24] Jahresbericht der k. k. Kriegs-Marine 1882., str. 34.

[25] Linija koja je dijelila unutarnju od vanjske luke protezala se od otoka Sv. Petra – Sv. Andrija – Sv. Katarina. Dio od te linije do lukobrana smatrao se vanjskom lukom, a područje od linije do otoka Uljanika bila je ratna luka C. kr. ratne mornarice.

[26] W. Aichelburg Register der k. (u.) k. Kriegsschiffe na str. 434. navodi: Lansiranje je obavljeno s Tb V. koji je prvi put u eskadri. Nakon lansiranja Whiteheadova torpeda s udaljenosti od oko 400 m, pri brzini od 15 km, *goelette Aretuza* pogođena je i potonula. Tb V. zapovijedao je *L. Sch*. L. Edmund Herrmann.

[27] Poznati su njihovi priručnici za torpedo – *Torpedo Unterricht* i *Atlas zum Torpedo Unterricht* (dva dijela sa po tri sveska iz 1894. i 1895.).

■ **Tablica 2.** *Organizacija C. kr. mornaričko-tehničkog odbora 1885.*

C. kr. mornaričko-tehnički odbor *(K. k. Marine-technische Comité)*	
ODJEL *(Abteilung)*	
I.	Brodogradnje (*Schiffbau*)
II.	Strojarstvo (*Maschinenwesen*)
III. grupa A	Artiljerija (*Artillerie*)
III. grupa B	Artiljerija (*Artillerie*)
IV.	**Torpedo (*Torpedowesen)***
V.	Mine (*Seminenwesen)*
VI.	Tehnologija i elektrotehnike (*Tehnologie und Elekrotechnik*)
VII.	**Hidrografija i navigacija (*Hydrographie und Navigation*)**

- ***Osoblje Mornaričko-tehničkog odbora 1885.***[28]
  - predsjednik: *Contre-Admiral* Pitner, Maximilian Freih v. / *vitez plemeniti* (od 1. kolovoza 1885.)
  - zamjenici predsjednika:

    Freg. K. Cassini, Oskar Conte / *grof* (od 28. srpnja 1885.)

    L. Sch. L. Adolf Lorber, direktor ureda (29. srpnja 1885.)

    L. Sch. F. Csesznák v. Cserszegi-Gárda Ludwig, službenik ureda (od 3. kolovoza 1885.)

- ***4. Odjel*** (Abtheilung). Osoblje:
  - *Freg. C.* Julius Heinz (od 28. srpnja 1885.)
  - *Corv. C.* Se. k. k. Hoheit Erzherzogl / *NJ. V., Nadvojvoda* Karl Stefan (od 24. kolovoza 1885.)
  - *L. Sch. L.* Josef Bayer (od 29. srpnja 1885.)
  - *Maschb.- u. Betriebs-Ing. 2. CI.* Moriz Rammetsteiner (od 29. srpnja 1885.)
  - *Mar. Art. Ing. 3. CI.* Anton Hermann (od 29. srpnja 1885.)

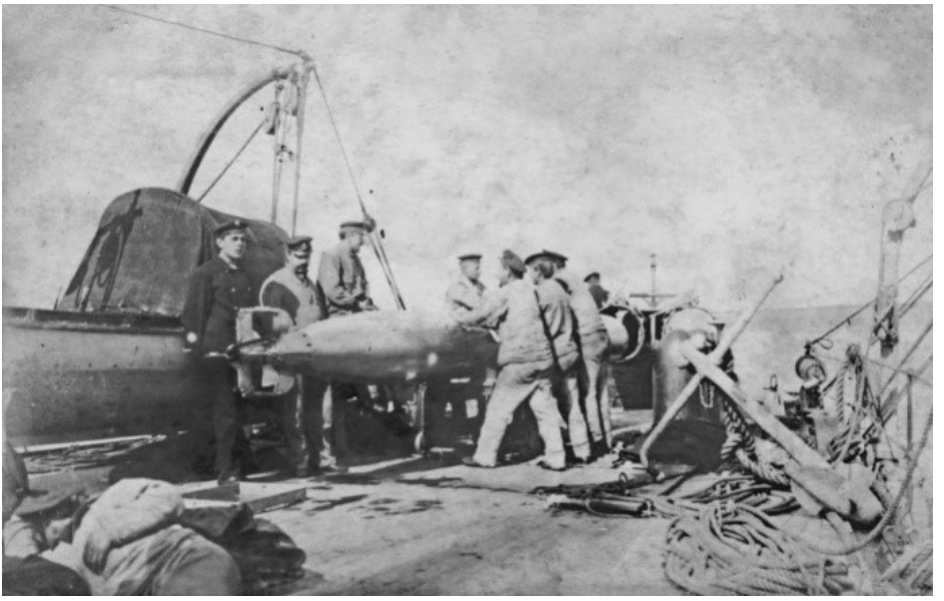
2.4. Ispitna lansirna stanica za torpeda

Godine 1886. obavljeno lansiranje torpeda s torpednih brodova *Zara, Lussin, Sebenico, Spalato, Prinz Eugen* (ukupno 174 lansiranja, od toga 145 pogodaka).[29] Godine 1887. izvedena su 343 lansiranja.[30] Nakon 1888. testiranja se provode u C. (i) kr. arsenalu na novosagrađenoj ispitnoj lansirnoj stanici. Godine 1888. obavljena su 454 testna lansiranja torpeda. U vježbi taktike obavljena su još 220

[28] Rangsund Eintheilungs- liste der k. k. Kriegs-marine 1885. (od 15. studenoga), str.81–82.

[29] Jahresbericht der k. k. Kriegs-Marine 1886., str. 22.

[30] Jahresbericht der k. k. Kriegs-Marine 1887., str. 24.



Slika 4. *Fažanski kanal, vježba lansiranja torpeda, ujedno i testiranje torpeda (kolekcija J. Vretenar)*

lansiranja torpeda s torpednih brodova.[31] Godine 1889. obavljena su 532 testna lansiranja te 231 lansiranje torpeda s torpednih brodova.[32]

- ***Izgradnja torpedne lansirne stanice*** započinje 1884.

Izgradnju vodi direkcija za opremanje C. kr. pomorskog arsenala (*Ausrüstungs-Direction*). Iako je riječ o razmjerno malenu objektu, izgradnja traje pune četiri godine. Za potrebe torpedne lansirne stanice, u njezinoj neposrednoj blizini izgrađena je i priručna radionica-skladište. Na izgradnji se izmjenjuje više stručnjaka iz tog područja:

- ***Torpedna lansirna stanica*** (*Torpedo-Lancier-Station*) ***1884.***[33]
  L. Sch. L. Rudolf Labrés (*Torpedo-Lancier-St.*) (od 15. svibnja 1884.)
  Maschst. 3. Cl. Anton Fabian (*Torpedo-Lancier-St.*) (od 14. travnja 1884.)

- ***Torpedna lansirna stanica*** (*Torpedo-Lancier-Station*) ***1886.***[34]
  L. Sch. F. Wilhelm Pacher (*Torpedo-Lancier-St.*) (od 21. svibnja 1885.)
  Maschst. 2. Cl. Wenzel Weidig (*Torpedo-Lancier-St.*) (od 9. veljače 1886.)

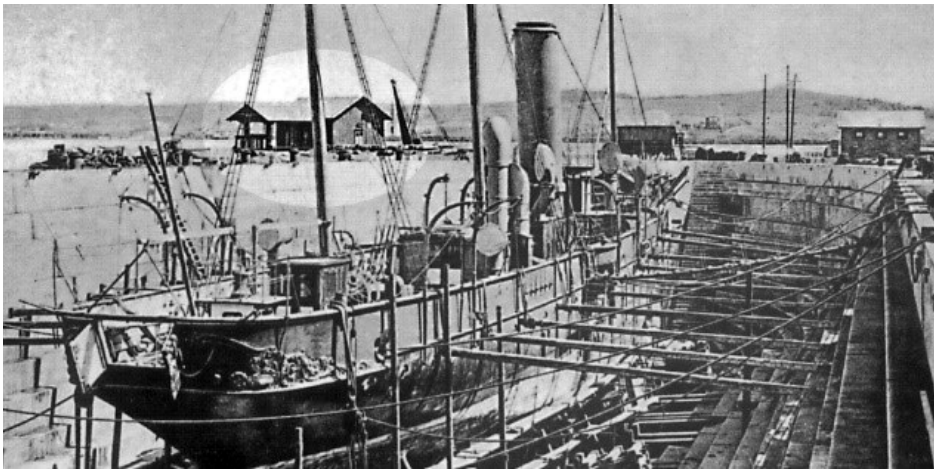
[31] Jahresbericht der k. k. Kriegs-Marine 1888., str. 20.

[32] Jahresbericht der k. und k. Kriegs-Marine 1889., str. 21.

[33] Rangsund Eintheilungs- liste der k. k. Kriegs-marine 1885. (od 15. veljače), str. 76.

[34] Rangsund Eintheilungs- liste der k. k. Kriegs-marine 1886. (od 15. kolovoza), str. 76.

- ***Torpedna lansirna stanica*** (*Torpedo-Lancier-Station*) ***1887.***[35]
  L. Sch. F. Karl Kailer[36] (*prov. für die Torpedo-Lancier-St.*) (od 5. svibnja 1887.)
  Maschst. 2. Cl. Wenzel Weidig (*Torpedo-Lancier-St.*) (od 9. veljače 1886.)
- ***Torpedna lansirna stanica*** (*Torpedo-Lancier-Station*) ***1888.***[37]
  L. Sch. F. Moriz Huber (od 1. studenoga 1887.)
  Maschst. 2. Cl. Wenzel Weidig (od 9. veljače 1886.)
- ***1888. stalna posada torpedne lansirne stanice***[38]
  L. Sch. F. Karl Seidensacher
  L. Sch. F. Ludwig Treitl (od 27. srpnja 1888.)
  Maschst. 2. Cl. Pasqual Spazapan (od 18. travnja 1888.)



Slika 5. *Lansirna stanica za testiranje torpeda: od 1888. stalna postava, 1894. dovršena je treća postaja za lansiranje, testiranje torpeda. (Franz F. Bilzer, Die Torpedoschiffe und Zerstörer der k. u. k. Kriegsmarine 1867–1918, str. 30.)*

2.5. Direkcija za torpiljarke (*Torpedoboots-Direction*)[39] (osnovana u C. i kr. pomorskom arsenalu 2. svibnja 1890.)

- Direktor: *Freg. K.* Carl Renvers (od l. siječnja 1890.)

[35] Rangsund Eintheilungs- liste der k. k. Kriegs-marine 1887. (od 15. svibnja), str. 81.

[36] V Admiral Kailer v. Kaltenfels Karl (Pula, 1862. – Beč, 1917.). Od 1913. zamjenik zapovjednika, a od 16. veljače 1917. zapovjednik Mornaričkoga sektora Ratnoga ministarstva u Beču. Nakon smrti admirala Antuna Hausa (8. veljače 1917.), Kailer (do smrti 28. travnja 1917.) postaje "prvi čovjek" C. i kr. ratne mornarice.

[37] Rangsund Eintheilungs- liste der k. k. Kriegs-marine 1888. (od 15. veljače), str. 83.

[38] Rangsund Eintheilungs- liste der k. k. Kriegs-marine 1888. (od 15. studenoga), str. 83.

[39] Rangsund Eintheilungs- liste der k. und k. Kriegs-marine 1890. (od 15. studenoga), str. 86.



Slika 6. *C. i kr. pomorski arsenal u Puli: 1. artiljerijska direkcija, 2. skladište torpeda, 3. torpedna lansirna stanica, 4. Direkcija za torpiljarke, 5. Mornaričko-tehnički odbor, 6. Mornarička strojarska škola, 7. Škola za pripravnike i radnike C. i kr. arsenala, 8. radionica za održavanje torpeda i artiljerijska radionica (uredio J. Vretenar, kolekcija J. Vretenar)*

- Stalna postava, časnici:
  L. Sch. L. Heinrich Dennig (od 25. kolovoza 1890.)
  Maschst. 1. Cl. Raimund Lauer (od 4. rujna 1890.)
  Maschst. 2. Cl. Josef Prašil (od 1. srpnja 1890.)
  Mar. Com. Adjct. 1. Cl. Christian Érdien (od 21. lipnja 1890.)

- Privremeno dodijeljeni:
  L. Sch. L. Regner v. Bleyleben, Otto v. Ritt (od 15. listopada 1890.)
  L. Sch. L. Johann Tarabocchia (od 3. svibnja 1890.)
  L. Sch. F. Karl Veltzé (od 2. rujna 1890.)
  L. Sch. F. Johann Gf. Firmian (od 10. svibnja 1890.)
  L. Sch. F. Otto Balzar (od 27. svibnja 1890.)
  L. Sch. F. Karl Stahlberger (od 4. svibnja 1890.)
  Maschst. 3. Cl. Constantin Seitz (od 13. srpnja 1889.)

Za potrebe održavanja torpiljarki, u Puli je 1908. – 1909. izgrađen dok *T* nosivosti 868 t.[40]

Osnivanjem direkcije za torpiljarke zaokružena je izgradnja infrastrukture potrebne za poslove vezane za torpedo.

2.6. Razvoj torpedne škole

- **Novi pravilnik za tečajeve torpedne škole** (donesen 1895.)[41]

Torpedna škola svojim programom prati sve potrebe C. i kr. mornarice za raznovrsnim kadrom i promtno u svoj program uvodi nove stručne tečajeve.

- **1886. Torpedo-tečaj** (*Torpedo-curs*)[42]
  - Torpedo-tečaj za vojne radnike
  - Torpedo-tečaj za radnike, strojarske dočasnike
- **1887. Torpedo-tečaj** (*Torpedo-curs*)[43]
  - Tečaj za testiranje torpeda, za časnike
- **1897. osnovana je Torpedna škola** (*Torpedo - Schule*)[44]

Škola počinje s radom 1898. na brodu *Alpha*.[45] Školu je polazilo ukupno 112 polaznika, a obuhvaćena su ova zanimanja:

- radnici i mornari za pripremu torpeda
- instruktori za torpedo
- majstori za torpedo
- radnici za torpedo

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[40] W. Aichelburg Register der k.(u.)k. Kriegsschiffe, str.149.

[41] Organische Vorschrift für das Personale der k. und k. Kriegs-Marine (VI. Hauptstück. III. Abschnitt). Pravilnik se odnosi na sve tečajeve i škole koje organizira C. i kr. ratna mornarica.

[42] Jahresbericht der k. k. Kriegs-Marine 1886., str. 18–21.

[43] Jahresbericht der k. k. Kriegs-Marine 1887., str. 19–22.

[44] Jahresbericht der k. und k. Kriegs-Marine 1897., str. 33.

[45] Jahresbericht der k. und k. Kriegs-Marine 1898., str. 33.



■ **Slika 7.** *Niži časnici na praksi u Mornaričko-strojarskoj školi (Sv. knjižnica Pula)*

- **1907. Torpedo-tečaj** (*Torpedo-curs*)[46]
  - Tečaj za testiranje torpeda, za dočasnike

1913. Torpedo-tečaj (*Torpedo-curs*)[47] na brodu *Zara*

- **Torpedo-tečaj za časnike:**
  - I. tečaj: 26 *Freg. L.* (16. lipnja 1913. – 4. listopada 1913.) korištenje i rukovanje
  - II. tečaj: 29 *Freg. L.* (2. časnika, tečaj 15. listopada 1913.)
  - 14. *Freg. L.* testiranje (17. studenoga 1913. – 22. prosinca 1913.)
- **Tečaj za vojne radnike** (1. siječnja 1913. – 1914.)
  - 54. radnika za torpedo i mine
- **Torpedna škola:**
  - 28 mornara za rukovanje torpedom, poslužioci
  - 201 mornar za pripremu torpeda
  - 51 instruktor za pripremu torpeda
  - 10 instruktora i majstora
- **Torpedo-tečaj za radnike**
  - 32 polaznika
  - 8 dočasnika-strojara

[46] Jahresbericht der k. und k. Kriegs-Marine 1907., str. 37., 40. i 47.

[47] Jahresbericht der k. und k. Kriegs-Marine 1913., str.14., 39., 42. i 49.



Slika 8. *Uvala Fizela, školski brodovi* Alpha *(1888. – 1897., 1898. – 1918.) i* Zara *(1898. – 1913.) (Sv. knjižnica Pula)*

- **Tečaj za testiranje torpeda – dočasnici** (1. – 31. srpnja 1913.)
  - 15 majstora za torpedo
  - 6 instruktora
- **Polaznici tečaja započetih 1913.**[48]
  - 6 majstora za torpedo (1. listopada 1913. – 1914.)
  - 52 instruktora (1. listopada 1913. – 1914.)
  - 126 mornara za pripremu torpeda (17. studenoga 1913. – 1914.)
- **Torpedna škola** (*Torpedoschule*) **1913.**[49] Hulk *Zara*, 1350 t (glavni brod)
  Freg. K. Heinrich Seitz (zapovjednik)
  Korv. K. Alfons Wünschek (instruktor)
  L. Sch. L. August Hawlik (teorija)
  L. Sch. L. Georg Ritt v Wolff (učitelj torpedo-časnički tečaj)
  L. Sch. L. Rudolf Grä, (torpedo-instruktor, tečaj)
  L. Sch. L. Karl Walluschnig (torpedo-majstor, tečaj)
  L. Sch. L. Karl Želisko
  Freg. L. (---)
  L. Sch. Arzt dr. Rudolf Hessler
  Maschbetrltr. 1. Cl.
  Mar. Komr.1. Cl. Kasimir Zachar

[48] Nisu mi dostupni podaci o tečajevima koji su se održavali za vrijeme ratnih godina, 1914. – 1918., kao ni kada su završeni tečajevi započeti krajem 1913.

[49] Eintheilungs- liste der k. und k. Kriegs-marine 1913. (od. 5. srpnja), str. 84.

■ **Tablica 3.** *Pregled broja polaznika torpedo-tečajeva po strukama*

Školski brod	***See Hund***		***Velebich***		***Alpha***				***Zara***
	1876.	**1878.**	**1886.**	**1887.**	**1893.**	**1898.**	**1900.**	**1907.**	**1913.**
Stožerni časnik			8	18					
Časnik	6	36	29	25	22	35	20	18	26
Časnik, instruktor			5	1					
Časnik, ispitivač				11	9	10	20	9	14
(tečaj) Σ 1	6	1	42	55	31	45	40	27	40
Dočasnik, majstor			3	3	4		5	6	8
Dočasnik, majstor, ispitivač								13	15
Dočasnik, instruktor								14	6
(tečaj) Σ 2			3	3	4		5	33	29
Mornar, poslužilac						13	7	15	28
Mornar, priprema						55	76	60	201
Poslužilac, instruktor						30	32	25	51
Instruktor za majstore						6	6	6	10
Radnici						8	8		32
(škola) Σ 3						112	129	106	322
Instruktor	3	6	24	18	26				
Poslužilac		4	39	60	16				
Priprema		4	65	64	80				
Majstor, radnik		2	5	3	7				
Vojni radnik			20		4	10	12	9	54
Poslužilac I.	6								
Poslužilac II.	8								
Poslužilac (ST)		9							
Priprema (ST)		11							
(tečaj) Σ 4	17	36	45	149	133	10	12	9	54
Σ 1 + Σ 2 +Σ 3+ Σ 4	23	37	90	207	168	167	186	175	445

(ST – *Schlepp- Spieren tip torpeda*)

Napomena: Početkom rata prestaje se objavljivati *Jahresbericht der k. und k. Kriegs-Marine;* zadnje godište, izvještaj za 1913., objavljen je 1914. tako da podaci o polaznicima tečaja u tablici 3. završavaju s 1913. godinom.

2.7. Školski brod, *Hulk Alpha* (1914. – 1918.)

- **Torpedna škola** (*Torpedoschule*) **1914.**[50] Hulk *Alpha*, 1350 t. (glavni brod)
  Freg. K. Heinrich Seitz (kapetan)
  Korv. K. Ernst Edl. v. Račić (instruktor)
  L . Sch. L. Georg Ritt. v. Wolff (časnik T-tečaj)
  L . Sch. L. Karl Löwe (teorija)
  L . Sch. L. Rudolf Gräf (T-instruktor tečaj)
  L . Sch. L. Karl Walluschnig (T-majstor tečaj)
  Freg. L. Heinrich Simueel
  L. Sch. Arzt dr. Karl Vojvoda
  Maschbetrltr. 1. Cl.
  Mar. Komr. 1. Cl. Kasimir Zachar

- **Torpedna škola** (*Torpedoschule*) **1916.**[51] Hulk *Alpha*, 1350 t (glavni brod)
  L. Sch. K. d. R. Johann Indrak
  Kor. K. Rudolf Freih v. Schönberger
  L. Sch. L. d. R.
  Mar. St. Artz d. R. dr. Karl Weiser
  Mar. Komr. 1. Cl. Rudolf Schmidl
  Mar. Km. El. 1. Cl. Eugen Martinek
  Werkf. Franz Siebert

- **Torpedna škola** (*Torpedoschule*) **1918.**[52] Hulk *Alpha*, 1350 t (glavni brod)
  Freg. K. Johann Laufberger (upravljanje torpednim sustavom)
  Freg. K. Georg[53] Ritter v. Wolff (instruktor Torpedne škole i upravljanje torpednim sustavom)
  Korv. K. Ernst Edl. v. Račić (instruktor)
  L. Sch. L. Hugo v. Kless
  Mar. St. Arzt d. R. dr. Karl Weiser
  Mar. Komr. 1. Cl. Josef Scheuchenstuhl
  Oberwerkf. 2. Cl. Franz Siebert
  Werkf. Johann Baumgartner
  Werkf. Johann Anzulovich

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[50] Eintheilungs- liste der k. und k. Kriegs-marine 1914. (od 25. siječnja),str. 240.

[51] Kriegseintheilungsliste der k. und k. Kriegs-marine 1916. (od 6. studenoga), str. 125.

[52] Kriegseintheilungsliste der k. und k. Kriegs-marine 1918. (od 26. kolovoza), str. 56.

[53] Freg. K. Wolff, Georg Ritt. v., slikar. I danas su poznati njegovi akvareli objavljeni na razglednicama – dvanaest motiva Pule i dvanaest motiva Brijuna. Vila *Wolf,* sagrađena u neposrednoj blizini Osnovne škole *Stoja,* jedna je od najljepših u Puli.



Slika 9. *Polaznici torpedo-tečaja, 1916. (kolekcija Franjo Zeljak)*

2.8. Ostali resursi

- **1909. Podmornice**

Uza sve veći broj torpiljarki i torpednih brodova, u sastav ratne flote od 1909. ulaze i podmornice. Do kraja Prvoga svjetskog rata C. i kr. mornarica raspolaže s ukupno 27 podmornica i 32 novougovorene. Osnovno je naoružanje svake podmornice torpedo pa je za sve njih trebalo osposobiti posadu, naročito torpediste.

- **1913. Izgrađena nova radionica za održavanje i popravak torpeda.**[54]

- **1917. Hidroavion za torpedo**[55]

Krajem 1917. sagrađen je prvi hidroavion predviđen da nosi torpedo. H-avion oznake T1, tip GW, tvrtke *Brandenburg*, u službi je od 23. studenoga 1917. Nabavljena su još dva H-aviona, T2 i T3, tvrtke *Gotha* tipWD 14, u službi od srpnja 1918.

Avioni su opremljeni lansirnom rampom u tvornici *Whitehead* u Rijeci i služili su uglavnom u eksperimentalne svrhe.

- **Zaštita od napada torpeda**
  - Brodova – *zaštitna čelična mreža*
  - Luka – obale
    – *zaštitna mreža*
    – *torpedna bitnica (Mali Brijun, Šibenik i dvije u Boki kotorskoj)*

[54] Jahresbericht der k. und k. Kriegs-Marine 1913., str. 59.

[55] P Schupita; Die K. u. k. Seeflieger, str. 56., 57. i 134.



Slika 10. *Torpedna bitnica na otoku Mali Brijun (foto Josip Vretenar, svibanj 2016.)*

- **Mobilna torpedna lansirna stanica[56] (1916.)**
  S. M. B. 18
  L. Sch. L. Hermann Berger
  Seefähnrichin d. R. Karl Hofman (*offiziersdiensttuend)*

Budući da se spominje samo jedna takva stanica, može se zaključiti da je to bila eksperimentalna jedinica bez većega vojnog značenja.

3. ZAKLJUČAK

Početak razvoja torpeda bio je uvjetovan tehnološkim napretkom industrije i tehnike. Pojavio se u vrijeme industrijske revolucije, što je bila sretna okolnost jer se u razmjerno kratko vrijeme od testnih primjeraka razvio do najmoćnijeg oružja ratnih mornarica.

Pojava torpeda, a poslije i podmornica u naoružanju ratnih mornarica uvjetovala je potpunu promjenu sastava dotadašnjih ratnih flota. Već pri prvim upotrebama u ratnim uvjetima, početkom Prvoga svjetskog rata, sve su zaraćene strane bile zatečene učinovitošću novog oružja. Torpedo je "preko noći" postao glavno naoružanje ratnih mornarica i kao ni jedno oružje u povijesti promijenio taktiku vođenje pomorskih ratova.

[56] Kriegseintheilungsliste der k. und k. Kriegs-marine 1916. (6. studenoga), str. 137.

PRILOG



■ **Slika 11.** *Pulski akvatorij tijekom Prvoga svjetskog rata: 1. Pomorski arsenal C. i kr. ratne mornarice, 2. Uvala Fizela, lokacija torpedne škole, 3. Fažanski kanal, pozicija vježbanja lansiranja torpeda prije Prvoga svjetskog rata, 4. Lokacija torpedne bitnice na otoku Mali Brijun, čm – čelična mreža, zaštita od torpeda (uredio Josip Vretenar, Sv. knjižnica Pula)*

KRATICE[57]

Časnička zvanja

Lin. Sch. K. (Linienschiffs- kapitän) – kapetan bojnog broda

Freg. K. (Fregaten- kapitän) **–** kapetan fregate

Corv. K. (Korvetten- kapitän) – kapetan korvete

L. Sch. L. (Linienschiffs- leutnant) – poručnik bojnog broda

L. Sch. F. (Linienschiffs- Fähnriche) – kadet bojnog broda

Obstl. (Oberstlieutenant) – glavni poručnik

Seef. in d. R (Seefähnrich) – kadet, iz pričuvnog sastava

Seeasp. (See aspiranten) – kandidat za pomorskog časnika

M.-Art.-Ober-Ing. 1. Cl. (Marine Artillerie Ober Ing.) – mornaričko-artiljerijski glavni inženjer 1. klase

Mar. Art. Ober - Ing. 3. Cl . (Marine Artillerie Ober Ing.) – mornaričko-artiljerijski glavni inženjer 3. klase

M.-Art.-Ing. 1. Cl. (Marine Artillerie Ing.) – mornaričko-artiljerijski inženjer 1. klase

Mar. Art. Ing. 3. CI. (Marine Artillerie Ing.) – mornaričko-artiljerijski inženjer 3. klase

Maschb . Ing. 1. Cl. (Maschinenbetriebs) – strojarski mehaničar, ing. 1. klase

Maschb. Ing. 3. Cl (Maschinenbetriebs) – strojarski mehaničar, ing. 3. klase

Maschb.- u. Betriebs-Ing. 2. CI. (Maschinenbetriebs und Betriebs -Ing) – strojar i mehaničar, ing. 2. klase

Mar. St. Artz d. R. (Marine stabsärtz) – stožerni liječnik, iz pričuvnog sastava

L. Sch. Arzt (Linienschiffsärtz) – liječnik bojnog broda (izraz „bojnog broda“ ne odnosi se na brod, to je stupanj zvanja)

Mar. Com. Adjet. 1. Cl. (Marinekommissäre) – mornarički ekonomist, pomoćnik 1. klase

Mar. Com. Adjet. 3. Cl. (Marinekommissäre) – mornarički ekonomist, pomoćnik 3. klase

Mar. Komr. 1. Cl. (Marinekommissäre) – mornarički ekonomist, 1. klase

Mar. Km. El. 1. Cl. (Marinekommissäre eleven) – mornarički ekonomist, pripravnik 1. klase

[57] Rangliste der K. u. K. Kriegsmarine 1918. (27. srpnja), str. 3.

Dočasnici, radnici

Maschst. 3. Cl. (Maschinisten) – strojar 3. klase

Maschst. 2. Cl. (Maschinisten) – strojar 2. klase

Maschst. 1. Cl. (Maschinisten) – strojar 1. klase

Maschbetrltr. 1. Cl. (Maschinenbetriebsleiter) –voditelj strojnih operacija

Werkf. (Werkführer) – nadzornik, voditelj

Oberwerkf. 2. Cl. (Oberwerkführer) – glavni nadzornik, voditelj 2. klase

d. R. (der reserve) – *pričuvni sastav*, rezervist

El. (Eleven) – pripravnik

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Periodika

Almanach für die K. K. Kriegs-Marine, Pula (1881. – 1889.)

Almanach für die K. und K. Kriegs-Marine, Pula (1890. – 1918.)

*Jahrbucht der Kais. Kön. Kriegs-Marine,*aus der kaiserlichen und königlichen hof- und staatsdruckerei, Beč, razna godišta (1871. – 1875.)

Jahresbericht der k. k. Kriegs-Marine, aus der kaiserlichen und königlichen hof- und staatsdruckerei, Beč (1876. – 1889.)

*Jahresbericht der k. und k. Kriegs-Marine,*aus der kaiserlichen und königlichen hof- und staatsdruckerei, Beč (1890. – 1914.)

Rangsund Eintheilungs- liste der k. k. Kriegs-marine, aus der kaiserlichen und königlichen hof- und staatsdruckerei, Beč (1876. – 1889.)

Rangsund Eintheilungs- liste der k. und k. Kriegs-marine, aus der kaiserlichen und königlichen hof- und staatsdruckerei, Beč (1889. – 1918.)

Kais. Königl. Militär-Schematismus, aus der kaiserlichen und königlichen hof- und staatsdruckerei, Beč (1868. – 1889.)

Kais. und Königl. Militär-Schematismus, aus der kaiserlichen und königlichen hof- und staatsdruckerei, Beč (1890. – 1914.)

Organische Vorschrift für das Personale der k. und k. Kriegs-Marine (VI. Hauptstück. III. Abschnitt), Beč, 1896.

SUMMARY

With the introduction of torpedoes to the Austro-Hungarian Navy, the ship "See Hund" was changed into a torpedo boat in 1869.
The torpedo school opens on 10th March in 1876. In the beginning, the school works on the first torpedo boat, the "See Hund", later in 1878, the ship "Velebich" is assigned to the school. In 1888, the "See Hund" is deleted from the fleet list, when the ship "Alpha" becomes assigned to it instead, in service until the disintegration of the Navy. From 1897 to 1912, the ship "Zara" is also in service with the school. When needed, other ships become engaged, torpedo boats in the first place.
After the regulation of the Fisela Bay, the school continues to work within the mining-torpedo-telegraphy school, where theory classes take place, while the practice is held in the Fažana Channel.
The school courses generally take place twice a year, separately for staff officers and junior officers, and separately for operators on torpedo boats and workers that maintain torpedoes. In addition to the school, various courses are organised regarding the maintenance and use of torpedoes.
The importance of torpedo school is manifested in World War I when the basic operational strength of the Austro-Hungarian Navy flotilla consists of torpedo boats and a flotilla of submarines. Officers in charge of vessels the main armament of which is torpedo are highly capable trained officers.
At the Pula maritime arsenal, torpedoes are maintained and tested; they are also designed and constructed. The naval port and the Fažana Channel were protected before the war by anti-torpedo steel nets, while an active torpedo was built on the island of Mali Brioni.

Keywords: *school, torpedo boat, Pula, Navy*

DOCK – CULTURE
A PROPOSAL FOR CONVERSION OF AUSTRO-HUNGARIAN BUILT FLOATING DOCK INTO A NEW URBAN PLATFORM FOR CULTURE, CREATIVE INDUSTRIES AND TOURISM

DOCK – CULTURE
Prijedlog za prenamjenu plutajućeg doka sagrađenog u doba Austro-Ugarske u novu urbanu platformu za kulturu, kreativne industrije i turizam

Bojana Vuksanović*

SUMMARY

The project outlines how the dock could potentially be transformed, re-invented architecturally and through a proposed change in use, integrated as a layer within the city, as an artefact that tells an authentic story within the cultural history.
The dock is envisaged as a floating "living museum", the object itself a historic "visitor centre", simultaneously providing a platform for various additional proposed usages. What is presented is potentiality for the integration of this historic object, newly redesigned architecturally, in the urban matter of the city of Cres, or alternatively, its relocation elsewhere. Consideration should be given to the significance of the floating dock-9 object in Cres in terms of cultural-industrial heritage, not solely at the local level, but within the broader context of Croatia also.
Dock-9 that was constructed for the Austro-Hungarian navy at the beginning of the last century, is not only is the oldest, but it is also the last remaining representative object of this typology left in Croatia from that era. An overview of key points in Dock-9 history is given, as very little is documented, considering the dock had remained a military secret until it was bought from the JRM in 1983.
The work has been done with the prime intent of raising the awareness of the dock's unique cultural-historic and architectural value, the realization of which might increase the chances for this rare object, that now, unfortunately, is forgotten and floats in the bay of Cres, to be given a new life, preserved as a part of culture, and remain central to the current cultural life.

Keywords: *floating dock, culture, Austro-Hungarian, Cres, revitalization, urban platform, urban integration*

* Bojana Vuksanović, ing. arh., Cres, Hrvatska, e-mail: bojanavuksanovic@gmail.com / Bojana Vuksanović, B.Arch., Cres, Croatia

Dock Culture represents the eponymous project and initiative by architect Bojana Vuksanović with the aim to preserve the floating Dock 9 (originally Dock F), the only remaining object of its kind from the Austro-Hungarian period in the world, and currently located in Cres. The conceptual project proposes preserving the construction as a historical industrial artifact, integrating the object, through a number of aspects, into the cultural, social and urban scene, and transforming the building into a new cultural platform. This dock was built for the needs of the Austro-Hungarian Navy at the beginning of the last century (1913), and after 104 years it is still in operation. Throughout this long period it has been used in the armies of Austria-Hungary, Italy, Yugoslavia and Croatia since its independence. It changed places several times during this period, from Pula, where it was built, via Tivat, to Cres, where it is located since 1983.

The goal of the project is to preserve and reanimate this object as a subject of Croatian industrial and cultural heritage and to prevent its decommissioning when it ceases to be used within the Cres Shipyard. According to the project, in the future the dock could be used as a summer stage for multimedia artistic interventions, an exhibition space for ship models and photographs from maritime history, a library and an archive, a space for art studios and residences, lectures, concerts, theater performances, cinema, but also as a berth for two hundred smaller boats, and thus it would generate new artistic contents. Such an object, which in itself is a kind of "shipbuilding museum", would represent a new layer of the city – an artifact that speaks an authentic story of a cultural history and thus creates new values. All these different functions and contents could coexist in the future along the "main street" – the deck of the dock, from the beginning to the end point, which provides a view of the sea. The walls of the upper dock deck are 100 m long on both sides, and would become walkways with views into the inner "street" of the dock, and would provide a view of the whole city.

Dock Culture was first presented in 2016 at the Maritime and History Museum of the Croatian in Rijeka, the Croatian Association of Interdisciplinary Artists in Pula, Lamparna LAE Underground City XXI Labin and Days of Architecture in Istria 2016. The exhibition at the HDD – Croatian Designers Association Gallery presents the architectural and design proposals for the transformation of the Cres dock.

CULTURAL CONTEXT / URBAN CONTEXT

In the current context of Cres, the architecture of the floating dock contributes a tension and diversity to the city's visual composition. The industrial architecture of the dock's floating walls, in contrast to the medieval aesthetic of the Old Town, presents the dynamic spirit of the Machine Age in the city, capturing and making visible various layers of the city's history, broadening the cultural and urban diversity of Cres.

Austro-Hungarian (?) dock presents not only a testimony of maritime history, but also creates the possibility for a new original and distinctive historical industrial space, which could enhance its historic and social content.

The proposal to repurpose the object through the establishment of innovative cultural and tourism programs for the venue represents an opposition to the current urban plans, which envisage its removal and the unification of the bay into a chain of soul-less new marinas.

Typical (standardised) "architectures" of marinas introduce monotony, erasing the historic physical landscapes, (and authentic characteristics of local comunities) and, in time, transform cities into a faceless and uniform configuration common to bay inlets throughout the country.

DOCK "F" / DOCK-G.O.14 / DOCK-9



Technical data[1]:

length: 91.44 m (water-line) – 100.75 m

width: 18.66 m (external); 12.6 m (internal, upper); 10.75 m (internal, lower)

height: 9.15 m

displacement: 5,742 t

lifting capacity: 1000 t

[1] W. Aichelburg, Registar der k.(u)k. Kriegschiffe , p. 148.

Historic data:

design (project)[2]: 1912

built in[3]: 1913 in Pula

in function since[4]: 17 December 1913

"Dock 9" was originally built as a navy (military) object by Austro-Hungarian engineers to service the repair of submarines and small army destroyer warships. For this reason the object has unusual proportions that it is, comparative to usually much larger sizes of objects of this type, very small and also long but quite narrow in dimension.

"Dock "F" – for 'Fahzueger', ie destroyers, is built in the dry dock in Pula 1913, and the very same year used for three docking. With its help is in 1915. lifted and sank a submarine CURIE [later U14].

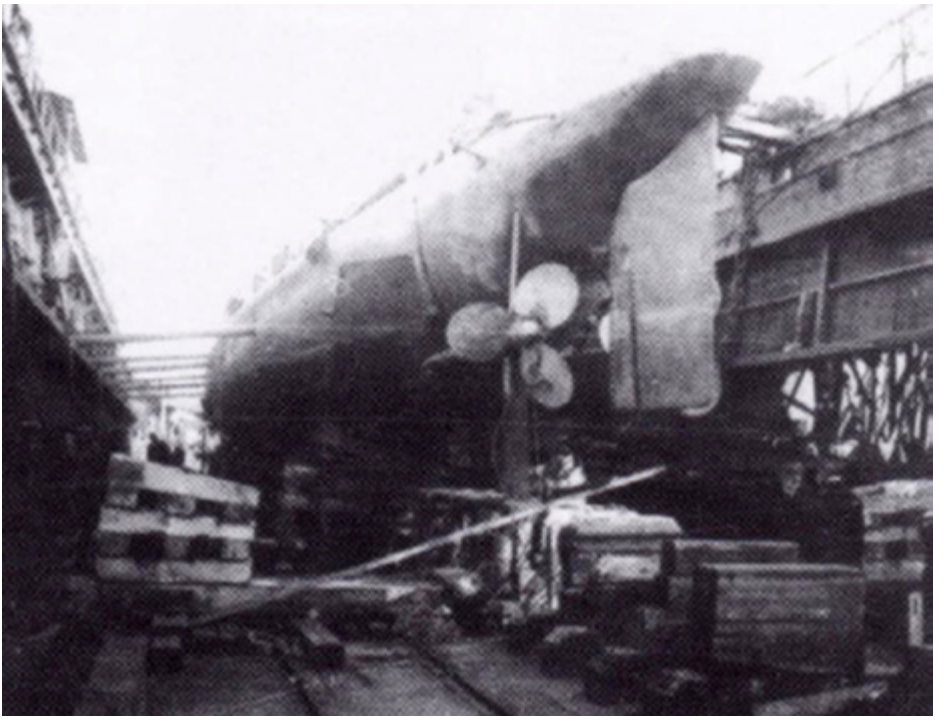


■ *Dock-F – Pula, The Austro-Hungarian Empire*

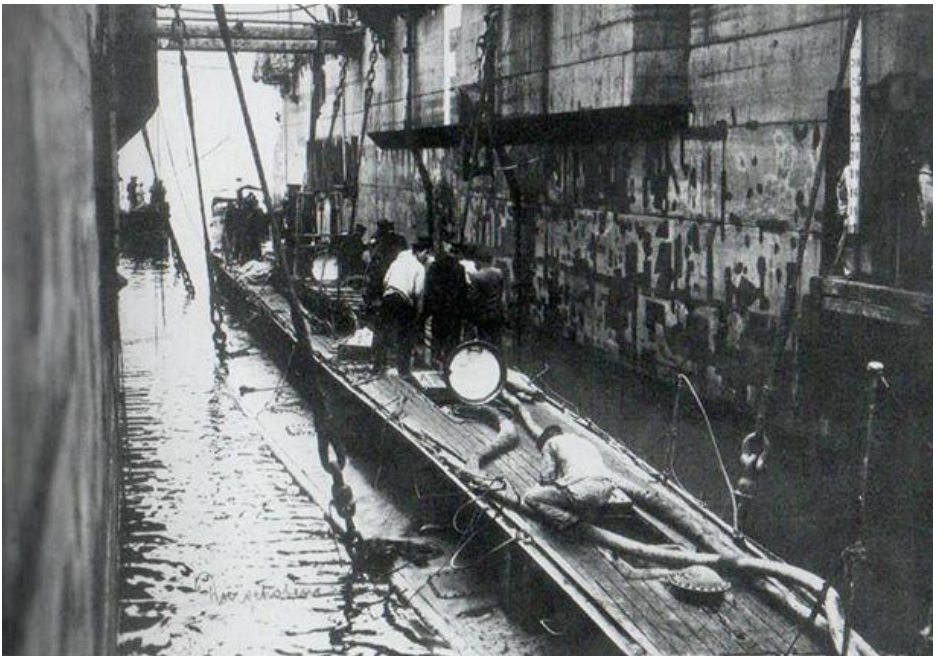
[2] *Jahresbericht* K.U.K. KRIEGSMARINE 1912, p. 67.

[3] *Jahresbericht* K.U.K. KRIEGSMARINE 1913, p. 19.

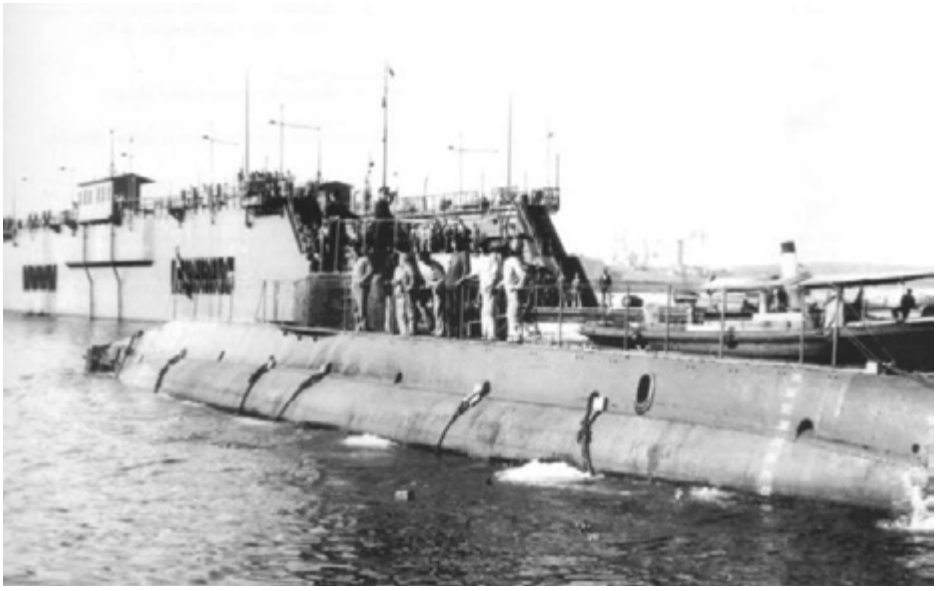
[4] W. Aichelburg, Registar der k.(u)k. Kriegschiffe, p. 148.



■ *Dock-F – Pula*

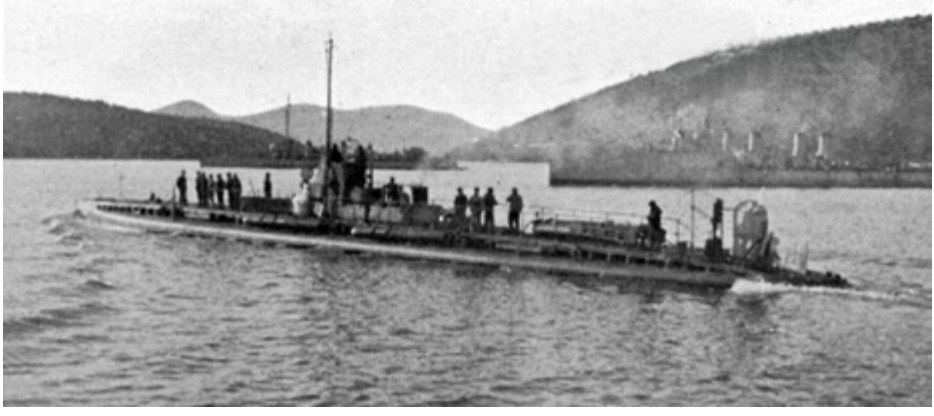


■ *From book: Wladimir Aichelburg, Register der k.(u.)k. Kriegsschiffe – Von Abbondanza bis Zrinyi, Neuer Wissenaschaftlicher Verlag, Wien – Graz 2002.*



■ *Dok-F, from the book "Austro-Hungarian submarines in World War 1", by Z. Freivogel*





■ *CURIE submarine [later U14]. lifted 1915. with the dock-F*

On 20 August 1920, the shipyard on the Island of Uljanik, including all the docks, was purchased by the Kozulić brothers, owners of the shipyard in Monfalcone[5].

Dock "F" changed its name into G.O.14 ex F.[6]

In 1928, the shipyard had at its disposal floating docks – a balanced dock and dock N22.

There are no exact data on whether the remaining docks have been transported to the shipyard in Mofalcone[7].

Dock "F" was sold to the Italian navy (date unknown).

A dock of 1000 t was included on the list of watercraft damaged by allied bombings of Pula in 1946. It is indicated it was heavily damaged and owned by the Italian navy, located outside of the pier on the western side[8].

In 1948, the ship "Brodospas" from Split pulled out from the Pula port a sunk floating dock of 1000 t and gave it to the Uljanik shipyard. The dock was located at a depth of 15 m**.**

Since at the time, until 1953, all shipyards were part of the Central Shipbuilding Administration (CUB) of the Ministry of Defense of the Federal Republic of Yugoslavia[9], and the dock itself, according to the legal succession of ownership of the Italian navy, became the ownership of the Yugoslav Navy, it was most probably transferred to Tivat immediately after being repaired.

Conclusion: although, without the direct documents, it cannot be stated with 100% certainty that the "Cres dock" is the former Dock "F", there is a great probability that this is the case. Namely, according to its structure, dimensions, technical characteristics and appearance, it can be said that this is one and the same object.

Dock-9 remained a military object all the way until 1983 when the shipyard of Cres purchased it from the Yugoslavian war navy (JRM) from shipyard in Tivat, where it was used for navy purposes. There is very little information about the original manufacture of the dock and up to this period. (There is still very little information available about the original construction of the dock.)

Before arrival in Cres, "Dok 9" was first taken from Tivat to Lošinj, for a repair, towed by the ship "Rovenska" and accompanied by the ship "Pernat", finally reaching Cres on May 21, 1983. On February 29, 1983. the first docking

5 R. Marsetič, *Brodogradilište Scoglio Olivi i područje Arsenala u vrijeme Italije*, in: *Stotinu i pedeset godina brodogradnje u Puli*, p. 196.

6 Ibid, p. 196.

7 Ibid, p. 208.

8 Lj. Marin, *Spašavanje brodova,* in: *Pomorski zbornik,* p. 887.

9 Ž. Šesnić, *Posljednjih 60 godina Brodogradilišta Uljanik,* in: *Stotinu i pedeset godina brodogradnje u Puli,* p. 243.

took place in Cres with a newly acquired dock, when the ferry "Kalmar" was lifted celebrating an important moment for the shipyard industry in Cres.

"Dock 9" remained in the bay of Cres ever since, docking numerous ships. To this day, more than 100 years later, "Dok 9" continues to fulfill its originally designed purpose.



■ *Dock – Tivat*



■ *Dock on the way from Tivat to Cres, 1983*



■ *Dock's arrival to Cres, 1983*



■ *Docking of ''Kalmar", Cres 1983 / first ship on dock in Cres/ Kalmar/ 1984.*

PROJECT DOCK – CULTURE

The idea proposal envisages the integration of the object, through a number of aspects, into the cultural, social and urban scene of the city, providing a new cultural platform and making strategically the most of its central position in the bay.

The dock is one of the main objects seen upon arriving to Cres, which offers the possibility of creating a dramatic impression.

Floating "living museum"

The dock is in itself a floating "living museum". In addition, an opportunity would be created to exhibit throughout the dock's various spaces, corridors and cabins, an obscure artifacts of ship building industry, photographic and other materials, incorporating the story of shipyard building history and Cres.

Urban context – Dock as a public space and part of the city

Through its preservation and re-purposing, the object could both provide a new environment for future tourism while preserving the historic shipyard industrial heritage and story of shipbuilding.

Through the proposed change from industrial to city space and public-private use, the dock location could evolve to become a new "node" in the city for the development of urban culture that would largely revolve around an authentic story of shipbuilding and docks navy's history.

In the future, the space of the dock could figure (?) as a new part of the city. The object could function as a shipbuilding museum – not as a closed institution, but as a multifunctional public space, featuring the future marina, a library on the history of shipbuilding, an exhibition space for ship models and photos, art studios, cafés. These diverse areas would line the 'main street' – the dock deck – up to end point, providing a view of the seaside and the "terrace" visible from all sides.

Views

Adjacent to main deck are dock's cc 7 m high "walls" (measured from deck) from which a visitor could overlook the inside "street" of the dock as well as get views of the whole city.

Dock as a multi-functional event space

With mobile elements such as surfaces on tracks and panels, the area could be quickly adjusted to the needs of individual events. The entire area (dock's deck) is architecturally rational and provides various possibilities of application.

Dock – changeable configuration

The dock space is envisaged as a changeable and flexible – "theater-set up" type of configuration – with movable elements and screens, either on rails or wheels, that can adapt to multi-purposed and varied use.

A permanent exhibition

Exhibition of shipbuilding artifacts and history from 1st, 2nd World War and from newer times. (Exhibition of tools and photographs from shipbuilding industry, docking process,)

It could be possible to include the permanent exhibition of shipyard and shipbuilding history and associated artifacts, souvenir shop, info-point, providing information about the current events, dock object and shipyard industry.

In addition the following functions could be integrated:

- From the cultural-commercial aspects, the main deck of the dock, 100m long and "street-like", could accommodate spaces for multi-purpose use, either as artist's studios, workshops and business spaces.
- Spaces could be rented out for events like lectures and art workshops, and art and souvenir shops.
- Library – a small library with books, maps, drawings and digital access point
- Cafes and restaurant

Dock marina

Along the entire length of the dock, a 2 meter wide platform could be attached on the external walls at the sea-level, that could provide an additional 200 meter of berthing space for boats and yachts in the middle of the city bay.

Boats could arrive at the end terrace and via walking platforms attached to external lower section of the walls, allow pedestrian traffic to the main space of the dock.

The berths of the marina could be placed along the platform, the lateral sides of the dock, in a length of 100 meters along each side.

Dock machine

A floating dock is a type of machine that operates on principles of pumps. It is essentially a floating structure divided into sections with a simple mechanism integrated in the form of tanks that empty or fill with water as necessary to immerse or emerge the dock together with the ship.

Dock-9 is built with a trussed structure and traditional shipbuilding technique of use of riveted metal from early 20th century, was used in construction.

The floating dock in Cres is 100 meters long, 11 meters wide and 6.8 meters high measured from the deck of the pontoons to the deck of the side walls,

The walls at the far ends are left open so that when the ship is raised, the water can freely flow out of the dock.

The dock was originally made with a 1000 tones lifting capacity that was recently reduced to 600 tones.

The total mass of the dock is approximately 1000-1500 tones.

The dock was originally built with the capacity to generate its own electricity. Today, the electricity is supplied from the shore.

DOCK – A CULTURAL HERITAGE

Consideration should be given to a significance of the floating dock object in Cres in terms of cultural-industrial heritage, not solely at the local level, but within the broader context of Croatia also.

Dock-9 constructed for the Austro-Hungarian* navy at the beginning of the last century (1913), is not only is the oldest, but it is also the last remaining representative object of this typology left in Croatia and the world from that era.

A major part of the cultural-industrial inheritance of shipbuilding industry in Croatia has already been demolished or modified beyond recognition. These objects are increasingly subject to destruction without an appropriate discussion or assessment regarding their unique and irreplaceable cultural and historic value.

It is worth considering whether the recognition of the historic and cultural value of this object, as the only remaining object of this typology from Austro-Hungarian era, could not only draw attention to the largely under-represented national industrial shipyard heritage of Croatia, but also evoke it in a role of one of city's main industrial icons.

Cultural context

There is an important cultural meaning in Cres in the narrative of the shipbuilding industry, and what it symbolizes for the city's history. The stories of shipbuilding are one of Cres' core and most interesting histories, deeply woven into the daily life of Cres and its many in-habitants. A central idea is to revive these core stories upon which the city of Cres has been built, whose presence adds diversity to the city's social fabric and local culture and to keep them in the present.

The Cres dock, with its presence in the city is a local industrial icon in its own right. The restoration and urban integration of the Cres dock is a way to

keep a sense of the past while allowing the transformation of the city towards a contemporary tourism, which comprises also industrial artifacts.

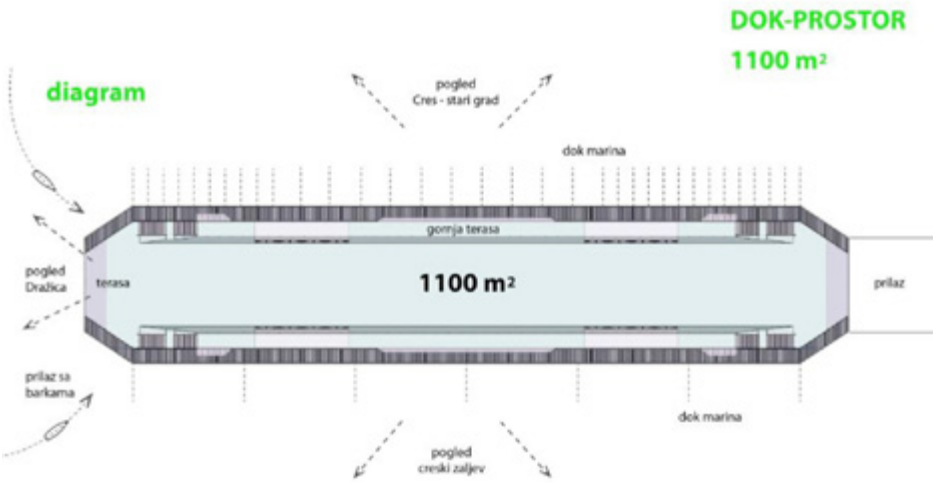
Feasibility study

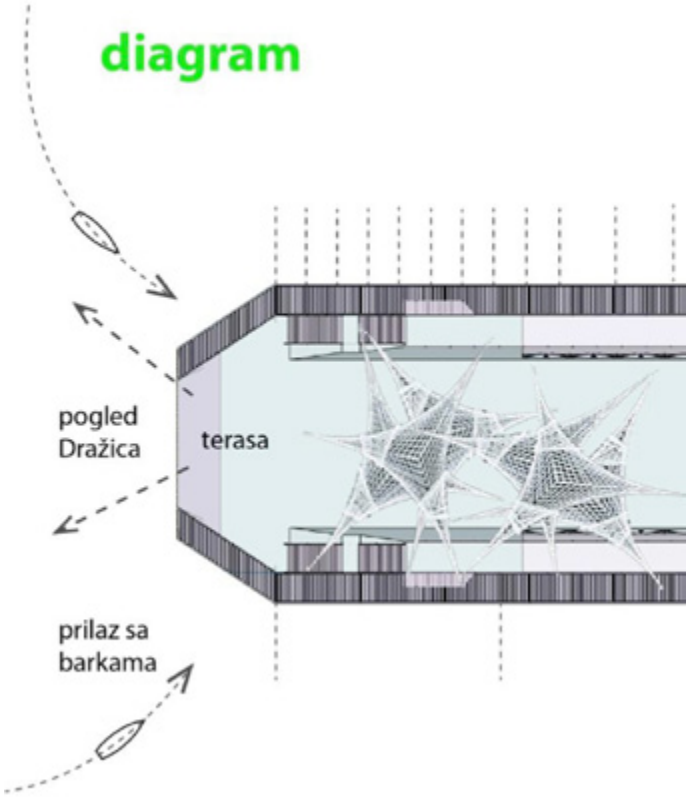
A technical expertise is required that would demonstrate the technical feasibility of the project in the area of security, water and electricity supply. Additional measurements of the dock structure are also needed, as well as digital data and a general feasibility study to test the profitability of the project.

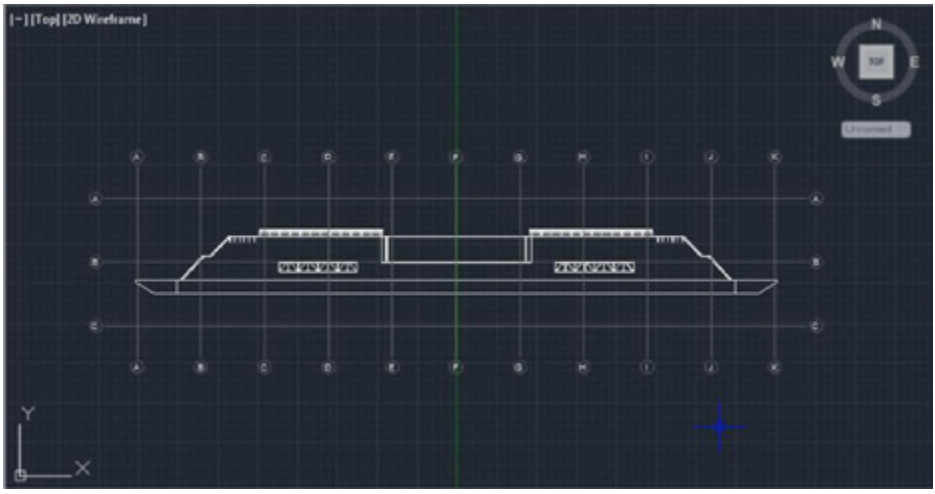
It is clear that the whole object requires major repairs and detailed maintenance. A detailed inspection of the condition of the tanks and structure is required. This could be provided by the Cres shipyard to determine accurately the current state of the object.

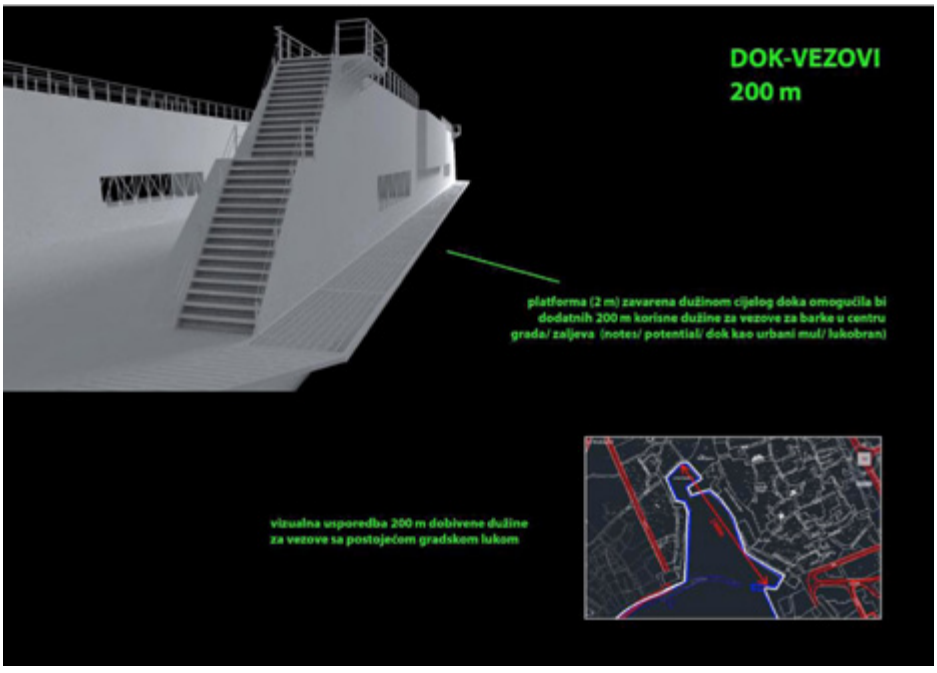
The object would have to be repaired, restored and would need all other necessary infrastructure installed, such as a water drainage system, additional electrical supply and distribution, ventilation, video surveillance, fire protection and other safety equipment.

Essential becomes consideration what strategies could be employed in reducing the cost of maintenance in terms of long term costs.

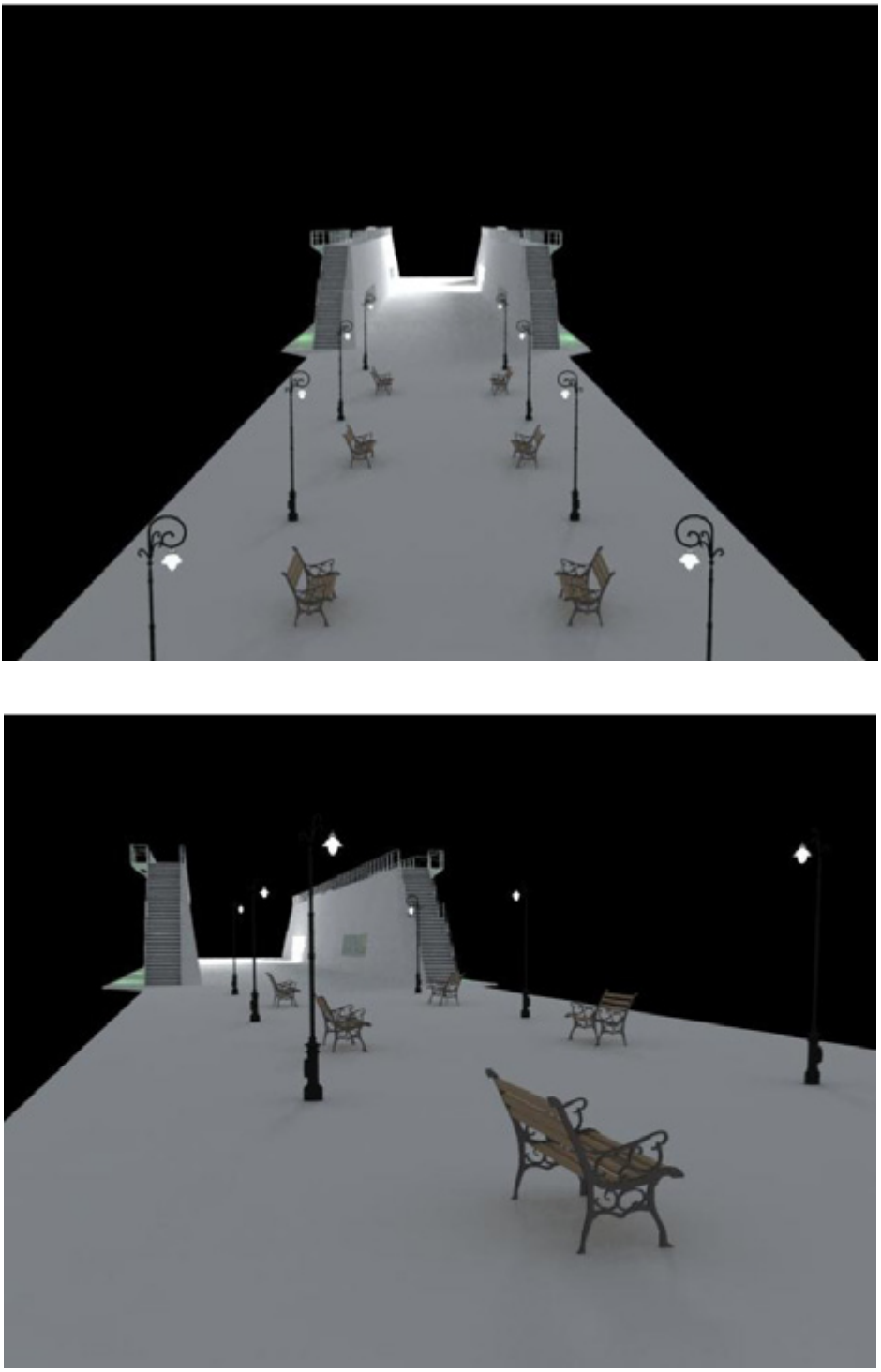

DOK-PROSTOR
1100 m²
diagram
pogled
Cres - stari grad
dok marina
gornja terasa
pogled
Dražica
terasa
1100 m²
prilaz
prilaz sa
barkama
dok marina
pogled
creski zaljev


diagram
pogled
Dražica
terasa
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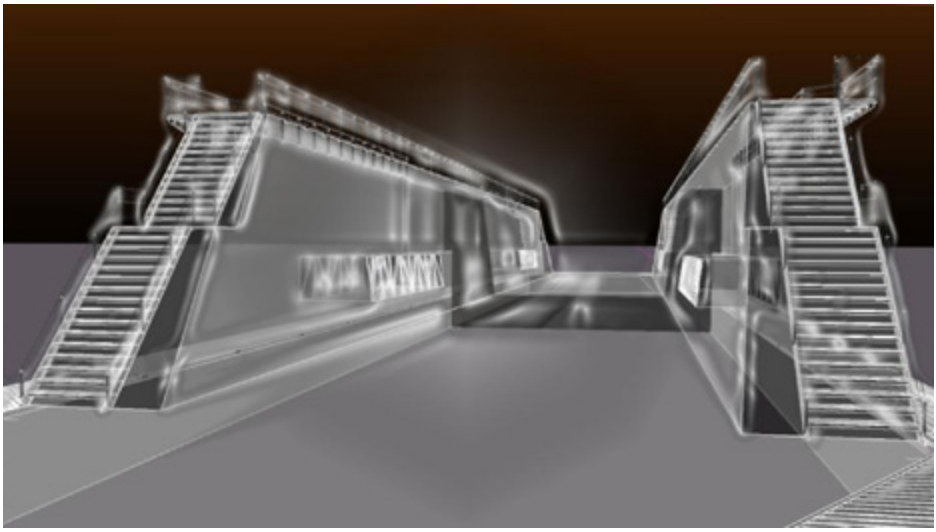




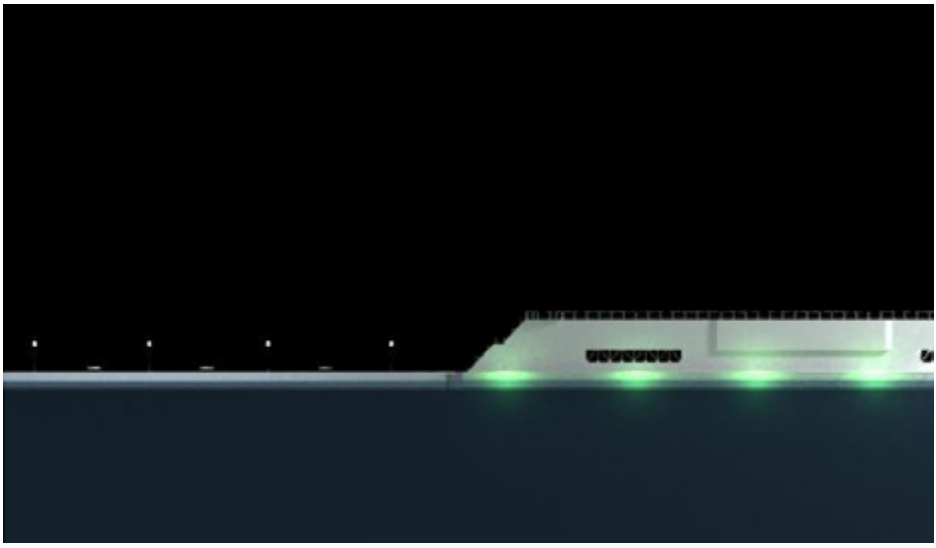
■ *With added external platforms, the dock could practically allow the additional 200 meters length of berthing space for boats and yachts along the external perimeter of its walls.*



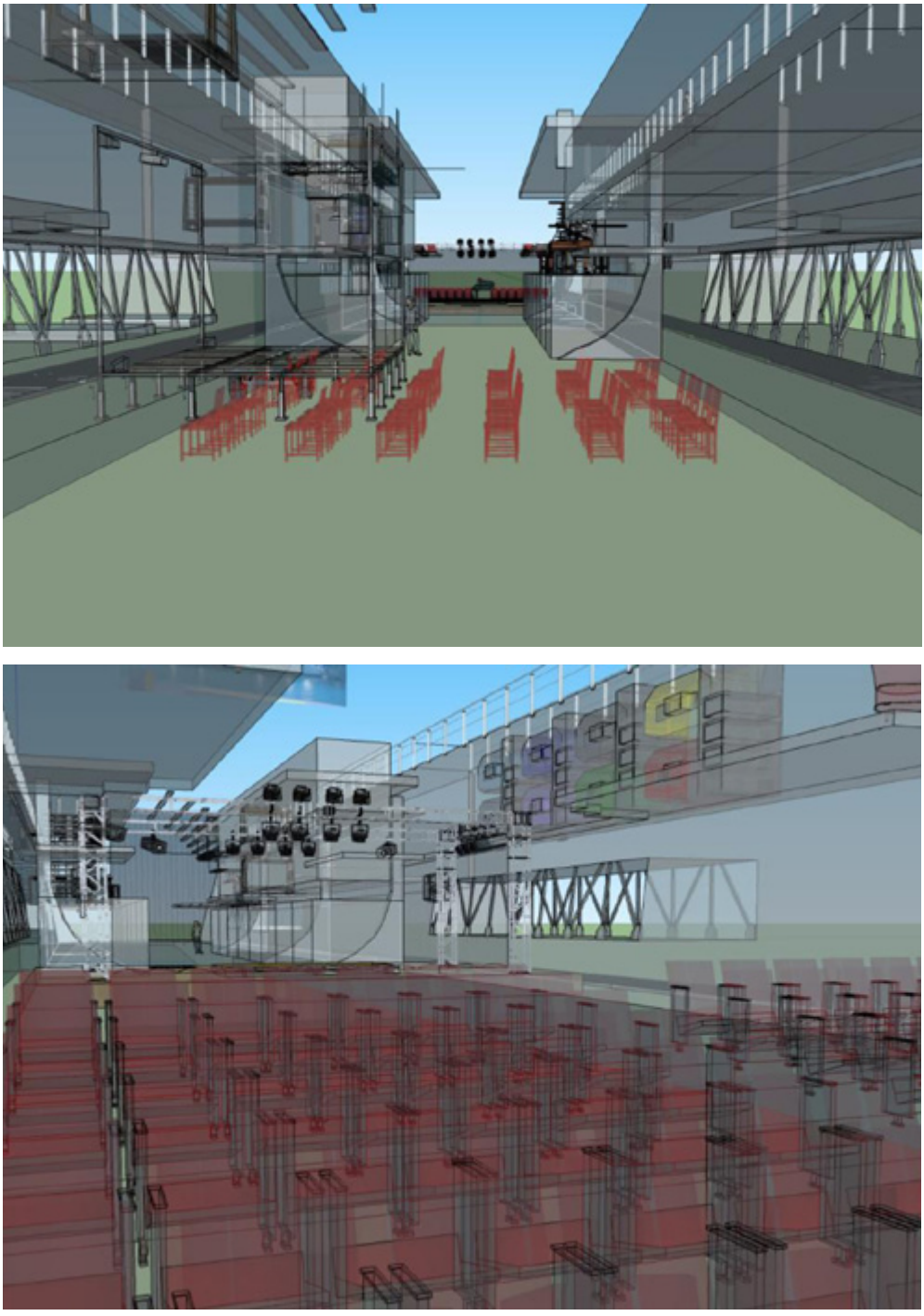
■ *Urban pier – the dock as a part of the city. In the city context, a historic dock could become a new platform for culture, an urban pier and city walkway.*



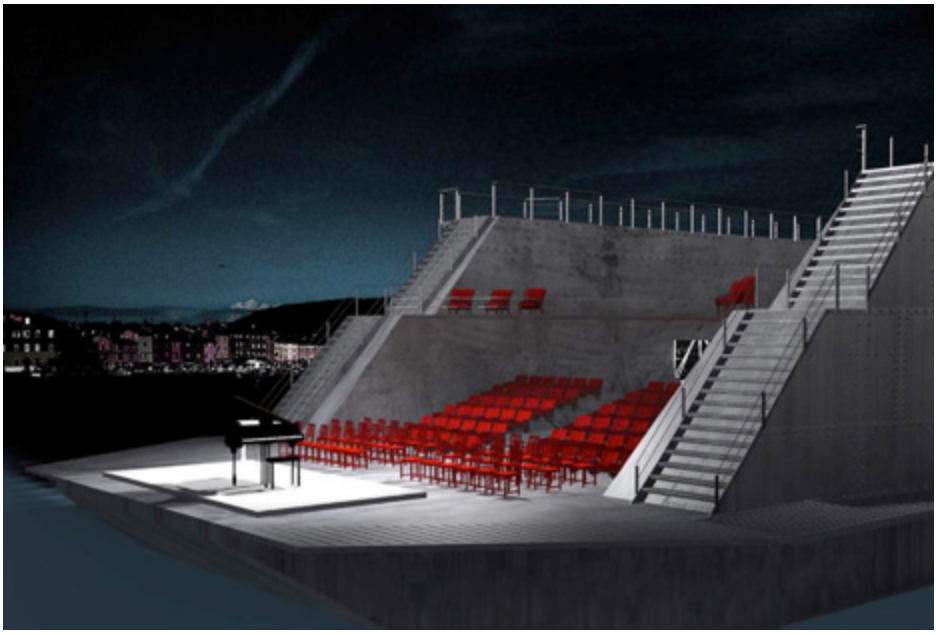
■ *Dock Space – public "street"*



■ *Dock – urban pier and a city space*



■ *Dock – a "theatre type of set up"*
The dock space is envisaged as a changeable and flexible – "theater-set up" type of configuration – with movable elements and screens, either on rails or wheels, that can adapt to multi-purposed and varied use.



■ *Dock Culture – A "terrace" area, located at the far end of the dock, restored and lit, with its central position could become a new focal point in the middle of the city bay.*



■ *The floating dock maintains a strong visual presence in the city, with a deep connection to one of Cres' core narrative – a narative of shipbuilding industry and ships.*

Thanks and acknowledgements

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SAŽETAK

Projekt ocrtava način na koji bi dok mogao biti transformiran, nanovo promišljen arhitektonski i kroz predloženu promjenu namjene integriran u okviru grada kao urbani sloj, artefakt koji prenosi autentičnu priču u sklopu kulturne povijesti.

Dok je zamišljen kao plutajući „živući muzej", objekt sam po sebi povijesni centar za posjetitelje, predstavljajući istodobno novu platformu za raznovrsne dodatne sadržaje. Prezentiran je potencijal za integraciju ovoga povijesnog objekta, u nanovo promišljenoj arhitektonskoj formi, u urbanu strukturu grada Cresa ili, alternativno, premještaj na drugu lokaciju.

Važno je razmotriti značenje plutajućeg doka 9 u Cresu kao kulturnoindustrijskog nasljeđa ne samo na lokalnoj razini, već u širim okvirima Hrvatske. Dok 9, konstruiran za Austrougarsku ratnu mornaricu početkom prošlog stoljeća u Puli, ne samo da je najstariji, već je i zadnji postojeći primjerak takva objekta koji je preostao u Hrvatskoj iz toga doba. Dan je opći pregled ključnih trenutaka povijesti doka 9, o čemu ima vrlo malo dokumenata s obzirom na to da je objekt ostao vojna tajna sve dok ga 1983. nije kupila JRM.

Studija ima primarnu namjeru povećati svijest o jedinstvenoj kulturnopovijesnoj i arhitektonskoj vrijednosti ovog objekta razumijevanjem kojega će se povećati mogućnost da ovaj posebni objekt, koji sada zaboravljen pluta u Creskom zaljevu, dobije nov život, očuva se kao dio kulturnog nasljeđa i ostane u središtu sadašnjega kulturnog života.

Ključne riječi*: plutajući dok, kultura, Austro-Ugarska, Cres, revitalizacija, urbana platforma, urbana integracija*

THE TORPEDO'S EVOLUTION

Evolucija torpeda

Peter Webberley*

SUMMARY

During the Napoleonic wars, Robert Fulton experimented with a naval mine and called it a torpedo after a fish that is able to give an immobilising shock simply by being touched. Hence the first torpedo was an explosive moored charge that would detonate on impact. Later that name was given to any explosive device, which could be laid right against the target without the use of a gun.

The first locomotive torpedo was invented in 1865 by Captain Johann Luppis of the Austro-Hungarian Navy. This was clockwork device, guided by steering lines. Luppis turned to his friend Robert Whitehead to improve the device. Whitehead produced a spindle shaped weapon 4.2 metres long by 35.5 cm. diameter that required no control lines. It was demonstrated to the Austrian Government who considered it should be adopted by the Austrian Navy.

An important figure in the Royal Navy was Commander John Fisher. He urged the Admiralty to set up a special committee to 'establish the theory and practice of torpedoes'. In 1872 he was appointed to HMS Excellent *experimenting and testing torpedoes. Fisher was later to become Admiral of the Fleet.*

The Admiralty bought the rights of manufacture and recognition of the merits of Whitehead's torpedo by the greatest sea power in the world brought orders for torpedoes from France, Italy, Germany and other nations, until every navy of importance in the world was using the Whitehead torpedo.

During WWI Britain operated a blockade of the North Sea and there was a stalemate with the strong British Grand Fleet stationed at Scapa Flow and a second stationed at Portland. The German Fleet were bottled up at Kiel. The frustration of the German sailors caused by inactivity brought about the German naval mutiny that helped in bringing the armistice to end the war.

Keywords: *torpedo, warhead, air motor, propeller and navy*

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SAŽETAK

Za vrijeme Napoleonskih ratova Robert Fulton eksperimentirao je s brodskom minom nazvavši je torpedo po ribi koja pri dodiru može prouzročiti šok iznenađenja. Tako je prvi torpedo bio plovilo ispunjeno eksplozivnim punjenjem koje bi pri sudaru eksplodiralo. Poslije se to ime upotrebljavalo za bilo koje eksplozivno sredstvo koje bi se stavilo na metu bez upotrebe oružja.

Prvi pokretni torpedo izumio je 1865. Johann Luppis, kapetan Austrougarske ratne mornarice. Taj je izum imao satni mehanizam kojim se upravljalo konopcima za navođenje. Želeći usavršiti izum, Luppis se obratio svome prijatelju Robertu Whiteheadu. Whitehead je proizveo oružje oblikovano poput vretena, 4,2 metra dugačko, promjera 35,5 centimetara, za koje nisu bili potrebni kontrolni konopci. Austrijska vlada, kojoj je taj izum prikazan, smatrala je da ga treba preuzeti Austrijska ratna mornarica.

Komandant John Fisher bio je tada važna osoba u Britanskoj kraljevskoj mornarici. Potaknuo je Admiralitet da osnuje posebno povjerenstvo koje je trebalo „postaviti osnove teorije i prakse torpeda". Godine 1872. dodijeljen je ratnom brodu (Njezina Kraljevskog Veličanstva) Excellent *kako bi ispitivao torpeda i eksperimentirao njima. Fisher ja poslije postao admiralom Ratne mornarice.*

Admiralitet je kupio prava za proizvodnju, a to priznanje koje je Whiteheadovu torpedu iskazala najveća pomorska sila u svijetu dovelo je do narudžbi iz Francuske, Italije, Njemačke i drugih zemalja, sve dok se sve važne mornarice svijeta nisu počele koristiti tim torpedom.

Za vrijeme Prvoga svjetskog rata Britanija je uz pomoć snažne britanske Velike flote koja je bila stacionirana u pomorskoj bazi Scapa Flow i druge flote stacionirane u Portlandu provela blokadu Sjevernog mora na kojemu je došlo do zastoja. Njemačka flota bila je opkoljena u Kielu. Frustracija njemačkih pomoraca do koje je došlo zbog nedostatka djelovanja, dovela je do pobune Njemačke mornarice, koja je pak pridonijela uspostavi primirja kojim će završiti rat.

Ključne riječi: *torpedo, bojna glava, zračni motor, propeler i mornarica*

INTRODUCTION OF TORPEDO BOATS

Uvođenje torpednih čamaca

Peter Webberley*

SUMMARY

With the introduction of steam power, naval warfare changed dramatically. No longer under the dictates of the wind, vessels could manoeuvre at will. The introduction of rifled cannon firing explosive shells meant that ships could fight from a distance. This caused a major change to the strategy. The introduction of iron ships allowed them to be longer and faster, so a new type of navy was born. In 1859, the naval architect John Scott Russell outlined its requirements as: – The Man of War (Battleship), The Single Great Gun Boat (with the introduction of the torpedo to replace the gun – the Torpedo-boat) and The Many Large Gunned Cruiser (Battle Cruiser).

Yarrow designed the first torpedo-boat, developed from the fast river launches he built, small class-II boats, speed 14 knots for sheltered waters and longer class-I speed 17 knots for ocean use. These were sold firstly to Argentina, but later to the world's navies, especially Russia. The Royal Navy was slow in adopting torpedo-boats but by 1889 it possessed 156 boats. The total of the world's navies was 1248 boats. Yarrow was always the foremost torpedo-boat builder.

In 1893, against strong French competition, Yarrow built two class-II boats for the French Navy. To save weight he built them of aluminium. French shipyards appealed to their government that they could have built them, but the reply was that they had not offered aluminium boats.

The final means of launching torpedoes took time to develop. Initially they were dropped from a davit type arrangement. It was not until 1880 that torpedo tubs were invented. Even then they were fired in the traditional broadside manner. It was almost thirty years before they realised that over the bow gave a cleaner, easier and better launch for small ships.

Key words: *The torpedo's revolution, Torpedo, Warhead, Air motor, Propeller and Navy*

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SAŽETAK

Uvođenjem pogona na paru način ratovanja na moru iz temelja se promijenio. Plovilima se sada moglo manevrirati po želji jer više nisu ovisila o diktatima vjetra. Uvođenje topa sa žljebovima koji gađa eksplozivnim granatama, značilo je da se brodovi mogu boriti na udaljenosti. To je dovelo do temeljne promjene strategije. Brodovi su postali dulji i brži kad su se počeli graditi od željeza, tako da je rođena nova vrsta ratne mornarice. Godine 1859. brodograditelj John Scott Russel zacrtao je što se od mornarice traži: ratnik (bojni brod), brod s jednim velikim topom (uvođenjem torpeda koji je zamijenio top – torpedni čamac) te krstarica s više velikih topova (ratna krstarica).

Yarrow je konstruirao prvi torpedni čamac koji je razvio iz brzih riječnih čamaca koje je izgradio. Bili su to mali čamci II. klase, brzine 14 čvorova za zatvorene vode te duži čamci I. klase, brzine 17 čvorova za oceane. Ti su se najprije prodavali Argentini, a poslije i drugim svjetskim ratnim mornaricama, posebno Rusiji. Britanska kraljevska mornarica bila je spora u prihvaćanju torpednih čamaca, međutim 1889. posjedovala ih je već 156. Ratne mornarice u svijetu imale su ukupno 1248 čamaca. Yarrrow je uvijek bio na prvome mjestu po izgradnji torpednih čamaca.

Godine 1893., usprkos snažnoj francuskoj konkurenciji, Yarrow je za Francusku ratnu mornaricu izgradio dva čamca II. klase. Da bi uštedio na težini, izgradio ih je od aluminija. Francuska brodogradilišta žalila su se svojoj vladi govoreći da su ih oni mogli izgraditi, ali su dobili odgovor da nisu ponudili čamce od aluminija.

Bilo je potrebno vrijeme da se razvije konačan način lansiranja torpeda. U početku su ih ispuštali s neke vrste dizalice za čamce. Tek je 1880. došlo do izuma torpedne cijevi. Čak i tada su ispaljivani na tradicionalan način, s boka čamca. Prošlo je trideset godina prije nego što se shvatilo da je lansiranje čišće, lakše i bolje ako se obavlja preko pramca.

Ključne riječi: *revolucija torpeda, torpedo, bojna glava, zračni motor, propeler i mornarica*

POLA FLOATING DRY-DOCK, THE DOCK THAT NEVER GOT TO POLA

Pulski plutajući suhi dok – dok koji nikad nije stigao u Pulu

Rienko Wilton*

SUMMARY

It was not only in the Rijeka area with its torpedo tests where the Austro-Hungarian Navy deployed its activities at the time, but also more to the south in Pola (Pula), where its main Navy-base and shipyards where located and where a growing need for docking facilities for battleships was felt. So in 1913, a special floating drydock was ordered, so big that it could not be built locally, only abroad, and that was at the German shipyard Blohm & Voss in Hamburg. It was complete in the May of 1915, too late to be towed by sea-tugboats all the way to Pola because of the outbreak of World War I a year earlier, and therefore it never got there. The immense drydock of 46,000 tons, at the time one of the largest in the world, stayed in Hamburg idle but unharmed by the war till 1920.

Enters my grandfather*, naval engineer John Henry Wilton, who at the time owned and ran (with his 2 brothers) Wilton Shipyards in Rotterdam, then already Holland's largest shipyard. With the financial support from the main shipping company in Rotterdam, the* Holland Amerika Lijn*, my grandfather* bought *the Pola Drydock in 1920 and had it towed from Hamburg up the Rhine/Maas river to Rotterdam, tripling Wilton's docking capacity in one stroke; from now on Wilton had the facilities to repair and build even the largest ocean liners and warships in Holland itself instead of having it done in England or Germany.*

The Pola drydock was in use for lifting many of famous ships at Wilton-Feyenoord Shipyards in Schiedam long after the death of my grandfather (1934) and father (1955) and was sold to Turkey only a couple of years ago. I grew up at my grandfather's shipyard and played as a young boy in the Pola dock, only at weekends of course, and then only when there was no ship in it. But I can still smell it.

Keywords: *Austro-Hungarian Navy, Pola, immense drydock – 46,000 tons, grandfather naval engineer John Henry Wilton, shipyard*

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1. INTRODUCTION

This is the story of an extraordinary floating dry-dock, the Pola-dock. Not built in Pola at the Adriatic coast of what was then still Austria-Hungary, but constructed in Germany of Kaiser Wilhelm II at that great shipyard Blohm &Voss in Hamburg. This shipyard was specialized in and had already built a number of increasingly larger floating dry-docks at the turn of the century. As such, the Pola-dock was part of a group of 3, one could say "sister-docks".

The first to be built – in 1914 – was the 40.000 t. dock for the German navy in Wilhelmshaven, where is was extensively used in during World War I, but then included to be handed over to Britain as war reparations after Versailles. For one reason or another this did not happen – bad weather most probably made a successful transport of the dock from Wilhelmshaven over the high seas to Britain impossible in 1920 and the dock stayed behind in Wilhelmshaven. In hindsight regrettable because 20 years later, in the last months of 1940, the Royal Air Force tried unsuccessfully to hit the same huge dock in which no less than battleship "Tirpitz", sister of the "Bismarck", docked regularly as she was fitted out at the Wilhelmshaven navy yard. So this time after World War II the Allies made sure that the huge dry-dock was indeed removed and towed from Wilhelmshaven to the navy shipyard Rosyth in Scotland in June 1946, the dock's fate after that unknown.

The second 40.000 t dock to be built by Blohm&Voss was ordered by the Ottoman navy, scheduled for 1918, and therefore never built. The third 40.000 t. dock was the Pola-dock, by far the most intriguing of the 3 "sisters" because – anno 2016 – it is still with us.

The dock was named because it was built *for* Pola, for the Imperial and Royal Austro-Hungarian Navy that had its major base there. The navy-base and the city of Pola, the greater Istria peninsula and its strategic position is described in its historical context as a real bone of contention between Italian irredentism, (pan) Slavic nationalism and declining Austro-Hungarian imperial power on the eve of the Great War. All this is discussed in chapter 1 to 4.

The Pola-dock – built to serve war-ships – was duly prevented in reaching its final destination due to the early outbreak of World War I. It stayed in Germany for a few years and came – by virtue of Dutch entrepreneurship and by a narrow margin of luck – into possession of Wilton's shipyard in Rotterdam.

There as Wilton's Dock IV – everybody still called it "the Pola dock" – it played a decisive role in the lives of my grandfather, great-uncles, father and uncle. The dock also employed tens of thousands of foremen, workers and dockers for more than 80 years. These years are described in chapters 5, 6 and 7. The World War II years and thereafter, including the final destination of Pola-dock is dealt with in chapter 8.

2. POLA'S HISTORY AND STRATEGIC LOCATION

Austria's rise as a proper sea-power started after the Vienna Congress in 1815, when the Empire obtained Venice, Istria and coastal Dalmatia. Real understanding of the strategic importance of the newly acquired lands and its possible naval implications was only recognized after some time. And even then the admirals and bureaucrats could not decide among themselves what the best location should be to develop Austria's major naval base: Venice (when it was still Austrian), Trieste, Fiume/Rijeka or Pola.

In the beginning of the 19th century Pola was an out-of-the-way little fishing village, on the site of an ancient Roman port with a magnificent amphitheatre. Surrounding swamps made it unsuitable for a naval base. And yet little by little it was realized that Pola – with its natural harbour and its almost ideal strategic position in relation to the east coast of Italy and for the protection of Trieste – could with the necessary extensive infrastructure in place, become the ideal major naval base for Austria, later Austria-Hungary.

The development of Pola as a naval base has been strongly influenced by amongst others, 2 Austrian Archdukes, a brother and a nephew of Emperor Franz Josef, and by numerous foreign experts who served in the Austrian administration or military, on a temporary basis.

The latter was Dane Hans Dahlerup, who as Vice Admiral in Austrian service, tried rather energetically to reorganise its country's Navy around 1850 – but had to give up only after two years because of an apparent incompatibility between North-European efficiency and the more relaxed Austrian/Adriatic temperament. Difference in mentality might have played a lesser role with the more technical foreign experts in Austrian service: in the late 1850's the Frenchman Eugene Sandfort became Head of the Austrian Navy's Corps of Engineers as successor of the Dutchman Scheffer and the Swede August Ljungstedt.

A dominant even vital role in the development of the Austrian-Hungarian Navy and of its major naval base Pola, was played by Emperor Franz Josef's younger brother Archduke Ferdinand Maximilian, the later Emperor of Mexico, who was Navy Commander from 1854 – 1864.

Under his command Pola's arsenal, shipyard and other basic naval facilities were built and its coastal defence fortified. In almost all his independent naval activities Ferdinand Maximilian enjoyed the cautious backing of his brother, which became more apparent when the Emperor formally decreed the fiscal separation of the Navy from the Army effective from 1857 onwards.

This led to the establishment in 1862 of the Ministry of Marine in Vienna – responsible for both the merchant marine and for the Navy – separate from the Ministry of War. By freeing the Navy from Army control – not only financially – and by introducing sweeping reforms – better training and new warships

(some of them partly screw-driven), Ferdinand Maximilian accomplished more than any of his predecessors.

The importance of Pola as an ideal navy base, in strategic terms, was clearly demonstrated in the 1866 war when the Austrian admiral Tegetthoff attacked a numerically superior Italian squadron of ironclads laying in waiting near the island of Lissa. The Italians lost 2 capital ironclads, Tegetthoff's squadron, partly consisting of still wooden ships, lost none.

Another royal strong supporter of the Navy – and thus also of the Navy base Pola and its infrastructure – was Archduke Franz Ferdinand, since 1896 Heir presumptive to the Austro-Hungarian throne. Although he never served on a ship of the Navy, Franz Ferdinand was appointed Admiral by his imperial uncle in 1902. Even without a formal naval command, the Archduke did everything in his power – and he could work miracles – to promote the Navy interests in circles of government, parliament and in the public domain.

From an obscure tiny fishing village at the beginning of the 19th century, Pola evolved over the years into Austria-Hungary's main Navy-base – with an almost perfect natural harbour, and with the Brioni Islands as roadstead for assembled ships nearby. By 1914 Pola had become a full fletched modern port with a navy shipyard and all its modern facilities, including fuel and coal storages and a railway connected with the hinterland for supply. Coastal artillery, torpedo-launching stations and patrol ships made the harbour almost impenetrable from the Adriatic Sea.

3. DOCKS IN POLA. A GERMAN POLA DOCK.

The strength of a naval base is measured not only by the number of navy ships it can harbour and supply, but also by the capacity of its docks – the space to repair and build war ships.

As for Pola it was Navy commander Archduke Ferdinand Maximilian who laid the first cornerstone for a new arsenal – the Staatsarsenal Pola – in 1856 and commissioned an American firm to build its dry-dock, which at the time was to be constructed from wood.

Within 20 years two graving dry-docks (see Figure 1) with gates and steam-pumps were built at Oliven Insel, the same dock where capital ships like the Turret Ship S.M.S. Kronprinz Erzherzog Rudolf (1887) of the Austro-Hungarian Navy were built and repaired. At the end of the 19th century the first iron floating dry-dock appeared in Pola's harbor. Larger ones followed, eventually with a lifting capacity of 15.000 tonnes. In 1911 this reached 22.500 tonnes.



■ **Figure 1.** *Turret Ship* S.M.S. Kronprinz Erzherzog Rudolf *in graving dock, Pola, circa 1880*

By then Austria-Hungary was already involved in the European Naval arms race, triggered by the introduction of a completely newly designed Dreadnought Battleship by the Royal Navy. Vienna's answer was the pre-dreadnought Radetsky-class, to be followed by 4 "real" dreadnoughts of the Tegetthoff-class, built between 1911 and 1914. The S.M.S. Tegetthoff and her 3 sister-ships were built later than many of the early British and German dreadnoughts, and although smaller and less well armed than their contemporaries in other countries, they were ahead in some aspects of design (especially compared to both the Italians and the French navies). This was evident by its modern equipment like the Marconi wireless and placing small anti-aircraft machine-guns on top of the ship's four 12-inch triple main-artillery turrets.

Even larger dreadnoughts, the Monarch-class, measuring 26.000 GRT, were planned but never built due to the outbreak of World War I.



Figure 2. *Battle-ships of the Austro-Hungarian Navy in Pola harbour 1914*

The entire Austro-Hungarian navy (see Figure 2) could be docked for repairs in Pola, its largest floating dry-dock of 22.500 tonnes lifting capacity. And yet in 1913 the navy still saw it fit to order a larger floating dry-dock with a lifting capacity of more than 40.000 tonnes. Was this an "airy castle/pipe dream" or simply good planning? The fact is at the beginning of the 20th century the rapidly growing civilian shipbuilding capacity in Austria-Hungary had already contributed highly to the strengthening of the Imperial and Royal Navy prior to World War I.

Major Austrian shipyards like Stabilimento Technico Triestino, Cantierre Navale Triestina at Monfalcone, the Danubius-, Lazarus-, and Whitehead shipyards in Fiume/Rijeka could build a range of craft from small ships to battleships, destroyers, sub-marines and torpedos. And yet the order to build the new mega-dock of 40,000 tonnes did **not** go to an Austrian shipyard at the Adriatic Sea, but to a German one, Blohm & Voss in Hamburg.

This decision caused an uproar in the Austro-Hungarian iron industry, leading to the Minister for Trade being questioned in the Parliament in Vienna. A lack of time – no Austrian shipyard could guarantee delivery of the dock in time – and a price difference of more than half a million Kroner were cited to justify the order going to Hamburg.

Blohm & Voss was selected, because the shipyard had experience in building mega floating dry docks quickly. In 1909 it built its own 46.000 tonnes dock, and started five years later a similar-size floating dry-dock for the Kaiserliche Werft, Wilhelms- haven. As noted before, this dock was actually a sister dock of the future Pola-dock built in 1915, which was offered to the Austro-Hungarian Navy at a relatively low price. We learned already that a third

sister-dock was planned – for the Turkish Navy – but was never built (see chapter 4).

Mega-docks, like the one for the German Navy in Wilhemshaven, are built in sections. Like thick slices of a cake they are built individually in a dry-dock or on a slipway, and then launched and put together into one big solid floating structure. The construction of the Wilhelmshaven-dock took only 14 months: The Imperial Navy Shipyard had its floating dry-dock ready on 1 June 1914, two months before World War I broke out.

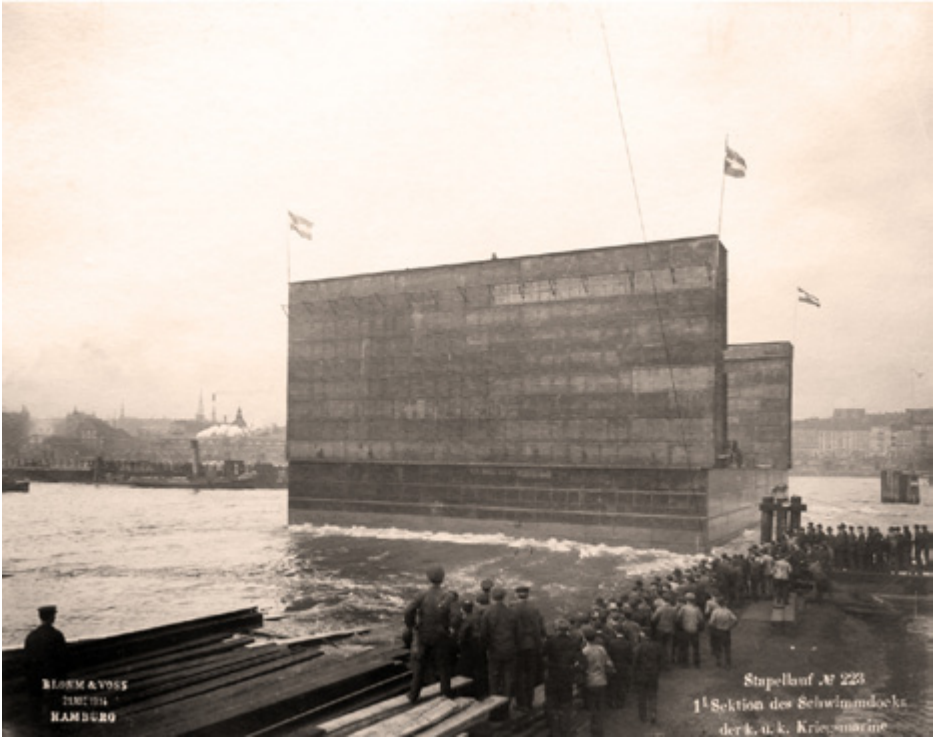


Figure 3. *First Section of Pola-dock after its launch at Blohm&Voss shipyard in Hamburg, 1914*

Work on the sister dock, ordered by the Kriegsministerium in Vienna for its Navy base in Pola, started around March 1914. Only 2 of the 6 sections were ready (see Figure 3) when the Great War broke out in August of that year. The giant dock was finished in May 1915, and it never reached its final destination in the Adriatic waters. To tow a dock of that size over the high seas would have been suicidal – one would sail via the North sea, Channel, Gibraltar, the Mediterranean, where the Royal Navy was waiting to strike any time – into the Adriatic where the Italian Navy also lay ready after Italy's declaration of war on Austria-Hungary on 23 May 1915. So the floating giant with a lifting capacity of more than 40.000 tonnes – by now generally called the Pola-dock – became the dock that never got to Pola.

4. NAVAL ARMS RACE. MEDDLING IN TURKISH WATERS

A similar situation – a dominant Royal Navy giving chase to a (potential) enemy in the waters of the Mediterranean – took place about 1 year earlier in the summer months of 1914. To get the full picture we should go back to the general naval arms race, set in motion by the introduction of the dreadnaught battleship in the 19-tens. The Ottoman Empire, could not resist taking part in the race – the Sublime Porte felt threatened by Greece and Italy – and ordered 2 dreadnaughts to be built by Vickers shipyard in the United Kingdom in 1913. A natural choice as Britain was, with its naval mission in Turkey, directly involved in the much needed modernization of the antique Ottoman Navy since the beginning of the 20th century.

Work on the 2 Turkish battle-ships at Vickers – named already "Rashadieh" and "Sultan Osman I" – progressed slowly, and in July 1914, when the clouds of war became menacing over Europe, the Turks became nervous. They demanded that the Turkish flag should be hoisted on "Sultan Osman I" on the 2nd of August during a special ceremony, and that a Turkish crew should take over the ship from Newcastle. Yet on the 1st of August, British troops took action at Vickers shipyard and forced the Turkish navy crew to evacuate their 27.500 GRT battleship, which the Turks had paid for, by the way, in full.

On the 3rd of August the First Lord of the Admiralty, Winston Churchill, declared that the 2 ships had been "taken over" by Britain, without compensation, because the Ottoman Empire "was allied with Germany". Formally this was questionable; Turkey was at that moment still neutral and certainly not at war with England. The seizure of the 2 dreadnaughts by Britain caused a shock in Constantinople. The pro-British Navy minister Djemel Pascha protested in vain to Admiral Limpus, Head of the British Navy mission in Turkey, whereas the pro-German War minister Enver Pascha spoke about "British treachery".

In the summer of 1914, a cat-and-mouse game was going on in the Mediterranean between a far superior Royal Navy and the Imperial German "Mittelmeerdivision", consisting of the battle-cruiser "Goeben" and light-cruiser "Breslau". Although the German admiral Wilhelm Souchon was outnumbered by the British, his "Goeben" (see Figure 4) was 2 to 3 knots faster than the battle-cruisers of his potential enemy. Still Souchon's ship was plagued by defective coal-fired boilers that leaked water, causing loss of steam power and consequently a slower run of the turbine-driven propellers. So, to be fully prepared for action, Souchon took the "Goeben" all the way to *Pola* for repairs. Austria-Hungary, being Germany's closest ally, could offer full protection for the German Battle-cruiser in its mayor Navy base Pola, which was also easily accessible overland to the experts and technicians from Blohm & Voss, where "Goeben" was built 2 years before.

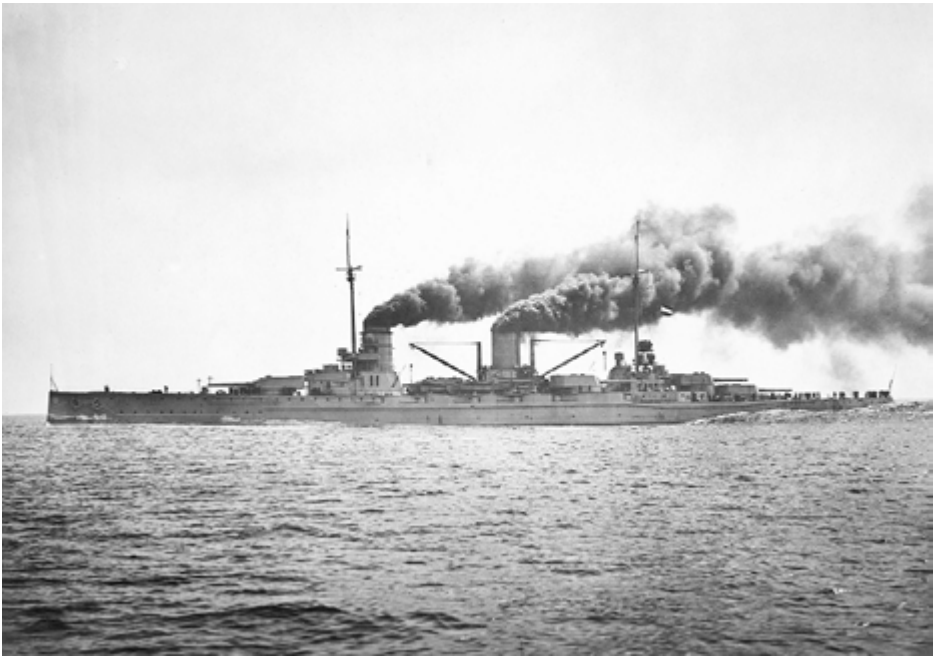


Figure 4. *German Battle-cruiser Goeben at full speed*

With the outbreak of war in the first days of August, and with repairs of Goeben's boilers still unfinished, Admiral Souchon was forced to leave Pola head over heels. After shelling the cities Philippeville and Bone on the French-Algerian coast, Souchons squadron did not do the obvious thing and head west to try and escape via Gibraltar to the Atlantic Ocean. Instead – on Berlin's orders – the squadron secretly steamed eastwards in the direction of Constantinople "in order to persuade the still neutral Turkish government to enter the war on Germany's side".

After taking on coal from German merchant colliers in the (neutral) Italian port of Messina in the middle of the night, and thanks to several tactical blunders of the Royal Navy, Souchon could escape further eastwards. He kept his British pursuers literally in the dark where he was going. The British Admiral believed that the fast German ships would either flee into the Adriatic and take shelter under Pola's coastal defence artillery or try to threaten even the Suez-canal. Souchon did neither of the two, he simply met with his next German coal-ship in the Aegean Sea and unobstructed by tailing British cruisers that did not dare to attack because of their inferior gunning range, he arrived safely at the Dardanelles and asked permission to enter the Turkish Straits.

When German diplomats in Constantinople got word of the arrival of "Goeben" and "Breslau" they persuaded the hesitant Turks to allow the German warships to at least enter the Capital's harbour. Thereafter German diplomacy had no difficulty reminding the Turks that Britain had recently broken a con-

tract to supply 2 new battle-ships for the Turkish Navy by simply seizing and incorporating them in the Royal Navy. Germany now was prepared to provide the Turkish Navy with the ships it needed, meaning the "Goeben" and "Breslau". After some negotiations Constantinople agreed to "purchase" the battle-cruiser and light-cruiser from Germany.

The ships retained their German crews and officers – from now on in Turkish uniforms though – and were renamed "Yavuz Sultan Selim" and "Midilli". Admiral Wilhelm Souchon was appointed as commander of the Imperial Ottoman Navy, marking growing German domination in Turkish Navy affairs that would last on until the end of the Great War. On 30 October 1914, Turkey officially joined the war on the side of Germany and Austria-Hungary.

Great efforts on the part of the German *private* shipbuilding industry to get a foothold in Turkey in co-ordinance with the new close cooperation between the 2 Imperial Navies of the 2 Central Powers, were not crowned with success. On the contrary. Founded in 1916, the "Deutsche Osmanische Werften Gesellschaft" (DOW) – in which German shipyards like AG Weser/Bremen, Germaniawerft/Kiel, Vulcan-Werke/Hamburg, Schichau/Elbing and the leading Blohm & Voss/Hamburg – joined forces in offering German expertise in naval infra-structure and shipbuilding to Turkey, with the aim of optimal German involvement in all processes. Plans were worked out to upgrade/modernize existing infra-structure in Turkey – like the Imperial Arsenal – and to build a complete new shipyard.

Because of structural procrastination on the part of the Ottoman government, the plans never bore fruit. But eventually in early 1917 a contract for the construction of a large floating dry-docks could be concluded with the Turkish Navy. The Imperial German government and Navy supported the new development whole heartily by approving, despite the shortage of steel in Germany, that construction of the dock could start on short notice. Material orders were placed and actually delivered at the constructing shipyard Blohm & Voss. Even Turkish cabinet-ministers showed polite interest. Both War Minister Enver Pascha and Navy Minister Djemal Pascha paid working visits to Blohm&Voss. The War Minister showed particular interest in the Hamburg shipyard because the flagship of the Turkish Navy "Yavus Sultan Selim" (ex-Goeben) was built there in 1911-1912.

At Djemel Pascha's visit to Hamburg, the Navy Minister certainly didn't witness any actual building activity of the ordered floating dry-dock for the Ottoman Navy. The 40.000 t dock was to be built in 6 sections – perfectly designed and planned already with the B&V-yard-nrs. 355-360. Yet construction never started because of the armistice negotiations and subsequently unfortunate end of the Great War for the Central Powers. Apparently till the very last moment, even after the disastrous Turkish raid on Imbros and Lemnos in which the pride of the Turkish navy with "Midilli" sunk and "Yavuz Sultan Selim" damaged, the management of Blohm & Voss had silent hopes to be able to start the construction of the Navy-dock for Turkey.

This dock – significant in this context – was in design and measurements an exact copy of the Pola-dock and the dock build in 1914 for the German Navy in Wilhelmshaven. Add similar dry-docks of this size, which Blohm & Voss built for several private shipyards in Germany itself, and one could speak of an internationally orientated and discretely diplomatically motivated flow-production of mega-dry-docks managed by the famous Hamburg shipyard.



Figure 5. *Pola-dock finished at Blohm&Voss in 1915*

For the duration of World War I, the still brand-new Pola-dock remained in Hamburg where Blohm & Voss used it for its own operations (see Figure 5). The largest Imperial German passenger-ships of that time were serviced here – the Imperator-class "Vaterland" and "Bismarck" both measuring more than 50.000 GRT. Austria-Hungary paid for a dock that never reached its intended destination, used ultimately by its Central ally Imperial Germany. After the war this state of affairs brought about both unexpected opportunities and problems.

5. EXPANDING SHIPBUILDING IN HOLLAND AND THE NEED FOR LARGER DOCKS

Neutral Holland had its own problems with floating dry-docks in the early years of the 20th century. Holland was of course a sea-faring nation, traders and merchants had sailed the seas for centuries. The ports of Rotterdam and Amsterdam became increasingly important for the West-European hinterland during the industrial revolution. It is not surprising that shipbuilding and repair developed considerably during this time in the Netherlands.

Several shipyards were founded in the 19th century in the Netherlands. In 1854 one of them was founded by Bartel Wilton Sr., starting as a forge actually, becoming a small ship repair shop in Rotterdam.

Around 1900, two of his sons had taken over the very fast expanding business: Bartel Wilton Jr. (1863-1938) and my grandfather John Henri Wilton (1869-1934). John Henri studied in Delft as a naval architect and mechanical engineer. In the early days Wilton's shipyard was predominantly a repair yard – this changed quite quickly to include construction. To accommodate the fast expansion of the Wilton shipyard, especially the docking yards and building facilities, a new site had to be found almost every 10 years. Every time these expanding sites would be situated further and further out towards the North Sea, along the Maas/Rhine river. None of the Dutch shipyards – including Wilton's – could build or repair the increasingly larger ships used for the Transatlantic route, which at a time of mass-immigration and expanding trade, was possibly the most busy and profitable route worldwide.

The leading shipping company in Holland was the "Holland Amerika Lijn" – in short HAL – based in Rotterdam. The company wanted have at least a substantial share in the transatlantic shipping business, dominated by British companies like Cunard and White Star, and German companies like Hamburg-Amerika Linie and Deutsche Lloyd. HAL's flagship SS "Rotterdam", for example, had to be built at Harland & Wolff in Belfast in 1907, due to the lack of shipbuilding capacity in the Netherlands itself.

The wish of John Henri Wilton, that mass-scale shipbuilding should become the de facto business of his company – whilst his brother Bartel Jr. wanted to concentrate on ship repair without interference of any big shipping companies whatsoever – eventually led to "informal preliminary discussions on points of mutual interest" between Wilton and the HAL in 1916.

Holland's neutrality during the Great War was a blessing for shipbuilding and even more for the repair industry. Many ships, heavily damaged by sea-mines that would tear their keels apart, were repaired at the Wilton shipyard. The yard even received a number of orders for new ships, more than could be handled due of scarcity of materials. At the end of the war Wilton was finan-

cially able to look for another site for its still expanding shipyard, necessary for shipbuilding and repair alike.

The "deal" that HAL and Wilton made, would entail Wilton buying a site for a complete new shipyard at the Maas/Rhine in Schiedam on the waterway "Nieuwe Waterweg" to the North sea. Wilton would build a double graving dry-dock and a slipway both of at least 200 meters in length, and provide room for a floating dry-dock of at least 35.000-40.000 tonnes lifting capacity. All this would come out of Wilton's own pocket. In exchange, HAL would provide an interest-free loan of Fl. 4.900.000 to buy this huge floating dock, and – by gentlemen's agreement – award Wilton all the repairs and maintenance services of the HAL-fleet in principle, even giving the shipyard priority for building new HAL ships.

This was a deal John Henri clearly did not want to ignore, as it opened many new possibilities for the Wilton company, unheard off a decade before. Bartel Jr. disagreed with the new policies but John Henri's view, supported by his younger brothers Jan Daniel and William – who became co-managing directors in 1906 – prevailed. To cement the agreement between Holland's largest shipping company and Holland's largest shipyard, two HAL-directors, Messrs Rypperda Wierdsma and Van Helden joined Wilton's Board of directors in 1917.

From then on work started to establish Wilton's New Yard in Schiedam. Wilton's Old Yard in Rotterdam would concentrate on the repair of smaller ships. The question now was: where to get a huge undamaged floating dry-dock immediately after the end of the Great War?

6. POLA DRY-DOCK COMES TO HOLLAND

The answer came surprisingly quickly: only weeks after the cease-fire of 11-11-1918, a delegation from the Kriegsministerium in Vienna presented itself at Wilton's shipyard in Rotterdam, offering to sell the so called Pola-dock – that had survived the war undamaged at Blohm & Voss in Hamburg. Henri Wilton certainly showed interest in buying the huge dock: the mastodon fitted perfectly in the company's plans for the near future. But he thought it too expensive, and the transport of the dock from Hamburg to Rotterdam was too risky due to the threat of Allied seizure as war-reparation.

The risk was a reality: German Admiral von Reuter's decision in June 1919 to scuttle more than 80% of his own navy interned at Scapa Flow, angered the Allies to the extent that they demanded an extra 192.000 tonnes of dock- and harbour-infrastructure as additional claim of war reparations. It was clear that these extra sacrifices could not only come from the floating dry-docks of the former-Imperial shipyards in Germany but that the private German shipyards like Blohm & Voss that had the most floating dry-docks, including the Pola-dock, should contribute as well.

In the aftermath of the "negotiations" in Versailles, Rudolf Blohm, representing the "Verein Deutscher Seeschiffwerften", tactically included one of Blohm&Voss largest floating dry-dock's (Dock VI) tonnage in the additional reparations. Later he managed to convince the Allies that though Dock VI was wide enough for the British battleships being built in future, it was now most probably too "short" – and so had his dock stricken from the list of extra demanded war reparations.

Though in the early months of 1920 the Pola-dock was already "available", the Wilton-brothers preferred to wait till July – when the first meeting since Versailles, took place between Germany, France and Britain. The Germans still felt humiliated and subdued, but showed some self-confidence and optimism with the creation of the Weimar Republic. With this climate in mind it seemed favourable to the Wilton- brothers to take a chance.



Figure 6. *Departure Pola-dock from Hamburg 1920*

On the 5th of July Wilton ordered the best of the sea-faring tug boats of the "Internationale Sleepdienst" – Donau, Humber, Schelde, Seine, Thames, Vulcan and Gladiator – to tow the Pola-dock out of the Elbe- estuary at 03.30 hours in the morning, in the direction North sea. At day break all was still peaceful (see Figure 6) but at open sea the weather changed dramatically: heavy showers and winds up to 8 BFT set in, yet these conditions were in fact a great blessing. It made it possible – even with a 40.000 tonnes floating dry-dock in tow – to pass the still patrolling British Destroyers near Helgoland. Wilton was still not sure whether the British would consider the sale of the dock as legal. The winds at

sea even increased to 10 BFT and it seemed for a couple of hours that the dock would sink.

Only by pumping 13.000 tonnes of water into the compartments of the dock, did it become more manageable for the tug boats to tow their cargo. The storm later subsided to 8 BFT and the runners could finally start to pump out some of the water in ballast. To make matters worse, a fog cloud engulfed the Pola-dock and its surrounding tug boats, whilst at the same time finding themselves in the middle of a mine-field! After hours of uncertainty, the big Dutch light-ship IJmuiden came into view, and after a real odyssey of 3 frightful nights and days, the Pola-dock finally "sailed" up the Nieuwe Waterweg to Rotterdam, cheered on by thousands enthusiastic Dutchmen – welcoming one of the biggest floating dry-docks in the world (see Figure 7).



Figure 7. *Safe arrival of Pola-dock in Holland*

It is interesting to note that some Dutch and German sources interpret the events surrounding the sale of the Pola-dock differently. Prager in his "Blohm & Voss" contends (p. 116) that the dock was "saved" from British war-reparation claims because the dock was legally sold to Wilton *before* the Treaty of Versailles was signed – implying that Wilton made the deal before June 1919.

Dutch sources (Bouman – "Wilton-Fyenoord History" & Brusse – "Wilton 1854-1929") contend that the sale took place in 1920, after Versailles, but before the dock was towed from Hamburg to Rotterdam in July of that year. According Wilton family lore, after the safe delivery of the Pola-dock in the Netherlands,

not the 2 familiar Austrian officials from the Kriegsministerium in Vienna showed up in Wilton's office to collect the money – but some 12 delegates from several (new) states, once part of the Austro-Hungarian Empire.

7. HEYDAY AT WILTON'S: THE DUTCH TITANIC

Holland Amerika Lijn's (HAL) investment in Wilton's purchase of the Pola-dock was a wise one – it guaranteed docking-facilities for all its existing ships in its homeport Rotterdam. For Wilton, having the Pola-dock enabled them to offer docking facilities to even the largest ships in the European arena. This was unique in Holland, and it contributed greatly to the international reputation of the company. Up until the late 1960's Wilton remained the largest shipyard in the Netherlands, ranking in the top 10 largest in the world. It was both logical and symbolic that the first ship to be docked in the Pola-mastadon was HAL's flagship S.S. "Rotterdam" (see Figure 8). She was built in Belfast and serviced in docks in Southampton – because it could not be done in Holland – but now times and fortune had changed. As the Pola-dock – considered a technical wonder at the time – became renowned in Holland, Cabinet-ministers came to inspect and admire it, as did H.M. Queen Wilhelmina in September 1921.

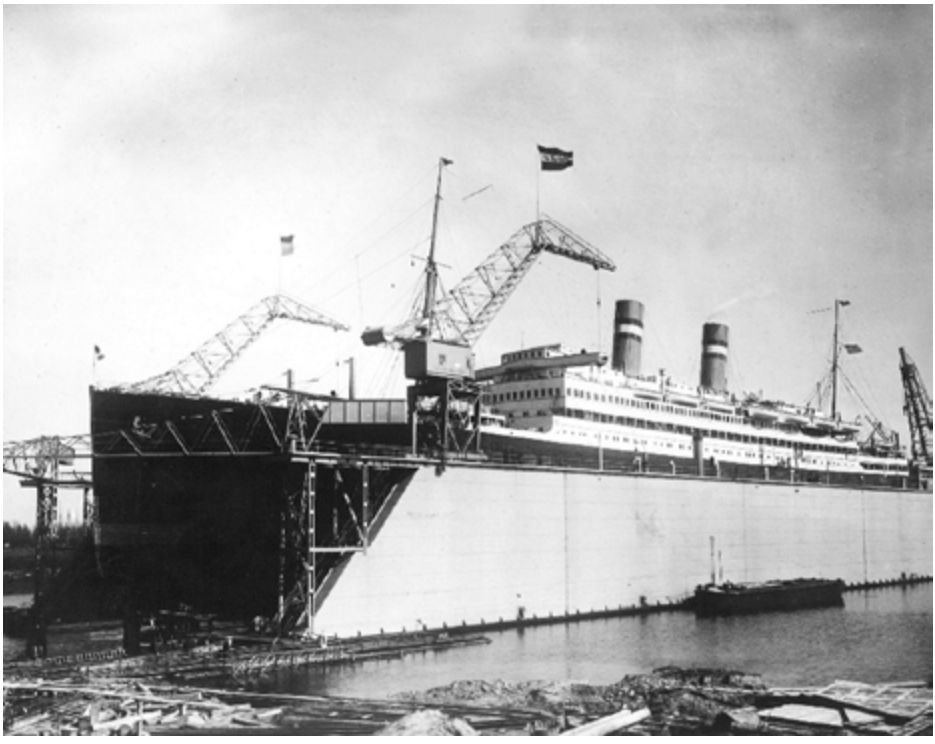


Figure 8. S.S. Rotterdam *of Holland-Amerika-Lijn in Pola-dock 1920*

During the almost 80 years it was in Wilton's harbour, hundreds of ships have passed through the Pola-dock – for servicing, repair or even completion of a vessel.

Special cases were the T.S.S. "Laconia" of the Cunard Line, built by Swan & Hunter at Wallsend-on-Tyne in 1922. Because of extended strikes in shipyards in England, Wilton was asked to complete construction of the Laconia and did so in the Pola-dock in exactly one month – instead of the 5 weeks Cunard had requested. When T.S. "Paris" of the Compagnie Transatlantique sustained damage when sailing into Le Havre, she was repaired in the Pola-dock (see Figure 9) because Wilton guaranteed to finish the job within 2 weeks, which in the end even became 2 days earlier. In 1926 "Paris" was the largest ship ever (34.569 GRT) to sail up the Nieuwe Waterweg to Rotterdam.



Figure 9. T.S.S. Paris *of the Compagnie Transatlantique in Pola-dock 1926*

But the real coup de theatre was John Henri Wilton's completing of HAL's "Statendam III"; he had the unfinished hull of the 28.291 GRT vessel towed from Harland & Wolff in Belfast to Rotterdam. The ship had been under construction since 1919 in Belfast, but after her launch in 1924 was never completed due to the huge political and social problems in (Northern)-Ireland at the time.

This story of the Statendam began with HAL's ambition, already apparent in the 1910's, to own a flagship as big as the giants of that time. Only superliners of 45.000 GRT, like the "Titanic" would do. In May 1911, after the Titanic's launch from slipway nr. 3 at Harland & Wolff, the keel for a new superliner was immediately laid. This time not for the White Star shipping company but for the Dutch HAL. The ship to be built was named "Statendam II" and was literally a smaller version of the "Titanic", not 45.000 GRT but 32.234.

The real drama is that "Statendam II" was in fact "a ship that never was". When she was finished, World War I had already broken out and since Holland was neutral in 1914-1918, HAL could only charter out the brand new Statendam II to the British government. The Allied powers would otherwise have commandeered the new Dutch ocean liner.



Figure 10. *Poster of* Statendam III *of Holland-Amerika-Lijn*

The British renamed her "Justicia" and fitted her out as a troop-transport ship. As such she was an easy target for the navies of the Central powers and indeed, German submarines found her en route from Belfast to New York – luckily without troops that is – and torpedoed her not far from the North Irish coast on 20 July 1918. 4 months before Armistice Day, Statendam II/Justicia, the ship that never sailed in HAL colours and under the Dutch flag, joined her sister Titanic on the bottom of the seas.

It may be Dutch stubborness, but not so long after the war finished, HAL ordered a *new* flagship to be built. She was to be a replacement for the lost Statendam II/Justicia, again to be built at Harland & Wolff in Belfast.

The British government provided 60.000 tonnes of steel and plate-work in compensation for the new liner, named "Statendam III". Again she was a copy of the Titanic, in design and construction, if not in tonnage: 29.000 GRT. When the ship was under construction the Holland-Amerika-Lijn HAL started a real public relation campaign in order to "sell" is new flagship to the international public (see Figure 10).

In 1927 it became clear that HAL preferred to have Statendam III completed in Holland, instead of having her half finished, idle moored at the Belfast shipyard. HAL managed to raise the necessary funds for completing the Statendam III at its "sponsored" Wilton shipyard in Schiedam. The Pola-dock was almost tailor-made for the job, even too big for "Statendam III". On the 20th of April 1927 she arrived in Wilton's harbour as a hull in tow (see Figure 11) all the way from Belfast, cheered on by thousands on the coastal dunes of Holland. She was commissioned in 1929 and in spite of being a 15 year old ship (in terms of design and construction), Statendam III was immensely popular with her passengers from both sides of the Atlantic.



Figure 11. *Unfinished hull of* Statendam III *towed from Belfast on arrival in Schiedam 1927*

She docked very regularly at Wilton's shipyard, once in early 1936 by sheer accident, at the same time as the brand-new flagship of the Royal Netherlands Navy Cruiser "De Ruyter", laying in a smaller floating dry-dock by the side of Pola's, was about to be commissioned. Six years later, leading an allied Navy Squadron, Rear-Admiral Karel Doorman's flagship "De Ruyter" went under with blazing guns in the battle of Java Sea against invading Japanese naval-forces (see Figure 12).

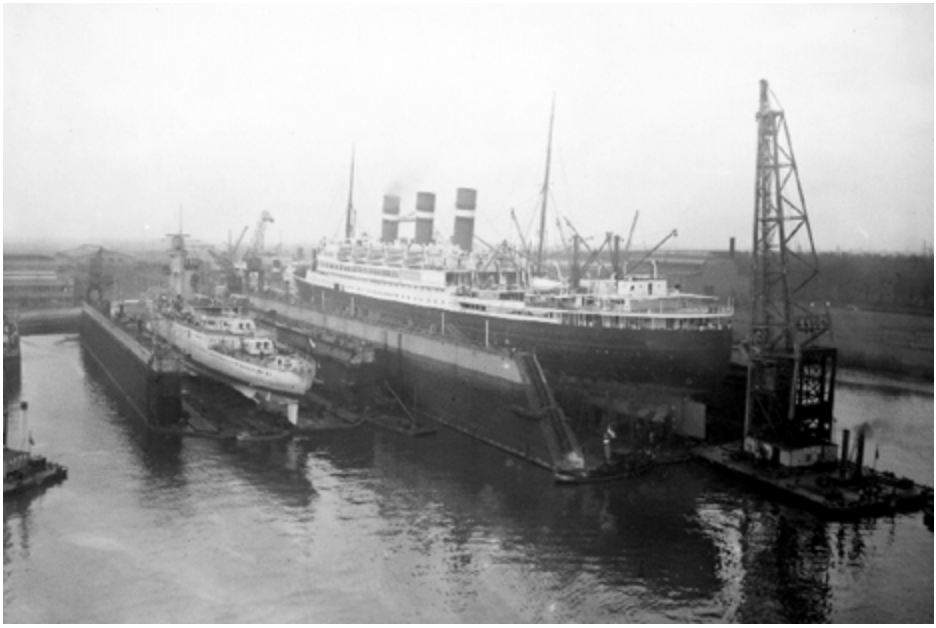


Figure 12. *Finished* Statendam III *in Pola-dock, 1936, in next dock newly built Cruiser De Ruyter, Flagship of the Netherlands Navy that went under at the battle of Java Sea in 1942*

8. WORLD WAR II AND RECONSTRUCTION. FINAL DESTINATION.

During World War II, the German occupying forces tried to keep the Wilton-Fijenoord shipyard in business, by forcing them to build small ships for Nazi-Germany, with limited success. The company was now called Wilton-Fijenoord, because in 1929 Wilton had merged with the much older Rotterdam based shipyard.

The Allies considered both Wilton shipyards in Rotterdam and Schiedam legitimate military targets, and so the Pola-dock was hit by by Allied bombs on 5 separate occasions between 1941 and 1943 (see Figure 13). Only after the liberation in May 1945 did it became clear how extensive the damage was. It was now partially sunken, and a lack of finances and material – dismantled by

the occupier, later pillaged – made reconstruction of the Pola-dock a long term affair. Though technically highly complicated, 5 of the 6 sections of Pola-dock could be repaired by Wilton-Fijenoord while the shipyard Gusto built a complete new section. On the 11th of April 1950, in a totally renewed Pola-dock, the first ship to be docked since the end of World War II was HAL's newest flagship of 36.287 GRT "Nieuw Amsterdam" (see Figure 14).

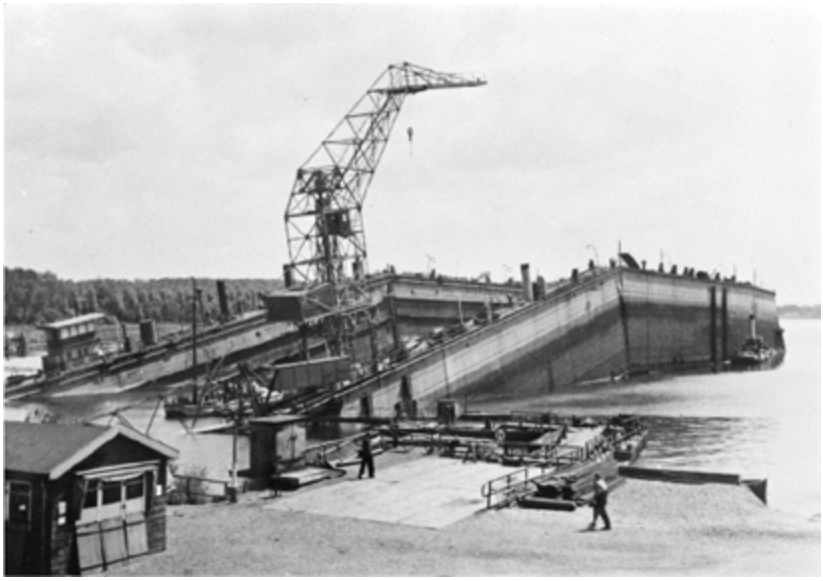


Figure 13. *Bomb damage in World War II at Pola-dock 1945*



Figure 14. *Nieuw Amsterdam, new Flagship of Holland-Amerika-Lijn in repaired Pola-dock 1950*

In the years that followed, development and expansion in the shipping industry went so quickly that the Pola-dock received new pumps and was lengthened up to 252 meters. This increased the dock's lifting capacity with a couple of 1000 t.

After a long and loyal service of almost 80 years – a "sailor's lifetime" – , the Pola-dock left Wilton harbour in 1999 to continue as a floating facility at its new home, the shipyard Damen. From there, in 2004, it was sold to a company in Turkey. They had the dock transported over sea by the huge semi-submersible "Boabarge 19", towed in parts by the sea-going tug "Englishman", making a speed of 7 knots. Like before, 1 or 2 sections of the Pola-dock were taken out – as big slices of a cake – and put into the main dock during the transport over sea.

More than a century ago the Pola-dock failed to be towed into the Adriatic sea to reach Pola. Yet now it "sailed" above the waves through the Aegean via Gallipoli into the Marmara Sea towards Istanbul. As her sister-dock, planned but never built at Blohm&Voss in 1918, was supposed to have done: towed all the way to and serving in Turkey.

Presently the Pola-dock is Dock I of Desan shipyard in Tuzla (see Figure 15), reportedly in full glory, good shape and serving order – not for Austro-Hungarian battleships but for super tankers of the 1990's. Not bad for a structure of 104 years old, a great compliment to the German (and Dutch) shipyards that built and maintained it in the first place all these years. I grew up at my grandfather's shipyard and *played* as a young boy in the Pola-dock in the early 1950's. Only at weekends of course, and when there was no ship inside. But I can still smell it.

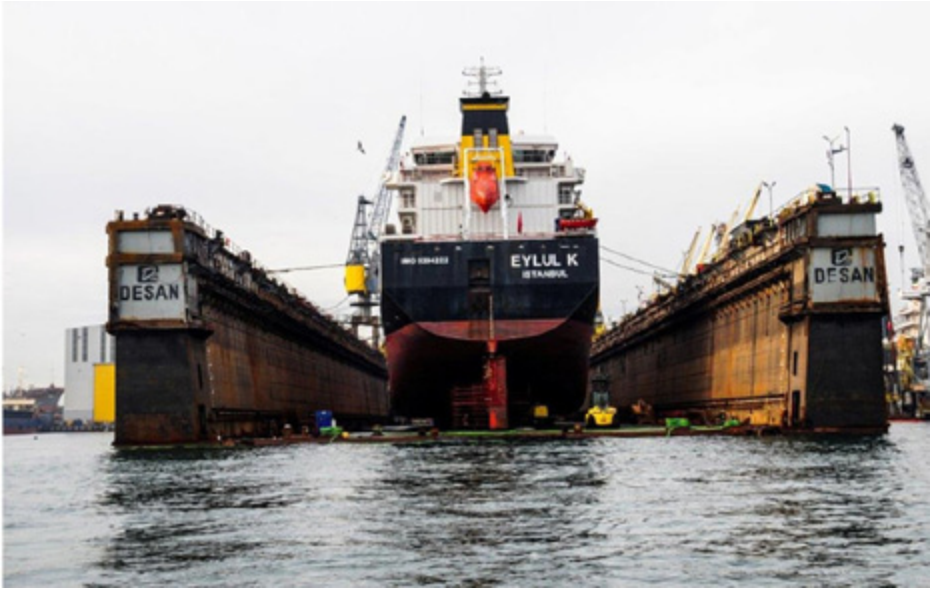


Figure 15. *Pola-dock at Desan Shipyard, Tuzla/Istanbul, Turkey 2016*

GRT = Gross register tonnage; refers not to the weight or displacement but to the total *volume* of a ship. 1 GRT= 2,8 cubic meters.

T = in this essay refers to the lifting capacity of a floating dry-dock

BFT = Beaufort Wind Force Scale, ranging from 0 (sea like a mirror) to 13 (hurricane).

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SAŽETAK

Austrougarska mornarica nije djelovala samo u Rijeci u kojoj se testirao torpedo, već i u Puli gdje je bila njezina glavna baza i brodogradilište i gdje se osjećala sve veća potreba za dokovima za ratne brodove. Tako je 1913. naručen poseban plutajući suhi dok, tako velik da se nije mogao tu izgraditi, već jedino u inozemstvu, odnosno u njemačkom brodogradilištu Blohm & Voss *u Hamburgu. Dovršen je u svibnju 1915., prekasno da bi se teglio morskim putom do Pule zbog izbijanja Drugoga svjetskog rata godinu dana prije, tako da tamo nije nikad ni stigao. Golem suhi dok od 46.000 tona, u to vrijeme jedan od najvećih na svijetu, ostao je u Hamburgu neiskorišten, ali ga ni rat nije oštetio, sve do 1920.*

U igru tada ulazi moj djed, inženjer brodogradnje John Henry Wilton, koji je u to vrijeme bio vlasnik i upravljao (zajedno s dva svoja brata) brodogradilištem Wilton Shipyards *u Rotterdamu, već tada najvećim nizozemskim brodogradilištem. Uz novčanu pomoć glavne brodarske kompanije u Rotterdamu the* Holland Amerika Lijn*, moj je djed kupio pulski suhi dok 1920. i dao ga tegliti od Hamburga do Rotterdama rijekama Rajnom i Maas, utrostručujući tako jednim udarcem kapacitet doka. Otad je brodogradilište* Wilton *popravljalo i gradilo i najveće oceanske linijske i ratne brodove u samoj Nizozemskoj, umjesto da ih da izgraditi u Engleskoj ili u Njemačkoj. Pulski suhi dok korišten je za podizanje mnogih poznatih brodova u brodogradilištima* Wilton-Feyenoord *u Schiedamu dugo nakon smrti moga djeda (1934.) i oca (1955.), a prodan je Turskoj tek prije nekoliko godina. Odrastao sam u brodogradilištu svoga oca i kao dječak igrao se u pulskom doku, naravno samo tijekom vikenda i kada u njemu nije bilo broda. Ali još uvijek osjećam njegov miris.*

Ključne riječi: *Austrougarska mornarica, Pula, golemi suhi dok od 46.000 tona, djed, inženjer brodogradnje John Henry Wilton, brodogradilište*

THE INFLUENCE OF TORPEDO OPERATION ON SUBMARINE

Utjecaj djelovanja torpeda na podmornicu

Maik Wunsch*, Herwig F. Brun**

SUMMARY

The presentation sets out the systems and arrangements which have to be provided on board of submarines to enable the operation of torpedoes. The types and arrangement of the launching devices are shown and the advantages and disadvantages of the different solutions are discussed. The possibilities for the placement of the torpedoes into the torpedo tubes and the pressure hull and as well their handling are described for smaller and larger submarines. The design features of torpedo tubes including the tube closures, adjustment and guiding devices are set out and the principles for torpedo flow respectively torpedo discharge are explained. Hydraulic systems are used if large forces and torques are required and noise emissions to be avoided, e.g. for the operation of mouth flaps or the handling of spare torpedoes.

The operation of torpedoes affects also the floating behavior of the submarine. What is needed are facilities for weight and trim compensation through appropriate volumes and arrangement of regulating/compensating tanks, trim and torpedo tanks. For the water management between these tanks more auxiliary equipment, such as pumps, air compressors, pumping and drainage facilities are needed.

The electrical system is fed by various air dependent (diesel generators) and air independent (nuclear power, special motors, fuel cells) power generators via the batteries of the submarine. In the context of this presentation the system is needed for electric drive of pumps, compressors, switching devices, controllers and control channels. In the operations room, the consoles shall be so integrated that the commanding officer has always a good overview of the entire operative situation.

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In particular observations by the sensors as well as the actual drive data of the submarine (course, speed, depth) are to be considered and the necessary calculations to be performed "in time".
The content of the presentation is demonstrated by 9 pictures.

Keywords: *submarines, torpedo storage/handling, torpedo tubes, torpedo run out and ejection systems, auxiliary sub-systems for torpedos*

1. INTRODUCTION

When designing a military submarine naturally the possibilities for storage and operation of the torpedo as main armament have to be optimized. This optimization has to be braught into line with the other technical and structural requirements of the boat.

Normally so-called heavy torpedoes with up to 2 tonnes in weight and 533 mm caliber are used. They generally have a negative static buoyancy up to abt. 0.5 t. That means their displacement is around 0.5 t less than their weight.

Missile armament, hoistable devices at the tower etc. etc. are – in accordance with the subject of this conference - not considered in this paper.

2. TYPES AND ARRANGEMENT OF LAUNCHERS

The designer may select from the following options.

2.1. Types

- Torpedo tubes as an integral part of the pressure hull

  Torpedoes can be loaded from inside or outside the pressure hull (latter in surfaced and trimmed condition).

- Torpedo tubes outside the pressure hull

  Torpedoes are mounted waterproof; if not only storage is intended for later, emerged reloading into the boat interior, but launch has to take place directly from the torpedo tube, a re-adjustment of the torpedo is technically complex and maintenance during mission is impossible.

- Launching racks outside the pressure hull

  Torpedos are exposed to seawater; there is a risk of corrosion; maintenance and during mission is problematic. This option corresponds no longer to „state of the art".

2.2. Arrangement (see Fig. 1)

- Torpedo tubes in the bow area in exact longitudinal alignment with the boat; Standard arrangement consisting of a group of 2 - 8 tubes, welded in the front end of the pressure hull, leading through the exostructure and seated at the torpedo supporting bulkhead.
- 1 to 4 torpedo tubes at the stern in exact longitudinal alignment with the boat and launching astern; aft assembly on older boats usually above propellers and rudders; for better controllability of torpedoes and boat propulsion by a large propeller nowadays no longer up to date.
- Torpedo tube or launching rack with lateral angle to boat axis, the latter may be swiveled out. For example assembly 7 – 8 degrees from the longitudinal boat axis to get free of sonar dome at the bow (USS Miami) or as side groups launching astern (planned at German Type XXVI).

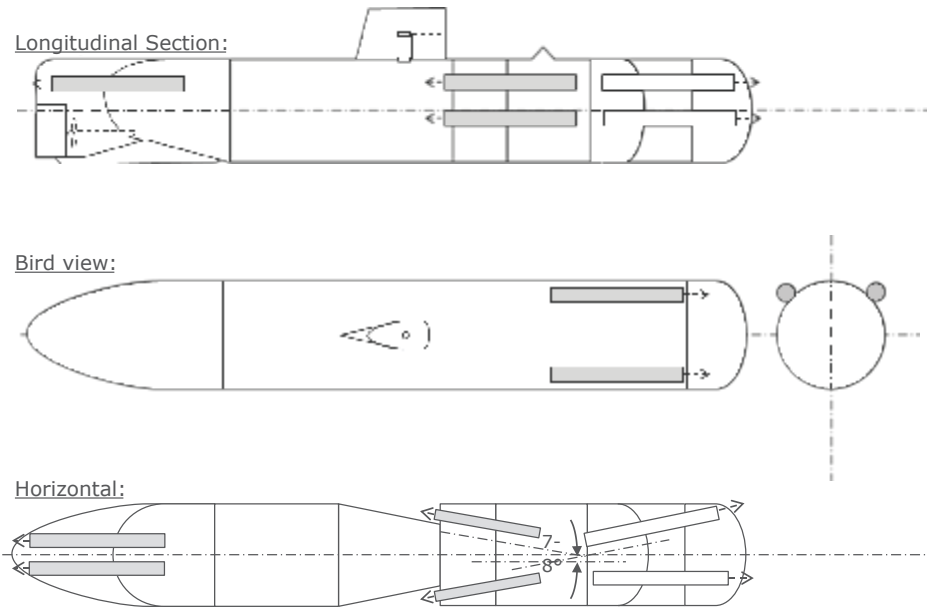


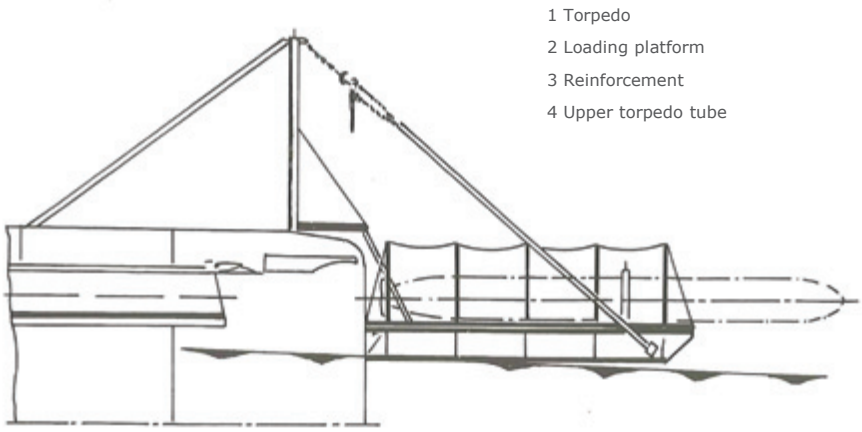
Figure 1. *Possible location for launching torpedo tubes*

3. LOADING AND STORAGE OF TORPEDOES

3.1. Loading into the pressure hull

3.1.1. Muzzle loader principle

For submarines, with limited inside space in front of the torpedo tubes for loading and storage, the torpedo tubes can be loaded with torpedoes from outside. The boat has to be trimmed so that the tube openings come into a position above the waterline. For every type of boat a corresponding takeover rack with movable torpedo troughs is used normally, see Fig. 2.



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Pressure & Underwater Technology – Maik Wunsch

Figure 2. *Loading of torpedos according to muzzle loader principle*

For arrangements with more than 4 torpedo tubes, normally the upper torpedo tubes are used to take the torpedoes into the boat. Torpedos are then braught from the upper tubes by means of transport devices inside the boat to the torpedo tubes below the waterline. For this purpose, it may be necessary to obtain the necessary space by dismantling the furnishing temporarily. Therefore furnishing elements should be of modular design.

3.1.2. Larger submarines

For larger boats with a torpedo storage space in front of the torpedo tubes a torpedo hatch in the pressure hull with inclination to the horizontal is used. The torpedo hatch is similar to a main hatch and as an elementary part of the pressure hull it has to be equipped inside and outside with pressure and shock-resistant hatch covers. See Fig. 3.

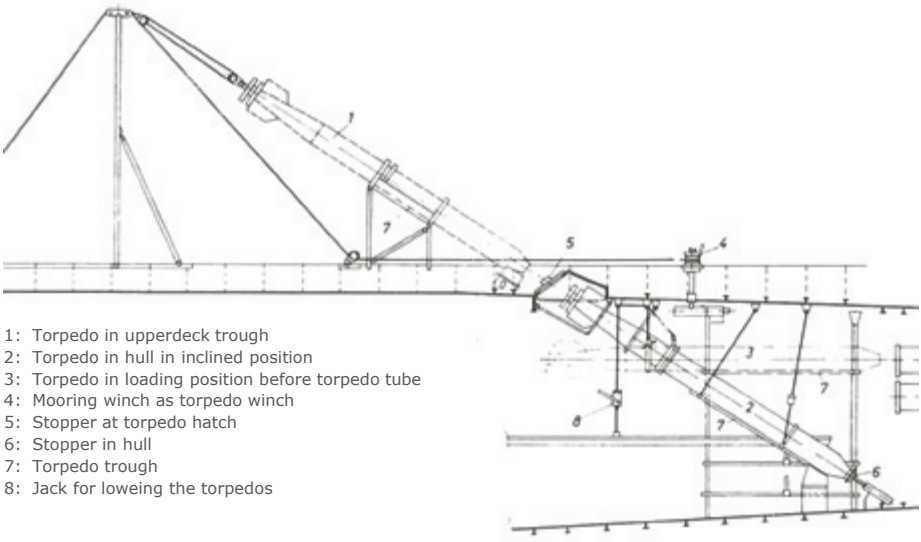


Figure 3. *Loading of torpedos via torpedo hatch*

On the upper deck of the boat a rack has to be built up temporarily with the same slope as the axis of the torpedo hatch and continuation into the torpedo storage space. From land or a supply ship the torpedos are to be put on this rack by a crane and internally lowered by a winch or a hydraulic device. Inside the boat the torpedos are taken over by a lifting element and braught into a horizontal position. Here especially weight and acceleration forces have to be observed for the individual movement situations and stowage positions.

3.2. Storage and handling (see Fig. 4)

3.2.1. The loaded torpedoes are to be fixed in the designated troughs so that they can withstand all loads occurring during dynamic operation of the submarine. Through horizontal and vertical transport, it must be possible to position the desired torpedo type behind each torpedo tube. If necessary, the torpedo can be loaded via a hydraulic or mechanical traversing unit (via chains or rack gear) into the torpedo tube. For the stowage and use at sea particularly the acceleration forces by operating in the seaway and the effects of the trim and heeling are to be considered. Unless otherwise specified, accelerations of 2 g m/s^2 in direction vertically downward and of 1 g m/s^2 in directions vertically upward, longitudinally and laterally may be assumed.

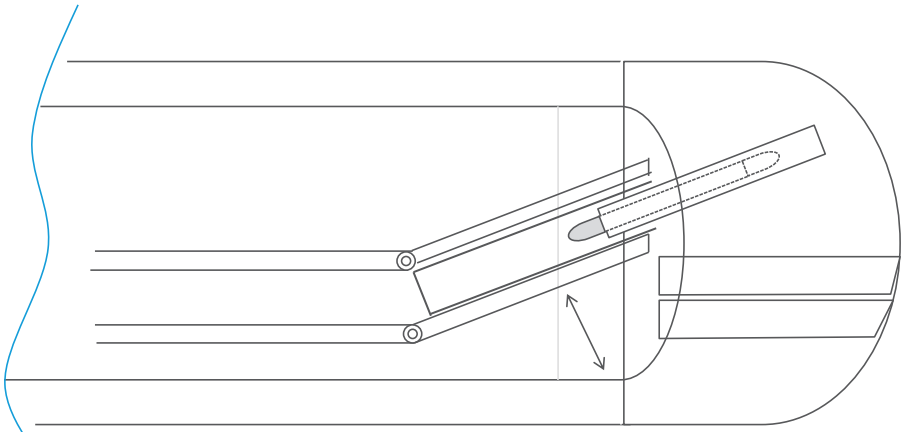


Figure 4. *Torpedo loading and storage*

3.2.2. For the calculation the following operating modes have to be considered:

- Permanent unrestricted operation of the inner system (transfer of stored torpedoes etc. / internal loading) should be possible up to abt. +/- 15 ° heel and +/- 10 ° trim.
- A holding position (system in operation / torpedo at defined end, stowage and loading points) should briefly be possible up to abt. +/- 45 ° heel and up to +/- 30 ° trim.
- In the permanent storage position (system out of service) the torpedos are permanently fixed by tie-down or by holding elements).
- For storage of lightweight or sectionwise torpedos appropriate materials and adequate reinforcements are installed to cover the influence of external loads.

3.2.3. An exact alignment of torpedoes to be traversed is indispensable nowadays.

Through complex and lightweight design of torpedoes even a slight deviation of this alignment can lead nowadays to damage or loss . As an aid to determine the exact positioning in front of the torpedo tube, the optical method by means of laser on a reticle plate has been proven. Here the torpedo, which is lying on the transfer and storage system, has to be so positioned that the laser is in coverage with the loading mark on the reticle plate.

4. DESIGN FEATURES FOR TORPEDO TUBES

4.1. Integration of the torpedo tubes in the submarine structure (see Fig. 5)

Torpedo tubes are elementary components of the pressure hull. Therefore, they are to be designed and calculated taking into account all load cases of the pressure hull. The torpedo tubes are subject to a high test and surveying effort in accordance with construction and classification rules, e.g. of DNV GL.

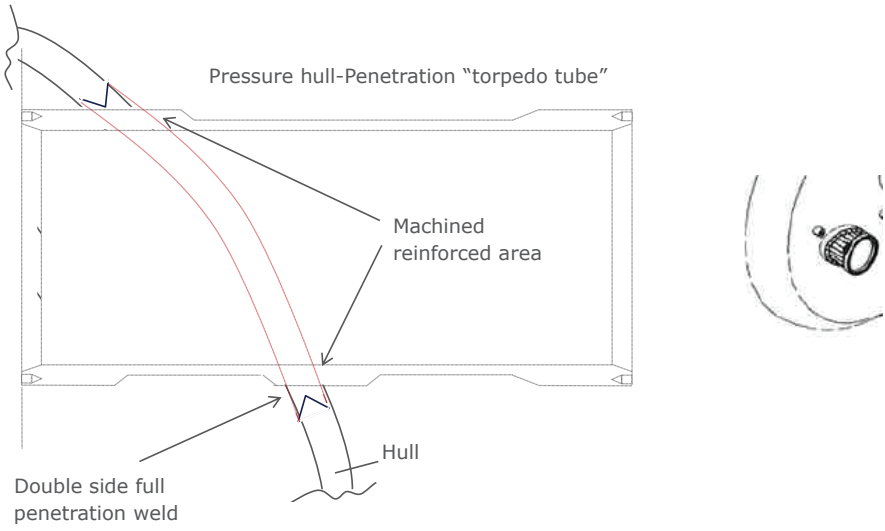


Figure 5a. *Integration of torpedo tubes in hull structure*

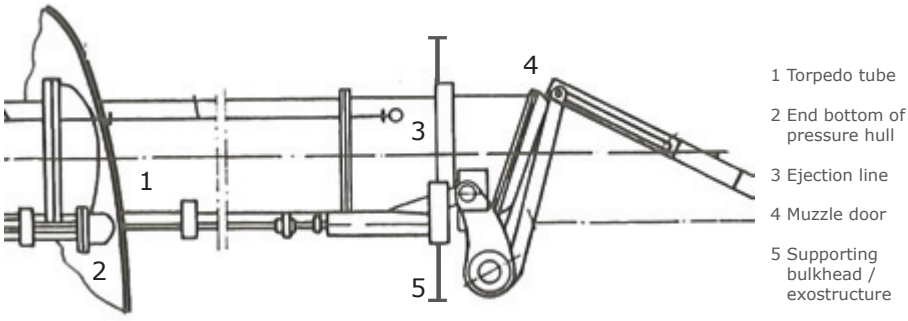


Figure 5b. *Penetration of PH and linkage for muzzle door*

Normally two thirds of length are outside the pressure hull and areintegrated in torsionally rigid way tot he exostructure. Due to influence of seawater on corrosion it is important is to ensure that the different materials have similar electrical properties.

4.2. Tube construction

In case of open muzzle door (equalization of inside and outside pressure) the tube is stressed by inside pressure according to diving depth. The torpedo tubes outside the pressure hull are mainly stressed by diving pressure from outside and should be strengthened by outside frames.

Here the same construction requirements as for the pressure hull apply, e.g. strength of materials, requirements for the welding performance, defined weld material, tested additives, proved welding procedures, approved welders etc. Since the outer area is difficult to access during later operation, there special corrosion protection measures are indispensable.

4.3. Tube closing devices

4.3.1. Torpedo tubes have a muzzle door which opens outwards against the water pressure and seals normally by a rubber gasket. If the muzzle door cannot be adapted to the streamlined shape of the submarine, a flooded trap is to be arranged. This trap is connected to the muzzle door plug by an arrangement of rods. The drive of door and trap is done from inside the boat by lever and spindles which are driven mechanically or hydraulically.

For torpedos without remote steering, the muzzle door can be closed after the launch and preparation for a new launch can start. To unwind the control wire for wire-guided torpedos muzzle door and trap have to remain open during the torpedo run. After completion of this mission the wire is cut by a mechanical device.

4.3.2. The torpedo tubes inside the boat have a manually operated internal lock which opens into the boat interior. Here an interlock mechanism for preventing the simultaneous opening of the muzzle door and the internal lock is installed. As a rule, the internal lock is blocked by a linkage with the muzzle door and the trap, so that only one of the two closures can be opened. A sealing of the internal lock is effected by rubber profile or plane sealed by a bajonet locking device.

4.3.3. For torpedo tubes arranged entirely outside the pressure hull in the exostructure, generally a muzzle door is sufficient. It shall be dimensioned to withstand outside pressure and in the case of the torpedo launch the muzzle door is to be operated from inside the boat.

4.4. Adjustment and control system

The torpedo tubes have to enable the adjustment of running depth, shot direction and other drive parameters of the loaded torpedo before shot. This was carried out for a long time by mechanical methods. Nowadays, electric or electronic input sub-systems are used with a cable connection to the weapon control system of the submarine. For non wire-guided torpedoes the necessary cable connections will be cut-off at launch.

For wire-guided torpedoes a change in the target parameters is possible throughout the entire mission. The fine control wire must uncoil from within the torpedo tube. The necessary penetrations of the torpedo tube are to be designed pressure-proof / shock resistant. See also classification requirements, e.g. DNV GL.

4.5. Torpedo run out principle

If a torpedo tube is formed as a so-called flow or run out tube, the diameter of the tube is increased in relation to the torpedo diameter and guardrails are to be provided. For the torpedo shot the drive is activated by the propellers. Thus the torpedo leaves the tube under its own power and with increasing speed.

Advantage of this principle is that no acoustically detectable shooting swell arises and a runout is possible without depth limitation. The extra weight is relatively low and production easy.

The disadvantage is a relatively large volume of casing surrounding water between inner wall of the tube and torpedo and the weight change associated with it, see 5.2.

4.6. Torpedo ejection principle

With this principle, the torpedo is ejected with high speed and then accelerated to its final speed by its own drive. For this purpose, several methods have been developed:

- Ejection by compressed air produced in the boat with a pressure above the resulting ambient pressure of the position-related water depth. Adverse effects are e.g. air bubbles and acoustic signatures that can allow locating of the boat position. This type of ejection has been applied by the end of the 1st World War.
- Indirect ejection moves a piston in the tube by compressed air and the piston pushes the torpedo out of the torpedo tube. After the shot, the piston is pushed back by the external water and compressed air passes through an air flap into the boat interior. Thus no swell occurs at the water surface, but this method may be used only near the water surface. The tubes must be manufactured very precisely due to the piston guide, are heavy and relatively

expensive. Therefore the required structural and mechanical effort is very high. This method has been used, among others, by the German submarines of World War 2.

- Ejection with compressed air where the torpedo is in a larger tube with guide rails and only sealing is done in front. Once the torpedo passes through the end sealing point, the air pressure is lowered slightly under the actual diving pressure. If the torpedo has completely left the tube seawater penetrates into the tube and pushes back the ejection air through a flap into the boat interior. There is almost no air swell. Again, a shot is possible only in limited depth. The tube is relatively easy and cheap to manufacture, since only the sealing point must be accurate.
- Ejection with pressurized water which is created in special tanks by applying compressed air. There will be no swell of water and a shot is possible from greater depths. The disadvantage here is that the extra weight is greater than that for the classic pneumatic ejection.
- Ejections with mechanically or hydraulically actuated piston (cable driven or piston arrangement in trombone) behind the torpedo. The torpedo itself has no sealing, but the piston rod of the mechanical drive rod. There will be no swell and a shot is possible from greater depths.
- Today, the swell-free ejection is carried out by means of hydraulic support via a pressure reservoir partially separated from the torpedo tube. For this purpose, the amount of water required for the ejection is suppressed towards the drive side of the torpedo by means of hydraulic pistons. The torpedo is ejected by the generated increased pressure.

5. REQUIRED AUXILIARY SYSTEMS OF THE SUBMARINE

5.1. Means for weight and trim balancing of the boat

After the takeover or delivery of torpedos the weight change is compensated by deballsting or filling of compensating tanks or torpedo tanks. Since generally the compensating tanks are in the boat center of gravity and the torpedos usually before, trim changes are to be equalized by pumping of water between the fore and aft trim tanks.

To counterbalance weight changes various auxiliary systems are available:

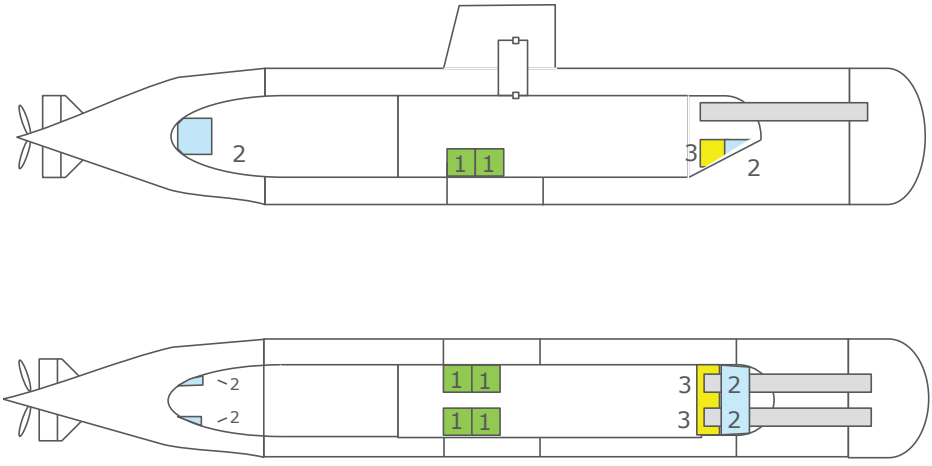
- Compensating tanks: These tanks are normally used to allow fine adjustment of the desired diving depth and to compensate for displacement changes as a result of consumption of provisions and materials, changes in water density, changing of boat speed during an underwater mission and embarkation or delivery of military goods.

- Torpedo tanks: These tanks are intended to compensate the weight of fired torpedoes by flooding and should be placed as close as possible to the center of gravity of the torpedos.

Should this counterbalance of weights involve a shift of the longitudinal boat center of gravity, this can be corrected by trimming tanks. These changes are effected by flood and discharge distributors that are installed usually in the technical control center or partially near the torpedo tubes. Flooding is carried out by the external pressure via pressure hull valves, deballasting by means of compressed air or bilge pumps.

5.2. Water management and torpedo tanks (see Fig. 6)

5.2.1. In accordance with the run out and ejection systems described in 4. the torpedo tube is to be fully or partially flooded before firing and opening the muzzle door. In order not to significantly change the total weight of the boat, flooding takes place from the torpedo tanks. These tanks are arranged within the pressure hull in proximity of the torpedo tubes in order to minimize the possible side effect of a trim change caused by flooding. Miscellaneous trim changes are corrected by the trimmming system of the boat with trim tanks according to 5.1.



1. Compensating tanks
2. Trimming tanks
3. Torpedo tanks

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Figure 6. *Water management for torpedo operation*

5.2.2. After firing of a heavy torpedo with negative buoyancy the water penetrating into the torpedo tube does not fully compensate the torpedo weight. It is therefore necessary to compensate this difference in weight by additional flooding of torpedo tanks with the aim of not changing the flying and trim condition of the whole submarine.

5.2.3. Before a new torpedo may be loaded into the torpedo tube, the muzzle door is to be closed and the water in the tube to be drained to the torpedo tanks.

5.2.4. The volume of torpedo tanks depends on the number of torpedo tubes to be flooded and of the spare torpedos. Depending on the type of runout or ejection the amount of torpedo water between torpedo and inner tube wall can be estimated.

Thus, the volume of the torpedo tanks is given by:

$$V = n \times H + r \times W \ [m^3]$$

n = number of tubes to be flooded simultaneously

H = volume of surrounding water per torpedo tube [m^3]

r = number of spare torpedoes

W = quantity of water corresponding to the weight of the spare torpedoes [m^3]

For complicated load cases further measures are to be taken considering trim diagram and trim polygon. See Fig. 7.

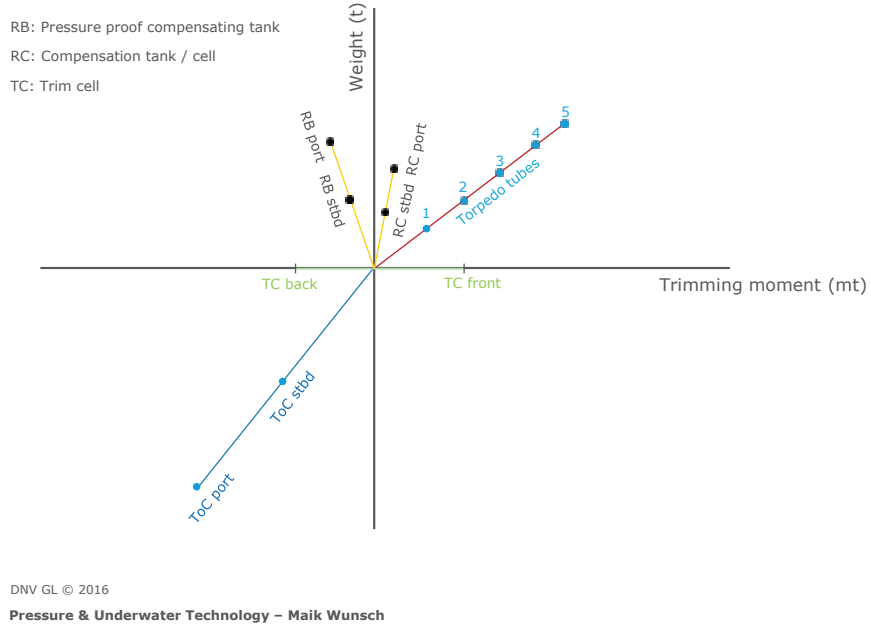


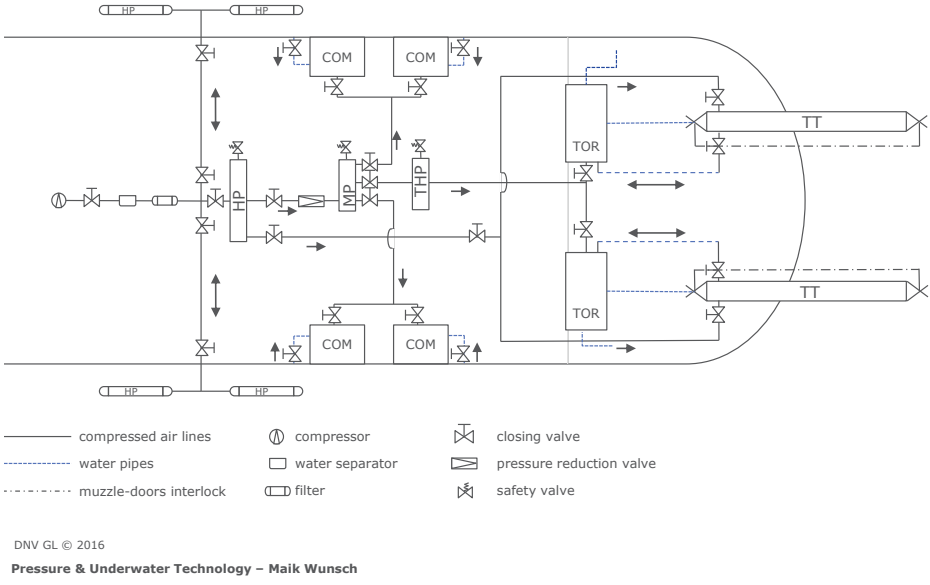
Figure 7. *Trimming diagram*

5.2.5. The transport of water from torpedo tanks into torpedo tubes and vice versa can be accomplished by compressed air (about 2 bar overpressure). This pressure determines, inter alia, the strength design of the torpedo tanks, since they are not exposed to the diving pressure. The pipes between each torpedo tube and the torpedo tanks have closures, which are interlocked with the muzzle door of the torpedo tube. Thus the torpedo tanks can not be flooded with open muzzle door via these pipes. To compensate for the positive buoyancy after a shot own flood lines are provided.

The torpedo tanks are connected to the drainage system of the submarine.

5.3. Other auxiliary equipment

5.3.1. Compressed air system (see Fig. 8)



■ **Figure 8.** *Compressed air system and water system for torpedo operation*

As explained in 4, with many ejection systems compressed air is used to eject the torpedo. Furthermore compressed air is needed for flooding and draining the torpedo tubes and for certain earlier torpedo types also for driving the torpedos themselves.

The compressed air with a pressure up to 250 bar is produced by means of compressors in the boat and stored in compressed air receivers. These receivers can be arranged inside or outside the pressure hull. Most common are four-stage, water-cooled piston compressors which are driven electrically. The weight of the stored air is part of the boat weight and is therefore to be considered for the design of the boat. The compressed air receivers are connected in

groups to the high-pressure manifold. From there, among other things, the system of torpedo high-pressure distribution and the low pressure manifold for operating the torpedo tanks and controllers etc. are supplied.

5.3.2. Hydraulic system (see Fig. 9)

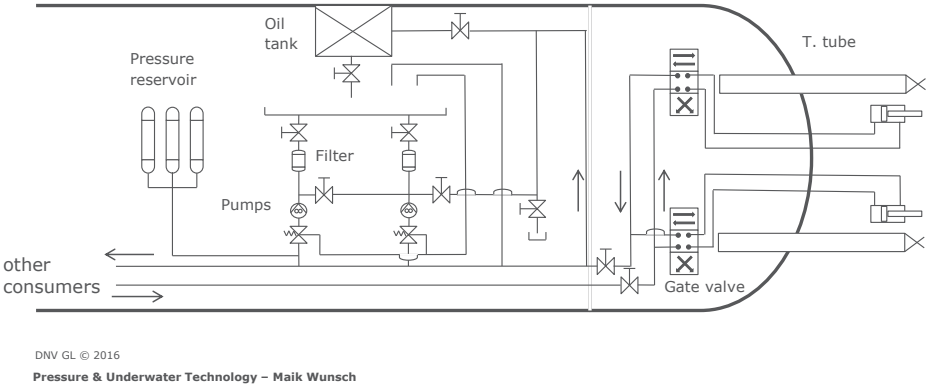


Figure 9. *Hydraulic oil system for torpedo operation*

Hydraulics are used **if** large forces and moments are required and have the advantage of low noise emission. As part of a torpedo plant the system is therefore used for operating the muzzle door or handling of the spare torpedoes etc.

In order to achieve the smallest possible drive performance of the hydraulic pumps even for large consumers, pressure oil accumulators are used. Usually these are technically proven nitrogen bubble accumulators.

5.3.3. Electrical power supply

The electrical system is here mainly needed for the electric drive of pumps, compressors etc. as well as for all kinds of control systems, monitoring equipment and remote control devices.

The onboard power supply system may be fed via the boat batteries by nuclear-powered drives and steam generators, diesel generators, generators with air-independent drives or fuel cells. The AC power required for control systems was formerly produced by rotating converters, but nowadays mostly static converters are applied.

6. WEAPON CONTROL SYSTEMS

The consoles for the weapon control system are to be integrated into the operations centre of the submarine in a way, that the commanding officer has a

good overview of the entire operating situation. The consoles are used as input and output devices which have to implement the following tasks:

- consideration of target data (periscopes, radar, sonar) delivered by the sensors of the boat
- consideration of the driving data of the submarine (course, speed, depth)
- execution of necessary calculations based on the input data

7. CONCLUSIONS

The systems and arrangements which shall be provided on board of submarines to enable operation of torpedoes are set out.

In particular, arrangement and design of the torpedo tubes, their integration into the boat structure, handling and stowage of torpedos, runout and ejection of torpedos, regulation of boat weight and trim by comp ensating, trimming and torpedo tanks as well as other auxiliary equipment are stated.

SAŽETAK

*Ova prezentacija iznosi sustave i njihovu strukturu koje podmornica treba imati kako bi se osiguralo djelovanje torpeda. Prikazani su tipovi i organizacija sustava za lansiranje, a razmatraju se prednosti i nedostaci raznih rješenja. Opisuju se mogućnosti za postavljanje torpeda u torpedne cijevi te u trup podmornice pod pritiskom, a opisano je rukovanje torpedima za manje i veće podmornice. Prikazuje se nacrt karakteristika torpednih cijevi, uključujući poklopce za cijevi, naprave za prilagodbu i vođenje te objašnjavaju načela za protok i otpuštanje torpeda. Hidraulički sustavi koriste se ako su potrebne velike sile i zakretni moment, a trebaju se izbjeći emisije buke, primjerice pri djelovanju zakrilca (*mouth flaps*) ili rukovanju rezervnim torpedima.*

Torpeda svojim djelovanjem utječu i na samo plutanje podmornice. Potrebni su uređaji za kompenzaciju težine i trima putem odgovarajućih volumena i strukture regulirajućih/kompenzirajućih tankova, trim i torpedo tankova. Za upravljanje vodom između tih tankova potrebna je pomoćna oprema poput pumpi, zračnih kompresora, uređaja za pumpanje i otjecanje vode.

Električni sustav napaja se raznim, o zraku ovisnim (generatori na dizel) i zraku neovisnim (nuklearna snaga, posebni motori, gorive ćelije) generatorima struje putem akumulatora podmornice. U kontekstu ove prezentacije potreban je sustav za električni pogon pumpi, kompresora, naprava za paljenje, naprava za kontrolu i kontrolnih kanala. U sobi za djelovanje, konzole trebaju biti integrirane tako da zapovjednik uvijek ima dobar pregled cijele operativne situacije. Posebno se trebaju razmotriti opažanja senzora kao i aktualni podaci o pogonu podmornice (kurs, brzina, dubina) te „na vrijeme" napraviti nužne kalkulacije. Sadržaj prezentacije prikazan je uz pomoć devet slika.

Ključne riječi: *podmornice, skladištenje torpeda/rukovanje, torpedne cijevi, sustavi otpuštanja torpeda, sustavi podmornice namijenjeni torpedu*

SPOMENICI INDUSTRIJSKE BAŠTINE U NACIONALNOM PARKU KRKA – ARHEOLOGIJA, KONZERVACIJA, PREZENTACIJA

Monuments of industrial heritage in the Krka National Park – archeology, conservation, presentation

Nataša Zaninović*, Nataša Mučalo**

SAŽETAK

Koncem 19. i početkom 20. stoljeća rijeku Krku zahvatio je val industrijalizacije. Duž njezina toka izgrađene su od 1895. do 1911. četiri hidroelektrane koje su električnom energijom opskrbljivale grad Šibenik i novosagrađene tvornice i industrijske pogone, u prvom redu SUFID u Šibeniku (Crnica) i ugljenokope u Siveriću. To su HE Krka (1895.) i HE Jaruga na Skradinskom buku (1904.), HE na Roškom slapu (1911.) i HE Miljacka (1907.) na slapu Miljacka. U planu je bila izgradnja još dviju hidroelektrana koje nikada nisu realizirane (Skradinski buk i Bilušića buk). Tri od četiri hidroelektrane i danas proizvode električnu energiju i dio su jedinstvenoga elektrifikacijskog sustava Republike Hrvatske.

Najstarija HE Krka izgrađena je i puštena u pogon u kolovozu 1895. u svrhu postavljanja električne rasvjete na izmjeničnu struju u Šibeniku koji ju je, zahvaljujući njezinim graditeljima, dobio prije mnogih europskih gradova. Inženjer Vjekoslav Meichsner izradio je projekte za izgradnju hidroelektrane, dalekovoda za prijenos električne energije i gradske mreže za rasvjetu. To je ujedno bila i prva elektrana u svijetu s cjelovitim zatvorenim sustavom proizvodnje, prijenosa i distribucije izmjenične struje. Prestala je s radom i zatvorena je početkom Prvoga svjetskog rata kada je rashodovana u vojne svrhe zajedno sa starim dalekovodom. Zgrada elektrane ostala je u cijelosti sačuvana do 1945. kada je razorena.

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U proljeće 2006. započela su sustavna arheološka istraživanja i konzervatorski radovi na ostacima hidroelektrane Krka, čemu je prethodila detaljna izrada dokumentacije. Istraživanja su otkrila izvrsno sačuvane prostorije za smještaj turbina te odvodne kanale za vodu ispod njih. U tijeku su konzervatorsko-restauratorski radovi i djelomična rekonstrukcija elektrane, a potom će slijediti njezina prezentacija. Zbog svoga povijesnog značenja te kao spomenik industrijske arhitekture, ova je elektrana zaštićena kao kulturno dobro Republike Hrvatske.
Tijekom 2015. započet je projekt istraživanja i digitalizacije arhivskoga gradiva o industrijskim postrojenjima na rijeci Krki.

Ključne riječi: *baština, Nacionalni park Krka, arheologija, konzervacija, prezentacija*

SUMMARY

Towards the end of the 19th century, the water power of the Krka was used for first industrial plants – hydroelectric power plants. Four hydroelectric power plants were built from 1895 to 1911 along the Krka River. These are: HEP Krka (1895) and HEP Jaruga at Skradinski buk (1904), HEP at Roški slap (1911) and HEP Miljacka (1907) at Miljacka waterfall. Two other hydroelectric power plants were planned, but never built (at Skradinski buk and Bilušića buk). Three out of four hydroelectric power plants are still in use and make part of the electrification system of the Republic of Croatia.
The oldest HEP Krka was built and put into operation on the 28 August 1895, followed by the installation of electric lighting in the alternating current in Šibenik. The engineer Vjekoslav Meichsner made the projects for the hydroelectric power plant, transmission lines for power transmission and public lighting of Šibenik. It was also the first integral alternating current electroenergetic system with the long-distance power transmission in the world.
At the beginning of World War I, military authorities destroyed the facilities in the old hydroelectric power plant Krka as well as two copper conductors in order to use the material for warfare purposes. The building itself remained fully preserved until 1945 when it was destroyed at the end of the Second World War.
In the spring of 2006, the systematic archaeological research and conservation work began on the remains of hydropower plant Krka, preceded by detailed technical documentation. During the archaeological excavations the perfectly preserved rooms for turbines and drains for the water beneath them have been found. Ongoing conservation and restoration works and partial reconstruction of the plant aim to present this unique object of the industrial heritage in Croatia. Because of its historical significance as a monument of industrial architecture, the remains are officially protected as cultural heritage.
The project on research and digitization of the archival documents on industrial heritage on the Krka river, began during the year 2015.

Keywords: *industrial heritage, the Krka National Park, archeology, conservation, presentation*

ZAŠTITA I KORIŠTENJE BAŠTINSKE DOKUMENTACIJE TEHNIČKE, VOJNE I INDUSTRIJSKE PROVENIJENCIJE: PITANJA, IZAZOVI I MOGUĆNOSTI

Preserving and using heritage documentation of technical, military and industrial provenience: issues, challenges and possibilities

Stjepan Zlatić*

SAŽETAK

Tehnička i industrijska baština iznimno su važan dio kulturne baštine u svijetu i u Hrvatskoj. Njihovo čuvanje i zaštita izazov su na mnogim razinama i u mnogim aspektima. Važan je dio tehničke i industrijske baštine i dokumentacija. Dokumentacija u kontekstu industrijske baštine obuhvaća sve pisane, tiskane i elektroničke dokumente vezane uz određenu industriju te svu dokumentaciju nastalu kao dio proizvodnog procesa. Tehnička dokumentacija obuhvaća svu dokumentaciju koja na neki način opisuje tehnički predmet ili je vezana za njega. Zaštita dokumentacije provodi se na strateškoj, tehničkoj i operativnoj razini, najčešće zasebno u sklopu rada arhiva i drugih ustanova kojima je primarna djelatnost zaštita dokumenata. Svrha je ovoga rada skrenuti pozornost na problematiku zaštite dokumentacije o industrijskoj i tehničkoj baštini te dati uvid u izazove istraživanja te problematike u Hrvatskoj.

Ključne riječi: *industrijska baština, tehnička baština, zaštita baštine, dokumentacija, zaštita dokumentacije*

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1. UVOD

Tehnička i industrijska kulturna baština neizostavan su dio kulturne baštine u svijetu, osobito kada govorimo o razdoblju od sredine 18. stoljeća do danas, otkad je industrijska revolucija potpuno promijenila svijet oko nas. Industrija, proizvodnja, tehnička proizvodnja i tehnološki procesi mijenjali su se kroz povijest, a mijenjaju se i danas, te je njihova važnost u svakodnevnom životu prepoznata u cijelom svijetu. U kontekstu industrijske i tehničke baštine dokumentacija je vrijednost kao potpora pojedinim predmetima, dokaz o radu i procesima te neiscrpan izvor za potencijalna istraživanja o konkretnim objektima. Položaj industrijske i tehničke baštine u Hrvatskoj nije u potpunosti jasno koncipiran niti su industrijska i tehnička baština izdvojene kao jedinstvene kategorije baštine. U tom smislu položaj dokumentacije još je manje definiran te često nije priložen samim predmetima iz područja industrijske i tehničke baštine.

U ovom radu[1] definirat će se industrijska i tehnička baština, naznačiti njihova važnost u kulturnoj baštini općenito, definirati dokumentacija vezana uz industrijsku i tehničku baštinu te predložiti mogući koraci za njezino očuvanje u sklopu očuvanja industrijske i tehničke kulturne baštine, kao i kulturne baštine općenito. Velik naglasak bit će i na predlaganju okvira kojim bi se industrijska i tehnička baština mogle nezavisno razmatrati u odnosu na ostale vrste baštine.

2. KULTURNA BAŠTINA

Kulturna baština, materijalna i nematerijalna, zajedničko je bogatstvo čovječanstva u svojoj raznolikosti i posebnosti, a njezina zaštita jedan je od važnih čimbenika za prepoznavanje, definiranje i afirmaciju kulturnog identiteta.

Pojam kulturne baštine je širok i stoga je njegovo pobliže određenje povezano s teškoćama.

Kulturnu baštinu najčešće smatramo javnim dobrom koje, da bi se okarakteriziralo takvim, mora ispunjavati dva uvjeta.[2] Prvo, javna dobra su neisključiva (engl. *non-excludible)*, što znači da je neisplativo onemogućavati korisnicima uživanje u dobru. Kulturna dobra variraju u razini svoje isključivosti – na primjer,

[1] Tekst je nastao na temelju diplomskog rada obranjenog 4. studenoga 2016. na Jednopredmetnom diplomskom studiju informatologije Filozofskog fakulteta u Osijeku pod mentorstvom doc. dr. sc. Maje Krtalić.

[2] Valuing Cultural Heritage. / Edited by Stale Navrud and Richard C. Ready. Cheltenham: Edward Elgar Publishing Limited, 2002., str. 3–5. URL: https://books.google.hr/books?hl=en&lr=&id=kBf_Lywk6XgC&oi=fnd&pg=PR7&dq=cultural+heritage&ots=w6SHIwvRU9&sig=BDFxGTO794-DW7-a3jwOXpHdUJA&redir_esc=y#v=onepage&q&f=true (pristupljeno 28. listopada 2016.)

muzejima je jednostavno ograničiti broj posjetitelja naplaćivanjem ulaznica, ali, s druge strane, razgledavanje povijesnog dijela nekoga grada u načelu nije isključiva aktivnost jer je nepraktično naplaćivati boravak u određenom gradu. Druga je osobina javnog dobra njegov nesuparnički aspekt (engl. *non-rival in consumption)*, što znači da različiti ljudi mogu uživati u javnim dobrima u isto vrijeme neovisno jedni o drugima i bez ometanja jedni drugih, a izvrstan su primjer tog aspekta spomenici u gradovima.

Strategija zaštite, očuvanja i održivog gospodarskog korištenja kulturne baštine Republike Hrvatske za razdoblje 2011. – 2015. kulturnu baštinu dijeli na pokretna i nepokretna kulturna dobra od umjetničkog, povijesnog, paleontološkog, arheološkog, antropološkog i znanstvenog značenja.[3] Ministarstvo kulture Republike Hrvatske zaduženo je za očuvanje kulturne baštine u cjelini, a to znači i za određivanje okvira za njezino održivo korištenje.

Važan preduvjet za zaštitu, očuvanje i korištenje kulturne baštine jest učinkovit sustav registracije i informatizacije kulturne baštine. Sustav registracije treba imati cjelovit, sveobuhvatan, transparentan stručnjacima, javnosti i investitorima dostupan središnji upisnik kulturnih dobara. Informatizacija treba osigurati brzo, efikasno i kvalitetno planiranje i određivanje prioriteta u financiranju zaštite i očuvanja, uz istodobno utvrđivanje uvjeta namjene i mogućnosti korištenja svake pojedine kategorije kulturne baštine. Navedena podjela baštine prema *Strategiji zaštite, očuvanja i održivog gospodarskog korištenja kulturne baštine Republike Hrvatske za razdoblje 2011. – 2015.* u skladu je s UNESCO-ovom podjelom prema kojoj se kulturna baština tradicionalno dijeli na materijalnu i nematerijalnu, pri čemu se materijalna baština dalje grana na nepokretnu (graditeljsku, arheološku i kulturne krajolike) i pokretnu (muzejsku, knjižničnu i arhivsko gradivo).

3. TEHNIČKA I INDUSTRIJSKA BAŠTINA

Prema definiciji rječnika Merriam-Webster, industrija je „proces proizvodnje dobara korištenjem mehanizacija i tvornica“[4], grupa poslovnih subjekata koji svojim radom proizvode određenu robu ili usluge. Tehnologija je prema Oxfordovu rječniku, „primjena znanstvenih saznanja u praktične svrhe, naročito u industriji“[5].

[3] Strategija zaštite, očuvanja i održivog gospodarskog korištenja kulturne baštine Republike Hrvatske za razdoblje 2011.–2015. URL: http://www.min-kulture.hr/userdocsimages/bastina/STRATEGIJA_BASTINE_VRH.pdf (pristupljeno 28. listopada 2016.)

[4] Industry. / Merriam Webster Dictionary. URL: http://www.merriam-webster.com/dictionary/industry (pristupljeno 28. listopada 2016.)

[5] Technology. / Oxford Living Dictionaries. URL: https://en.oxforddictionaries.com/definition/technology (pristupljeno 28. listopada 2016.)

Prema Hrvatskoj enciklopediji pod tehnikom se smatra „ukupnost iskustveno ili znanstveno utemeljenih vještina, umijeća i postupaka, s potrebnim priborom, pomagalima i strojevima, koji služe za zadovoljavanje ljudskih potreba u stvarnome životu“[6]. U kontekstu istraživanja situacije vezane uz industrijsku i tehničku baštinu ta se tri pojma mogu sagledati zajednički, bez dubljeg ulaženja u semantiku, naročito kada se u obzir uzme isprepletenost svih triju pojmova u svakodnevnom životu, ali i u kontekstu zaštite baštine.

Kao što je vidljivo iz definicija, vrlo je teško provesti točnu distinkciju između tehničke i industrijske baštine te ostalih tipova baštine na generalnoj razini. Krovna svjetska organizacija za zaštitu kulturne baštine, UNESCO, ne daje jasnu definiciju industrijske baštine. UNESCO se referira na industrijsku revoluciju koju smatra glavnim pokretačem i uzrokom industrijskog razvoja te navodi primjer industrijske arheologiju kao glavni element za proučavanje industrijske baštine.[7] Radi lakšeg snalaženja u samim pojmovima i definicijama, industrijsku baštinu mogli bismo opisati kao dio kulturne baštine vezane uz različite industrije, od prometne (željeznički, cestovni, zračni, riječni, pomorski, kanalski i drugi promet), proizvodne industrije (manufakture, tvornice roba, rudnici), poljoprivredne i šumarske industrije, prerađivačke industrije, industrije znanja i tehnologija (robotika, računalstvo i slično), vojne industrije i itd., sa svim materijalnim elementima koji predstavljaju tu industriju kao što su građevine, strojevi, sirovine, proizvodi, popratna dokumentacija, ali i svim nematerijalnim elementima poput ljudi i njihovih iskustava, intelektualnog vlasništva i načina na koji je industrija utjecala na svakodnevni život u široj ili daljoj okolici.

Unatoč izostanku kvalitetnije definicije, tehnička baština ukratko se može opisati kao baština vezana uza svu tehnologiju koja direktno ili indirektno služi čovjeku u različite svrhe. Tehnika ili tehnologija ne moraju nužno biti vezane uz industrijsku proizvodnju i procese te ih se do određene mjere može promatrati zasebno. No upravo zbog povezanosti tehnologije i industrije, teško je razgraničiti ta dva područja bez isprepletanja – primjerice, tehnološki proizvod i oruđe kao što je separator za kamen u kamenolomu nije moguće odvojiti od industrije kamena, iako je direktno gledano zaseban element koji bi spadao pod tehničku baštinu. Bilo koji kućanski uređaj poput mikrovalne pećnice ili televizijskog prijamnika koji koriste specifična tehnološka rješenja ne koriste se nužno u industrijske svrhe, ali neupitno su proizvod industrijskih procesa. Sličnih primjera ima mnogo.

Prepoznavanje industrijske baštine, valorizacija njezine vrijednosti, očuvanje izvornih baštinskih cjelina ili, u nuždi, samo njezinih najznačajnijih dijelova i to uz zadržavanje prvotne namjene ili prihvaćanje novih sadržaja, relativno je

[6] Tehnika. / Hrvatska enciklopedija. URL: http://www.enciklopedija.hr/natuknica.aspx?id=60655 (pristupljeno 28. listopada 2016.)

[7] Industrial Heritage. URL: https://bih.federation.edu.au/index.php/Industrial_heritage (pristupljeno 28. listopada 2016.)

novo područje koje se u Hrvatskoj prilično mukotrpno integrira u sukus stručnoga djelovanja.

3.1. Tehnička i industrijska baština u Hrvatskoj

U Hrvatskoj su legislativni i institucionalni okvir zaštite industrijske i tehničke baštine prilično nedorečeni. U *Strategiji zaštite, očuvanja i održivoga gospodarskog korištenja kulturne baštine republike Hrvatske za razdoblje 2011. – 2015.* industrijska i tehnička baština ne spominju se kao zasebni elementi, već su u određenom dijelu uvršteni u područja kulturne baštine definirana *Strategijom*, od nepokretne (graditeljska baština), pokretne (muzejska i knjižnična baština, arhivsko gradivo) pa čak i nematerijalne.[8]

U Hrvatskoj ne postoji značajan institucionalni okvir vezan uz čuvanje i zaštitu industrijske i tehničke baštine, ali postoje mnogi projekti u sklopu zaštite kulturne baštine koji se tom tematikom više bave. Primjerice, udruga *Pro Torpedo*, osnovana u Rijeci radi očuvanja riječke industrijske i tehničke baštine, redovito organizira međunarodne konferencije s različitim tematskim sadržajima iz područja industrijske i tehničke baštine.[9] Na razini Hrvatske samo 2015. priređeno je nekoliko izložbi u sklopu *Dana europske baštine*[10], primjerice *Izložba o industrijskoj baštini Hrvatske: Baština kao gospodarsko-razvojni resurs*[11], prezentacija Tehničkog muzeja pod nazivom *Prezentacija parnih strojeva: Punom parom!*[12] te predavanje *Industrijska baština Osječko-baranjske županije* u organizaciji Konzervatorskog odjela u Osijeku[13].

U Hrvatskoj se o industrijskoj baštini, njezinoj identifikaciji i valorizaciji počelo raspravljati 80-ih godina 20. stoljeća.[14] Na tragu toga bili su planovi i razmišljanja o revitalizaciji i prenamjeni tvornica i industrijskih postrojenja koji su se prestali funkcionalno koristiti. Kao primjer mogu se istaknuti planovi o revitalizaciji zagrebačkog Paromlina koji je izgrađen 1862. i koji je u vrijeme izgradnje bio najjače industrijsko postrojenje u Hrvatskoj, a ujedno i najmoderniji mlin u Austro-Ugarskoj Monarhiji. Posljednjeg desetljeća 20. stoljeća

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[8] Strategija zaštite, očuvanja i održivog gospodarskog korištenja kulturne baštine Republike Hrvatske za razdoblje 2011. – 2015., n. d., str. 3.

[9] Pro Torpedo: udruga za zaštitu i promociju riječke industrijske baštine. URL: http://protorpedo-rijeka.hr/wp/konferencije/ (pristupljeno 28. listopada 2016.)

[10] Dani europske kulturne baštine, 2015. URL: http://www.min-kulture.hr/userdocsimages/NAJNOVIJE%20NOVOSTI/Dani%20europske%20ba%C5%A1tine%202015%20bro%C5%A1ura11__.pdf (pristupljeno 28. listopada 2016.)

[11] Isto, str. 7.

[12] Isto, str. 16.

[13] Isto, str. 53.

[14] Bunijevac, H. Željeznička industrijska baština: resursi koji vape za identifikacijom i valorizacijom. // Informatica museologica 38, 1-2 (2008), str. 33. URL: http://hrcak.srce.hr/134656?lang=en (pristupljeno 28. listopada 2016.)

počelo se razmišljati i o reurbanizaciji šireg područja u Trnju koje je od tipičnoga industrijskog kvarta s perifernim radničkim naseljima s vremenom preraslo u integralni dio gradskog središta. U pristupu reurbanizaciji tog područja posebna je briga posvećena području s južne strane zagrebačkoga Glavnog kolodvora, na kojemu je od 1962. djelovao Paromlin, a od 1894. do izmještenja 2011. neprekidno radio TŽV *Gredelj*.

Kao drugi primjer valja spomenuti riječku udrugu *Pro Torpedo*. U Rijeci je sredinom 19. stoljeća grupa poduzetnika pokrenula inicijativu o osnivanju tada nove moderne industrije – lijevanja i obrade metala. Riječka je tvornica motora *Torpedo* započela svoj život kao ljevaonica metala, a desetak godina poslije u njoj je izumljen prvi uspješni svjetski torpedo koji je slavu tvornice proširio diljem svijeta. U sklopu obilježavanja 140. obljetnice početka rada tvornice, Udruga *Pro Torpedo* organizirala je postavljanje izložbe o povijesti riječke tvornice *Torpedo*, koja je zatim pokrenula, odnosno potaknula nekoliko novih inicijativa vezanih za riječku industrijsku baštinu i njezino očuvanje.

Na otvorenju izložbe 1993. izražena je želja da u Rijeku treba vratiti riječka povijesna torpeda i obnoviti Muzej torpeda, što je dovelo do uobličenja *Prijedloga za ponovno formiranje muzejske zbirke torpeda u Rijeci*, elaborata omogućnostima ponovnog formiranja muzejske zbirke torpeda u Rijeci.[15] Godine 1998. osnovan je Odbor za obnovu zbirke torpeda u Rijeci čiji je primarni zadatak bio sačuvati ostatke lansirne rampe za ispitivanje torpeda. Pokrenut je niz inicijativa za premještanje arhivske građe iz *Torpeda* u prostore Državnog arhiva u Rijeci i registraciju lansirne rampe kao spomenika kulture te za pronalaženje financijskih sredstava za statičko, građevinsko i geomaritimno snimanje lansirne rampe kao preduvjeta za njezino sustavno saniranje i eventualnu obnovu.

3.2. Dokumentacija o tehničkoj i industrijskoj baštini

Dokumentacija u kontekstu baštine i njezine zaštite najbolje se može definirati prema Merriam-Websterovu rječniku kao „dokumenti, pisani dokazi korišteni kako bi se nešto dokazalo ili učinilo službenim".[16] Naziv dokumentacija najprikladniji je kada se govori o ovoj temi upravo zbog uporabe same riječi u muzejskoj struci,[17] ali i općenito u opisivanju različitih dokumenata vezanih uz

[15] Smokvina, M. Industrijska baština Tvornice torpeda u Rijeci: u povodu 150. obljetnice riječke Tvornice torpeda i procesa muzealizacije torpedne lansirne rampe. // Informatica museologica 33, 3-4 (2003), str. 81–82. URL: http://hrcak.srce.hr/index.php?show=clanak&id_clanak_jezik=207212 (pristupljeno 28. listopada 2016.)

[16] Documentation. / Merriam Webster Dictionary. URL: http://www.merriam-webster.com/dictionary/documentation (pristupljeno 28. listopada 2016.)

[17] Pravilnik o sadržaju i načinu vođenja muzejske dokumentacije o muzejskoj građi. // Narodne novine br. 142 (1998). URL: http://narodne-novine.nn.hr/clanci/sluzbeni/309509.html (pristupljeno 28. listopada 2016.)

fizičke ili pravne osobe. U arhivskoj se struci za dokumente koji se sakupljaju, obrađuju i čuvaju u arhivima ili drugim ustanovama vezanima uz njih, poput arhivskih spremišta ili pismohrana, prvenstveno upotrebljava izraz arhivsko gradivo. Važno je znati da za potrebe ovog rada ta dva izraza u nekim slučajevima možemo smatrati sinonimima jer unatoč tome što su izrazi različiti, u kontekstu industrijske i tehničke baštine svi dokumenti vezani uz tu baštinu koji se nalaze u različitim arhivima čine jedan dio dokumentacije o industrijskoj i tehničkoj baštini.

Iako ne postoje točne definicije izraza „tehnička dokumentacija" ili „industrijska dokumentacija", jednostavnom pretragom u bilo kojoj tražilici može se doći do zaključka da ti izrazi obuhvaćaju sve upute, upravljanje, dijelove ili sastav tehničkih ili industrijskih predmeta. U najužem smislu, dokumentacijom možemo smatrati sve dokumente koji opisuju ili govore o nekom industrijskom ili tehničkom predmetu ili lokaciji. U kontekstu tehničkih predmeta može se govoriti o uputama za korištenje, informacijama o sastavu, popratnim informacijana o cijeni, kvaliteti, proizvođaču, distributeru i slično.

Kada govorimo o industrijskoj baštini, dokumentacija obuhvaća sve dokumente o toj industriji, njezinu radu i proizvodima ili uslugama poput podataka o radu, djelatnicima, prihodima rashodima i profitu, ugovore, podatke o intelektualnom vlasništvu, zemljovide i planove, upute za upravljanje postrojenjima, pravilnike, podatke o radnim obavezama i zabranama, godišnjake, interna glasila, korespondenciju između djelatnika, tehničke crteže i fotografije. To je prije svega dokumentacija u najužem smislu, o kojoj možemo govoriti kao o primarnoj; mogu se, međutim, spomenuti i drugi važni dokumenti koji se mogu smatrati dokumentacijom o industrijskoj i tehničkoj baštini, a nisu direktno vezani uz artefakte koje opisuju – sam rad industrije, njezini proizvodi ili usluge. To su knjige poput općih tehničkih priručnika i leksikona, serijska i omeđena tehnička literatura, državna, područna i lokalna izvješća o industrijskom i tehnološkom radu i napretku te osobni popisi, izvješća ili fotografije u privatnom vlasništvu.

Unatoč tome što takva dokumentacija u kontekstu industrijske i tehničke baštine nije dovoljno znanstveno istražena, za potrebe ovog rada može je se nazvati sekundarnom. Još je jedan važan tip dokumentacije o industrijskoj i tehničkoj baštini u ovom kontekstu, a to su prije svega različiti popisi, analize i izvješća ustanova koje u sklopu svoga djelokruga rade s industrijskom i tehničkom baštinom. U taj aspekt dokumentacije spadaju arhivski popisi i opisi gradiva, muzejski popisi i opisi predmeta, popratna dokumentacija muzeja i drugih ustanova koje istražuju ili čuvaju predmete vezane uz industrijsku ili tehničku baštinu. Takvu dokumentaciju možemo nazvati tercijarnom. Za potrebe definiranja i traženja konkretnog okvira u kojemu se dokumentacija nalazi, valja reći da se prije spomenuti tipovi dokumenata mogu nalaziti u bilo kojem obliku – pisanom, tiskanom ili digitalnom te na bilo kojemu mediju – knjige, dokumenti u bilo kojem formatu, digitalni mediji poput optičkih i

magnetnih diskova ili u sklopu internih serverskih sustava ili na serverima kojima se može pristupiti preko interneta.

Dokumentacija o industrijskoj i tehničkoj baštini nastaje kao i sva druga dokumentacija pravnih ili privatnih subjekata, odnosno, arhivskim rječnikom, „zapisi ili dokumenti koji su nastali djelovanjem pravnih ili fizičkih osoba u obavljanju njihove djelatnosti".[18] Nakon nastanka, dokumentacija se uglavnom čuva ovisno o potrebama. Čuvatelji takve dokumentacije mogu se podijeliti u tri skupine. Prva su skupina subjekti, odnosno fizičke ili pravne osobe čijim je djelovanjem dokumentacija i nastala. Za bilo kakvo istraživanje ili procjenu stanja industrijske i tehničke baštine ta skupina je najnezahvalnija, prije svega zbog problema pristupa i privatnosti podataka, ali i zbog potencijalne neorganiziranosti samih dokumenata unutar ustanove.

Unatoč tome što neki subjekti, poput javnih poduzeća i trgovačkih društava koja su nastala iz bivših javnih poduzeća, podliježu Zakonu o arhivima i arhivskom gradivu[19], u nekim slučajevima nije moguće utvrditi količinu i stanje dokumentacije koju posjeduje neko poduzeće. U mnogim slučajevima, osobito kada je riječ o redundantnim dokumentima poput internih pravilnika ili uputa koje se diseminiraju djelatnicima, često se ne zna čak ni sam broj dokumenata. Ako se takva dokumentacija nalazi u elektronskom obliku, problem postaje još veći zbog nemogućnosti osiguravanja bilo kakve kontrole nad brojem i kompletnim stanjem dokumentacije. Druga su skupina specijalizirane ustanove javnog tipa poput arhiva[20] ili muzeja[21] čije je poslanje čuvanje i zaštita gradiva, odnosno predmeta od važnosti za kulturnu baštinu u svrhu edukacije, znanstvenog istraživanja, stručne i znanstvene obrade te trajnog čuvanja.

Sama dokumentacija različitim putem može doći u različite ustanove. Tako sva javna poduzeća na temelju Zakona o arhivskom gradivu i arhivima imaju dužnost dostaviti popise dokumenata i zbirki, a poslije i samu dokumentaciju, ovisno o njezinu statusu prema zakonu. Muzeji i druge ustanove za koje javna ili privatna poduzeća nisu zakonski vezana, svu potencijalnu dokumentaciju dobivaju kupnjom, darovanjem, nasljeđivanjem, zamjenom, terenskim radom i istraživanjem.[22] U Zakonu o muzejima dobro je uređeno i pitanje muzejske dokumentacije koja nastaje kao posljedica djelovanja muzejskih djelatnika na predmetima i objektima.

Najveći je izazov za čuvanje i zaštitu dokumentacije o industrijskoj i tehničkoj baštini, kada se govori o takvim javnim ustanovama, čuvanje jedinstvene

[18] Zakon o arhivskom gradivu i arhivima. // Narodne novine br. 105 (1997) i 64 (2000). URL:http://narodne-novine.nn.hr/clanci/sluzbeni/312026.html (pristupljeno 28. listopada 2016.)

[19] Isto.

[20] Isto.

[21] Zakon o muzejima. // Narodne novine br. 110 (2015). URL: http://narodne-novine.nn.hr/clanci/sluzbeni/2015_10_110_2121.html (pristupljeno 28. listopada 2016.)

[22] Isto.

dokumentacije. Arhivi, osim u iznimnim slučajevima, čuvaju samo jedinstveno gradivo, a kopije se uglavnom ne produciraju. Isti se problem pojavljuje i u muzejima čije su zbirke predmeta u najvećoj mjeri jedinstvene. Zbog toga je vrlo važno da se u okviru tih institucija sačini kvalitetna strategija čuvanja i zaštite dokumentacije o industrijskoj i tehničkoj baštini. U ovu grupu mogu se još svrstati i knjižnice kojima primarni cilj nije čuvanje i zaštita dokumentacije, ali u svojem fondu i zasebnim zbirkama često imaju različita omeđena i neomeđena djela vezana uz industrijsku baštinu.

Treća skupina možda je najmanje poznata i istražena od svih skupina zbog prilično očita razloga. U treću skupinu mogu se svrstati svi privatni subjekti i osobe, koji zbog vlastitih potreba, interesa ili drugih razloga skupljaju dokumentaciju o industrijskoj i tehničkoj baštini. U tu skupinu mogu se svrstati djelatnici u industriji koji dokumentaciju prikupljaju zbog osobnih razloga, entuzijasti u određenim poljima industrijske i tehničke baštine, kolekcionari antikviteta i dokumenata te trgovine antikvitetima i zalagaonice.

3.3. Mjere zaštite

Važni aspekti rada s dokumentacijom općenito, uključujući i dokumentaciju o industrijskoj i tehničkoj baštini, jesu odabir, prikupljanje, obrada, čuvanje i, naposljetku, zaštita i davanje na uvid, odnosno korištenje. Zaštita je jedan od najvažnijih aspekata rada s baštinskom dokumentacijom i integralni je dio poslovanja svih ustanova koje ju čuvaju. U najširem smislu, pojam zaštite stoga obuhvaća sva upravna, administrativna i kadrovska pitanja bitna za čuvanje i dobrobit baštinskih zbirki, uključivši pohranu i čuvanje građe u spremištima, kadrovsku politiku te postupke, tehnike i metode čuvanja građe i informacija koje one sadrže.[23] Iako je deklarativno istaknuto što sve treba činiti i na koji način da bi se kulturna baština i posebno građa s obilježjima kulturnog dobra[24] zaštitila, velik broj informacijskih ustanova suočava se s problemima u provođenju zaštite svoje građe koji velikim dijelom proizlaze iz slabe organiziranosti i nejasne podjele ili neprepoznavanja odgovornosti, kako na nacionalnoj, tako i na institucionalnoj razini.[25] Odgovornost za zaštitu na neki je način sveobuhvatna, a ovisno o opsegu razlikuje se kolektivna odgovornost, institucionalna odgovornost i osobna odgovornost.[26] Dio odgovora na pitanja odgovornosti te

[23] IFLA-ina načela za skrb i rukovanje knjižničnom građom / sastavio i uredio Edward P. Adcock u suradnji s Marie-Theresom Varlamoff i Virginiom Kremp. Zagreb: Hrvatsko knjižničarsko društvo, 2003., str. 9. i 11.

[24] Zakon o zaštiti i očuvanju kulturnih dobara. // Narodne novine br. 69(1999). URL: http://narodne-novine.nn.hr/clanci/sluzbeni/271022.html (pristupljeno 28. listopada 2016.)

[25] Hasenay, D.; Krtalić, M; Šimunić, Z. Obrazovanje studenata informatologije o čuvanju i zaštiti kulturne baštine – temeljna znanja i njihov prijenos u praksu. // Život i škola 57, 25 (2011), str. 63.

[26] Hasenay, D.; Krtalić, M. Terminološki i metodološki aspekti u proučavanju zaštite stare knjižnične građe. // Libellarium 1, 2 (2008), str. 203–220. URL: http://hrcak.srce.hr/37156 (pristupljeno 28. listopada 2016.)

načina vrednovanja baštinskih zbirki moguće je tražiti u zakonskoj regulativi. Odgovornost za zaštitu i načinima provedbe propisani su u nekoliko zakona i pravilnika relevantnih za problematiku zaštite baštine.[27]

Pitanje zaštite, kada se govori o industrijskoj i tehničkoj baštini, svodi se na sve razine – institucionalnu, tehničku i operativnu. Izazov zaštite te baštine najviše leži u činjenici da industrijsku i tehničku baštinu sačinjava mnogo različitih elemenata. Gledajući institucionalni i legislativni okvir može se vidjeti da je zakonska regulativa, zajedno s pravilnicima o postupanju s baštinom, u određenom mjeri kvalitetno postavljena. Međutim, pitanje same provedbe zaštite na tehničkoj i operativnoj razini je sljedeći izazov, osobito kada se uzme u obzir širina područja potrebna za zaštitu nekog industrijskog ili tehničkog objekta.

3.3.1. Mjere zaštite dokumentacije

Konkretne mjere zaštite na tehničkoj i operativnoj razini moraju se redovito i sustavno provoditi kako bi se osigurala trajnost i postojanost što većeg broja dokumenata. Što se tiče zaštite i očuvanja dokumenata na papiru, treba imati na umu najvažnije mjere zaštite i to od nastanka dokumenta preko samog rukovanja do osiguravanja pristupa ili digitalizacije. Sva papirna građa podložna je oštećenjima pri kojima dolazi do promjena u njihovoj strukturi i svojstvima. Budući da je sam papir prirodni materijal, njegov kemijski sastav s vremenom uzrokuje reakcije, a promjene koje nastaju tijekom reakcija nazivaju se prirodnim starenjem.[28] Osim prirodnog starenja, moguća su i mnoga druga oštećenja koja se najčešće dijele na mehanička, fizikalna i kemijska.

Mehanička oštećenja najčešće nastaju nepravilnim ili neopreznim upravljanjem, za vrijeme ulaganja i skladištenja dokumenata te pri transportu. Da bi se smanjila mogućnost mehaničkog oštećenja nužan je oprez i pravilno upravljanje dokumentima. Fizikalne promjene obuhvaćaju sve promjene na papiru uzrokovane fizikalnim uzročnicima poput vlage ili topline, odnosno mijenja se samo energijsko stanje tvari, a sastav tvari može ostati nepromijenjen.[29] Fizikalna

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[27] Zakon o zaštiti i očuvanju kulturnih dobara. // Narodne novine br. 69(1999). URL: http://narodne-novine.nn.hr/clanci/sluzbeni/271022.html (pristupljeno 28. listopada 2016.); Zakon o knjižnicama. // Narodne novine 105 (1997) i 5 (1998). URL: http://narodnenovine.nn.hr/clanci/sluzbeni/267274.html (pristupljeno 28. listopada 2016.); Pravilnik o zaštiti knjižnične građe. // Narodne novine 52 (2005). URL: http://narodnenovine.nn.hr/clanci/sluzbeni/288524.html (2016-10-28); Pravilnik o registru kulturnih dobara. // Narodne novine 37 (2001). URL: http://narodnenovine.nn.hr/clanci/sluzbeni/232236.html (pristupljeno 28. listopada 2016.). Citirano prema: Damir Hasenay, Maja Krtalić, Zrinka Šimunić, n. d., str. 63.

[28] Isto.

[29] Hasenay, D.; Krtalić, M.; Aparac-Jelušić, T. Upravljanje zaštitom pisane baštine u knjižnicama – teorijske pretpostavke. // Vjesnik bibliotekara Hrvatske 54, 1-2 (2011), str. 27. URL: http://www.hkdrustvo.hr/datoteke/1145/vbh/God.54(2011), br. 1-2 (pristupljeno 3. studenoga 2016.)

promjena može biti uzrok kemijske promjene, odnosno promjene samog sastava kemijskim reakcijama unutar papira. Osiguravanje zaštite od fizikalnih i kemijskih promjena može se postići upotrebom kvalitetnih materijala za pohranu poput beskiselinskih kutija i registara, osiguravanjem optimalnih uvjeta skladištenja dokumenata od temperature, vlažnosti, pa i kvalitetnoga svjetla, odnosno blokiranje sunčeva svjetla. Bitno je spomenuti i biološke uzročnike poput glodavaca, insekata, bakterija i plijesni. Za te uzročnike najvažnije je osigurati preventivne mjere kojima bi se spriječilo njihovo pojavljivanje, a u slučaju da se pojave, posavjetovati se sa stručnjacima radi provedbe korektivnih mjera zaštite. Nije nepoznato da je jedan od najvećih krivaca za oštećenje i uništenje papirne građe upravo čovjek, no s obzirom na nužnost zaštite radi potencijalnog korištenja, treba mu osigurati pristup dokumentaciji.

Jedna je od popularnijih i danas sve raširenijih metoda digitalizacija s kasnijim *on-line* pristupom. Već je naveden ozbiljan problem smještaja, odnosno vlasništva nad dokumentacijom, tako da bi se organizacija same digitalizacije na nacionalnoj razini mogla ispostaviti većim izazovom nego sami postupci. U Hrvatskoj je 2005. pokrenut projekt E-Hrvatska, a njime je obuhvaćena i kultura, na čijem se području predviđa razvoj informacijske i komunikacijske infrastrukture, no istodobno i stvaranje visokokvalitetnih digitaliziranih kulturnih i nacionalnih sadržaja na temelju materijala iz knjižnica, muzeja, galerija i arhiva.[30] U sklopu toga programa predviđena je digitalizacija velikog broja zbirki i fondova iz svih područja kulturne baštine, ali velik napredak u digitalizaciji još nije u potpunosti postignut. Digitalne dokumente Borgman dijeli na digitalne (eng. *digital*) – izvorno nastale u digitalnom obliku i digitalizirane (eng. *digitised*) – prepisane ili prevedene u digitalni oblik iz nekoga drugog medija.[31] Izvorni digitalni dokumenti u ovom slučaju nisu toliki problem kao dokumenti na drugim medijima koje treba digitalizirati.

Bez obzira na izazove, za digitalizaciju dokumenata postoji pregršt kvalitetnih smjernica i preporuka poput IFLA-inih smjernica za projekte digitalizacije za zbirke i građu iz javne domene.[32] Najbolja preporuka za digitalizaciju dokumenata bila bi digitalizacija s OCR konverzijom na licu mjesta, s organiziranjem jedinstvenog sustava unosa radi izbjegavanja redundancije, s pretvaranjem u stabilan i lako čitljiv format poput PDF-a te na kraju spremanje dokumenata u digitalnom obliku na barem dva različita medija.

Jedan od medija trebao bi biti vanjski optički ili magnetni medij duga trajanja poput DVD-a ili vanjskih SDD magnetnih diskova. Drugi medij bi mogao biti interni server ili server s *on-line* pristupom, kojemu bi slobodno ili na zahtjev mogli pristupiti potencijalni korisnici. Tom metodom replikacije

[30] Isto.

[31] Borgman, C. L. From Gutenberg to the global information infrastructure. Cambridge: MIT Press, 2000., str. 64–65.

[32] Isto.

osigurala bi se redundancija dokumenata na jednome mjestu s više različitih medija koji bi jamčili sigurnost samog sadržaja dokumenta. Time bi se osigurala i sigurnost od oštećenja pri manipulaciji fizičkim dokumentima, kojima bi pristup imali samo stručnjaci.

4. ZAKLJUČAK

Industrijska i tehnička baština sastavni su i neodvojiv dio kulturne baštine u Hrvatskoj i svijetu. Važnost toga dijela baštine očituje se ne samo u predmetima i objektima koji su sačuvani ili tek trebaju biti sačuvani već i u načinu na koji su industrija, industrijska proizvodnja i tehnologija promijenili prostor oko nas. Shvaćanje važnosti i premošćivanje svih problema oko zaštite industrijske i tehničke baštine još uvijek je jedan od najvećih izazova za stručnjake svih profesija vezanih uza zaštitu toga dijela baštine.

U radu je predstavljeno što industrijska i tehnička baština mogu značiti u cjelokupnom kontekstu kulturne baštine, s najvećim naglaskom na dokumentaciju. Problem dokumentacije, kao što se može vidjeti, jedan je od većih izazova prije svega zbog njezina upitnoga generalnog stanja, ali i zbog nedostatne povezanosti sa samim industrijskim i tehničkim artefaktima koje opisuje. Da bi se premostili ti problemi nije dovoljno samo istražiti stanje, legislativni i institucijski okvir, nego i provesti istraživanje unutar više institucija zaduženih ili na bilo koji način vezanih uz konkretan problem.

Važno je pitanje treba li pravno i institucijski odvojiti industrijsku i tehničku baštinu od ostalih oblika baštine, odnosno treba li uopće išta mijenjati u dosadašnjoj podjeli. Ako čitav sustav zaštite kulturne baštine funkcionira, promjene mogu biti minorne i bez velikih zahvata, ali u situacijama poput ove, kada nije u potpunosti razjašnjeno koja ustanova ima ingerenciju nad kojim aspektom čuvanja i zaštite industrijske i tehničke baštine s pripadajućom dokumentacijom, potrebno je iz više kutova sagledati problematiku i tražiti konkretna rješenja.

Sam tehnički aspekt zaštite dokumentacije, kao i baštine općenito, možda je i najistraženiji te najsređeniji dio sustava zaštite. Dok je institucionalni i legislativni aspekt u velikoj mjeri nedorečen, rad konzervatorskih ureda i poznavanje stručnjaka iz područja zaštite, konzervacije i restauracije na relativno je visokoj razini te u tom području ne treba mnogo mijenjati, već samo ustaviti proces zaštite na državnoj razini. Cjelovito rješenje ovog pitanja vjerojatno neće biti moguće naći bez sustavne analize ili provedbe istraživanja o temi, no neki prijedlozi mogu biti navedeni. Prije svega, potrebno je donijeti strategiju ili manifest o zaštiti industrijske i tehničke baštine sa svojom dokumentacijom, gdje god se ona nalazila. Strategijom bi se unaprijed odredile dužnosti i stavio naglasak na najvažnije aspekte zaštite industrijske i tehničke baštine te bi se time osigurao bar nekakav okvir za buduće postupanje.

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SUMMARY

The goal of this paper is to present issues, challenges and possibilities regarding the preserving of heritage documentation originating in military, industrial and technical fields. In many regards, the documentation is often the most valuable source of information for scientists and researchers of military, industrial and technical history, besides it being used for other purposes. In today's "online" age it is of utmost importance to ensure the continuous preservation of documentation in both printed and digitized form. This paper will focus on explaining the issue of military and technical heritage from the information science perspective starting from the hypothesis that all documentation of military, industrial and technical provenience should be freely accessible through the catalogue descriptions and digitisation, and used primarily for non-profit and research purposes. In order to achieve that, cooperation between all relevant institutions that safeguard such heritage must be ensured.

Most important research questions regarding these issues will be discussed, as follows: 1) Where and how can we access documentation of military, industrial and technical provenience? 2) How is such documentation described, organized, preserved and presented? 3) How important is the legislature in terms of document preservation?

Issues and guidelines presented in this paper could be used as a basis to improve the possibilities of preserving and using military and industrial heritage documentation. The above mentioned issues will be reflected through the example of the torpedo.

Keywords: *industrial heritage, preservation, heritage documentation, military heritage, technical heritage*

TVORNICA NA KRAJU GRADA

Factory at the end of the town

Marijo Zrna*

SAŽETAK

Tvornica motora Zagreb nastala je iz male radionice koju je 1948. osnovalo tadašnje Ministarstvo industrije NRH. Nekolicina entuzijasta, s inženjerom Rudolfom Fizirom na čelu, ručno je izradila prvi motocikl domaće proizvodnje u novoj Jugoslaviji. Izradili su četiri prototipa, zapravo kopije predratnog BMW motocikla sa 750 ccm. Taj „domaći" uradak javnosti je ponosno predstavljen već 1948. na prvomajskoj paradi u Zagrebu. TMZ službeno djeluje od 1949. s lokacijom na zagrebačkom Žitnjaku. Prvi zadatak Fizirova tima bila je izrada malolitražnih benzinskih motora za pogon traktora, plugova, kopačica, motornih kosilica, motora za motorne pile, pa čak i za pogon manjih ribarskih čamaca. Tako se 1952. na tržištu konačno pojavila Savica *285 kao potpuno domaća konstrukcija i proizvodnja, slijede* Savica *175 i* Dubrava *175. U TMZ-u su proizvodili reduktore te tri tipa centrifugalnih pumpi C-1, C-4 i X-100 koje, spojene s motorom* Savica *285, čine pumpne agregate AMS-C1, AMS-C4 i AMS-X-100. TMZ je 1957. sklopio licencni ugovor s austrijskom tvornicom HMW, prema kojem je preuzeo od Austrijanaca svu tehničku dokumentaciju za proizvodnju mopeda, budućega TMZ 50 SL. Godine 1959., nakon dvije godine razvoja, predstavljen je i* Švrća*, skuter nazvan po legendarnom liku Walta Disneya. S početnih 77 radnika 1950., u tvornici je 1954. radio 191 radnik, a na vrhuncu proizvodnje 1957. bilo je 215 zaposlenika. Proizvodne su mogućnosti tvornice 1960. s dvjestotinjak zaposlenih iznosile 2700 mopeda i skutera, oko 3000 stabilnih motora i 500 malih poljoprivrednih traktora, o čijoj je licencnoj proizvodnji TMZ pregovarao s francuskom tvornicom* Staub. *Kada je* Prvomajska *1961. preuzela TMZ, realiziran je prvi dio plana s ciljem likvidacije tvrtke. Moped i* Švrća *prvi su na udaru i staje njihova proizvodnja. Stabilni motori proizvode se dalje do 1963. kada su kompletni alati, strojevi i zalihe dijelova preseljeni u tvornicu* Progres *u Mali Zvornik (Srbija). Bio je to konačni kraj proizvodnje motora i motocikala u Zagrebu.*

Ključne riječi: *Rudolf Fizir, Tvornica motora Zagreb, TMZ, moped, skuter,* Švrća*, Dubrava,* Savica

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SUMMARY

The Zagreb Motor Factory developed from a small mechanical workshop, which was established by the Ministry of Industry of the NRC in 1948. A few enthusiasts headed by the engineer Rudolf Fizir made by hand the first locally produced motorcycle in the new Yugoslavia. They developed four prototypes, actually copies of the pre-war BMW 750 ccm motorcycle. That "domestic" product was presented proudly at the 1948 the first of May parade in Zagreb. The Zagreb Motor Factory started to work officially in1949, with the location in the Zagreb Žitnjak. The first task of the Fizir team was the making of a small engine petrol motor for the drive of tractors, ploughs, digging machines, mowers, chain-saw motor, even for the drive of smaller fishing boats. Thus, finally, in 1952, Savica 285 appeared on the market as a completely domestic construction and production, followed by Savica 175 and Dubrava 175. The TMZ produced reductors and three types of centrifugal pumps C-1, C-4 and X-100, which, connected with the Savica 285 motor make pump aggregates AMS-C1, AMS-C4 and AMS-X-100. In 1957, the TMZ signed the license agreement with the Austrian factory HMW, according to which it took over from the Austrians all the technical documentation for the moped production, the future TMZ 50 SL. In 1959, following a two-year development, Švrća *was presented, a scooter named after the legendary Walt Disney character. Beginning with 77 employees in 1950, in 1954 there were 191 of them, while at the peak of production in 1957, there were 215 employees. The production capacities of the factory in 1960, with around 200 employees, amounted to 2,700 mopeds and scooters, around 3,000 stable motors and 500 small agricultural tractors, the license production of which the TMZ negotiated with the French Staub factory. TMZ being taken over by the* Prvomajska *factory in 1961, marked the first part of the plan to put the TMZ out of business. Moped and* Švrća *were the first to be hit so that their production stops. Stable motors continued to be produced until 1963, when all of the tools, machines and spare parts' stock were moved to the* Progres *factory in mali Zvornik (Serbia). It was the final end of the motor and motorcycle production in Zagreb.*

Keywords: *Rudolf Fizir, Zagreb Motor Factory, TMZ, moped, scooter,* Švrća, *Dubrava,* Savica

OBRAĆANJE GĐE JOHANNE FLETCHER

U samoj završnici Konferencije, nakon održanih izlaganja i diskusije o izloženim temama, skupu se obratila gđa Johanna Fletcher. Učinila je to kao prapraunuka Roberta Whiteheada i njegove supruge Agathe (rođ. Breunner). Rad Konferencije pratila je sva tri dana u društvu kćeri Shele Fletcher. Njezin govor donosimo u cijelosti.

Thank you for letting me have a few minutes. It has been a pleasure to be here at the ***7th International Conference on Industrial Heritage.*** *I would like to thank Miljenko Smokvina and Velid Đekic for the warm personal welcome given to my daughter Shela and I, as well as the kind embrace from the participants and presenters we have had a chance to meet.*

Your passion and enthusiasm for the topic of industrial heritage is admirable and timely. In a time when disposable technology is the norm, preserving the past has become even more important. Rijeka's

Industrial time capsule is a treasure in this regard. You already know this and I commend your past and ongoing efforts to save the buildings of this bygone era. Undoubtedly the vision and hope of revitalizing this history and preserving it will come true.

I thought I might honor the memory of my great great grandfather Robert Whitehead by also speaking about the man. Listening to your presenters these past few days has given me a deeper appreciation for his engineering abilities. Many times I wished we could have sat in the Salon at Villa Whitehead, across from the torpedo factory, and conversed with him about his engineering processes – to get the answers from him – to some of the suppositions, but also just for the sheer pleasure of discussing the technological processes and questions he was grappling with in his time. To listen in to the conversations with Giovanni Luppis and other contemporaries in the field of maritime engineering. He would be very gratified to know of your passionate research done about every aspect of his torpedo development, so long after his death.

At heart my great great grandfather was a family man. (He wanted to make a difference with a deterrent.) From his financial success we know he was quite an able business man, but his passion was being an engineer. Inventing, improving and drafting.

He found a home in Rijeka at a time when his skills were valued and was fortunate to have become part of Fonderia Metalli, being able to establish Stabilimento Tecnico Fiumano and later the Whitehead torpedo factory. It was always his engineering abilities that brought him the trust and recognition of a product completed to a high standard. By all accounts he treated his employees well at a time when the industrial complex of that age was in many cases an abusive environment. He was rightfully proud of his achievements and accomplishments and, as this conference shows today, they have stood the test of time.

I am gratified to know so many keep his memory alive with books, research papers and these type of conferences. There is no true way of knowing his deep feelings about how his invention was and has been used. The question 'how to make war obsolete', he answered with his invention, yet the question is still with us today.

Thank you again for your kind hospitality and enthusiasm for Robert Whitehead.

