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Introduction | *Uvod*

Dear Readers,

I am proud that the first issue of the Faculty of Maritime Studies Kotor *„Časopis Pomorskog fakulteta Kotor – Journal of Maritime Sciences"* has come to light. As a continuation of the five-decade edition of the Collection of Papers of the Faculty of Maritime Studies, *„Časopis Pomorskog fakulteta Kotor – Journal of Maritime Sciences"* has now grown to translate projects, educational and pedagogical activities taking place at our faculty into the written word. One of the primary triggers to start this journal was the first international maritime conference KIMC held in September 2021 in Kotor, successfully organized by the Faculty of Maritime Studies ambitious team. After that event, we felt obliged to launch the journal that will sublime all the synergetic activities we have been undertaking years back, with the purpose of enhancing the quality of education, training and research in the maritime field. In addition, aware of the maritime legacy that the region of Boka Kotorska has, we decided to leave the written trace about all those individuals and institutions involved in keeping our maritime tradition.

In light of that, this online issue of the journal of the Faculty of Maritime Studies Kotor *„Časopis Pomorskog fakulteta Kotor – Journal of Maritime Sciences",* contains fifteen papers coming from six countries, of which an invited paper on the inscription of the Boka Navy in the UNESCO, eight original scientific papers, five review papers and one short report. All these papers offer a significant and state-of-the art insight into the actual domains of maritime and marine industry, navigation, marine engineering, energy efficiency and education.

I cordially invite all those involved in research, teaching, projects, cultural and historical domains, connected with the sea, blue growth, innovations in technical and social sciences, to send their papers and contribute to raising the quality of our maritime research community and keeping our maritime legacy.

Editor-in-Chief:
Špiro Ivošević, Assoc. Prof

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Invited paper

Statutes of the Boka Navy Kotor from 1463 to 2016

Antun Sbutega

Abstract: During more than 12 centuries of its history, the Boka Navy has changed its name, functions and statutes several times, maintaining the continuity based on fundamental values. From the beginning, it had statutes that regulated its activities, goals, rights and obligations of members, manner and governing bodies. The oldest surviving statute dates from 1463 and it was in force until 1873, a full 410 years. Later, the statutes were changed several times due to frequent changes in the states of which the Bay of Kotor was a part, i.e. changes in administrative and legal systems. This paper analyzes all known statutes from the oldest from 1463 to the current one from 2016, and follows the changes of the Navy itself, from the medieval brotherhood of sailors to the current NGO Boka Navy Kotor, which in 2021 was inscribed on the UNESCO Representative List of Intangible Cultural Heritage.

Keywords: statute, medieval fraternities, Boka Navy

Uvod

Bokeljska mornarica, prema tradiciji i nekim historijskim indicijama, osnovana 809. godine, najstarija je postojeća pomorska institucija na svijetu, a 2021. godine je upisana na Listu svjetske nematerijalne kulturne baštine UNESCO-a, kao prvo nematerijalno kulturno dobro iz Crne Gore.

Bokeljska mornarica je bila najvažniji svjedok i protagaonista duge i bogate povijesti, posebno pomorske povijesti, Boke Kotorske i postala je jedan od najznačajnijih simbola njenog specifičnog identiteta. Iz prvog perioda njene srednjovjekovne povijesti nijesu sačuvani dokumenti, kao ni dokumenti koji se odnose na povijest Kotora i Boke, pa je možemo neprecizno rekonstruisati na osnovu drugih historijskih izvora i analogija sa sličnim organizacijama toga doba na Mediteranu i u Evropi. Prvi poznati dokument koji se tiče Bratovštine pomoraca u Kotoru potiče iz 1353. godine i svjedoči da je ona u Kotoru postojala već davno prije toga i bila najbogatija od brojnih kotorskih bratovština.

Period vladavine Mletačke Republike Kotorom i Bokom (1420–1797) od izuzetnog je značaja za povijest ovoga kraja i njegovu kulturu, a posebno za pomorsku povijest i za Bratovštinu pomoraca u Kotoru, i iz toga perioda je

sačuvano mnogo dokumenata, među kojima i Statut Bratovštine iz 1463. godine. Na osnovu toga statuta i drugih izvora historičari koji su se bavili ovom temom zaključili su da su prije njega postojali drugi statuti Bratovštine koji nijesu sačuvani.

Bratovština pomoraca je od srednjeg vijeka do danas imala statute koji su precizno određivali njene najvažnije ciljeve i aktivnosti, način izbora upravnih organa, njihove zadatke i ovlaštenja, prava i dužnosti članova itd., odnosno, bili pravni osnov Bratovštine. U tom smislu analiza tih statuta, počev od prvog sačuvanog iz 1463. do zadnjeg iz 2016. godine značajna je jer ilustruje evoluciju Bratovštine, promjenu njenih funkcija, kao i sposobnost njenog prilagođavanja promjenama u političkom, pravnom, kulturnom i društvenom okruženju, što joj je omogućilo da preživi dramatične povijesne događaje, te da pored svih promjena ostane vjerna svojim temeljnim vrijednostima, oličenim u njenom geslu *Fides et honor – Vjera i čast.*

U radu se koncizno analiziraju svi statuti od 1463. do 2016. godine, uz objašnjenja povijesnog konteksta u kome su nastali. Proučavanje ovih statuta je značajno ne samo za povijest Bokeljske mornarice, Kotora, Boke i Crne Gore, već i za proučavanje pravne, kulturne i pomorske povijesti Jadrana i Mediterana.

Svi statuti su dostupni na sajtu Bokeljske mornarice Kotor.[1]

Statut kotorske Bratovštine Svetog Nikole Mornara iz 1463. godine

Dana 26. juna 1463. na zvuk zvona se sastala u Crkvi Svetoga Nikole u Kotoru Skupština kotorske Bratovštine Svetog Nikole Mornara, na kojoj je učestvovalo 48 članova, brodovlasnika i pomoraca, uključujući gastalda Ratkovića (Ratcovich), svećenika Rikarda (Ricardo), Ivana Božidarova (Coan de Bosidar), Luku Radojčina (Luka de Radoico) i Luku Mekiniča (Luka Mechinich), kasnijeg kapelana Bratovštine. Na ovoj izuzetno važnoj skupštini usvojen je Statut Bratovštine, od bitnog značaja za njenu povijest, jer je riječ o prvom sačuvanom statutu Bratovštine, koji je bio na snazi punih 410 godina. Svi historičari koji su se bavili ovom temom slažu se u tome da je Bratovština pomoraca u Kotoru znatno prije toga imala svoj statut koji nije sačuvan.

Zanimljiva je povijest sačuvanog originala ovog Statuta koji se danas čuva u Kotorskoj biskupiji. Tekst Statuta je prvi put u prepisu objavio Josip Đelčić 1889. na italijanskom, sa komentarima, ne navodeći gdje se nalazi originalni manuskript. U njegovom prepisu ima manjih skraćenja originala, a, osim toga, on je „brojne dokumente, koji su kasnije upisivani na praznim listovima iza teksta manuskripta Statuta, iz vremena poslije 1463. godine,

[1] http://www.bokeljskamornarica.com/-rubrika Arhiva

dao samo u više-manje sažetim regestima. A to nije uvijek dovoljno ni za razumijevanje samog Statuta, a pogotovo ne za praćenje daljeg razvoja Bratovštine".[2] Originalni primjerak Statuta dugo vremena je smatran izgubljenim, a pronašao ga je 1979. godine don Gracija Brajković, svećenik i historičar, u Kotorskoj biskupiji, gdje se čuva do danas, što je omogućilo da se povodom proslave 1200 godina od osnivanja Bratovštine, koja je svečano obilježena 2009. godine, objavi njegovo fototipsko izdanje sa prevodom i komentarima Miloša Miloševića i Sime Ćirkovića, a sa pogovorom Miloša Miloševića i Jelene Antović. Ovaj Statut je ostao na snazi sve do donošenja novog 1873. godine, dakle 410 godina. Tvrdnja historičara da su svakako i ranije postojali statuti Bratovštine pomoraca u Kotoru, koji nijesu sačuvani, proizlazi iz analize odredbi Statuta iz 1463, kao i iz činjenice da su sve srednjovjekovne bratovštine, uključujući i one u Kotoru, imale svoje statute, a da je Bratovština pomoraca postojala stoljećima prije 1463. godine.

U srednjovjekovnom Kotoru postojale su brojne bratovštine, od kojih je Bratovština pomoraca bila najvažnija, jer je pomorstvo bilo najvažnija privredna djelatnost grada i okoline. Bratovštine su bile veoma važne institucije srednjovjekovnog društva, a slične organizacije su postojale u starom vijeku. „Samoorganizovanje građana u formi bratovština je stoljećima bilo od bitnog značaja za zaštitu društvenih grupa povezanih zajedničkim interesima i imalo veliki uticaj na razvoj gradova, građanske klase, trgovine, zanata, manufakture, saobraćaja, obrazovanja, kulture, te na postepenu transformaciju feudalnog u moderno građansko društvo. Bratovštine su bile dobrovoljne organizacije građana koji su imali jednaka prava, iz njih su bili isključeni plemići, imale su svoje statute, na skupštinama su se demokratski donosile najvažnije odluke i biralo rukovodstvo."[3]

Prema tradiciji Bratovština pomoraca u Kotoru je osnovana 13. januara 809. godine, kada su relikvije Svetog Tripuna donesene u grad. Neki historičari, poput S. Mijuškovića, smatraju da ta tradicija nema osnova, te da je Bratovština pomoraca nastala najranije u XIII stoljeću.[4] No, on ne isključuje

[2] *Statut Bratovštine svetog Nikole mornara iz1463. godine sa alegatima do 1807. godine*, prir. M. Milošević i J. Antović, Kotor, 2009, str. 156.
[3] A. Sbutega, *Bokeljska mornarica, nematerijalna kulturna baština čovječanstva*, Kotor, 2022, str. 23.
[4] S. Mijušković, *Kotorska mornarica*, Podgorica, 1994, str. 33.

ranije postojanje pomorske organizacije vojnog karaktera zadužene za odbranu zaliva,[5] a istu tezu zastupa i A. Dabinović.[6]

„Međutim, ne čini se vjerovatnim da je ta organizacija imala samo vojno-pomorske funkcije, što zastupaju pomenuti historičari. Gradnja, oprema, održavanje i upotreba ratnih brodova i njihovo učešće u pomorskim ratovima i bitkama, o kojima svjedoče izvori u ovom periodu, zahtijevala je veoma visoki stepen razvoja pomorstva. Nije apsolutno moguće da jedan primorski grad bude u stanju da sagradi, opremi, održava, snabdije posadom i upotrebljava ratne brodove bez postojanja razvijene trgovačke flote, brodogradilišta, obučenih i iskusnih pomoraca, odnosno razvijenog pomorstva u cjelini. Imajući to u vidu, logično je zaključiti da je u Kotoru postojala drevna organizacija pomoraca koja je imala i vojno-pomorsku funkciju, stalno ili prema potrebi, poput bratovštine u vrijeme mletačke vladavine Kotorom. Da li je ta institucija imala kontinuitet iz antičkog vremena, kako je bila organizovana, da li je postojala bez prekida, naravno, ne možemo znati budući da za to nedostaju izvori.“[7]

Prvi sačuvani dokument koji se tiče Bratovštine pomoraca iz 1353. godine pominje *Pia sodalitas naviculatorum catharensis* (*Pobožno društvo kotorskih pomoraca*), koje je ustupilo svoju Crkvu Svetog Nikole van grada franjevcima.[8] To svjedoči ne samo o postojanju Bratovštine već i o tome da je ona svakako postojala davno prije toga i da je bila najbogatija, jer je imala, jedina od svih kotorskih bratovština, svoju crkvu. „Ovaj dokument je veoma važan, jer ne samo da govori o tadašnjem postojanju već indicira svakako i mnogo ranije osnivanje Bratovštine, dok je ona u to vrijeme ne samo bila u posjedu jedne crkve nego je istu već tada otuđila.“[9] Najstariji sačuvani statut kotorskih bratovština je onaj Bratovštine bičevalaca iz 1298. godine. „Tekst je ispisan dijelom latinskim, a dijelom srednjovjekovnim talijanskim jezikom

[5] Ibid., str. 18.

[6] A. Dabinović, *Kotor pod Mletačkom republikom 1420–1797*, Zagreb, 1934; A. Dabinović, „Može li se govoriti o kontinuitetu Kotorske Mornarice od 809 do danas?“, GPMK, VIII, 1957; A. Dabinović, „Kad je došlo u Kotoru do organizacije pučanskog staleža?“, GPMK, XII, Kotor, 1964; A. Dabinović, Crkveno-političke promjene u istočnojadranskom prostoru za vrijeme Karla Velikog, rukopis u Istorijskom institutu Crne Gore u Podgorici, br. 458, str. 1–107.

[7] A. Sbutega, *Bokeljska mornarica, nematerijalna kulturna baština čovječanstva*, Kotor, 2022, str. 36.

[8] D. Farlati, J. Coleti, *Illyirici sacri*, VI, Venecija, 1800, str. 449.

[9] S. Mijušković, *Kotorska mornarica*, Podgorica, 1994, str. 32.

mletačkog narječja i to književnom goticom. Pisan je na pergamentu dvobojnom tintom, crnom i crvenom".[10]

Kao i druge srednjovjekovne bratovštine, i Bratovština pomoraca je bila institucija građanskog staleža, a plemići nijesu mogli biti članovi.

Pučani su činili zajednicu koja se nazivala *universitas* i oni su bili „nerazdvojni dio gradske sredine i miljea. Taj srednji stalež je i u Kotoru, kao uostalom i ostalim srednjovjekovnim gradovima na istočnoj obali Jadranskog mora, u Italiji i čitavoj Europi, predstavljao većinu gradskog stanovništva, a pretežna djelatnost mu je bila trgovina, bilo pomorska ili kopnena-karavanska",[11] a pored toga je imao prihode od nekretnina, kuća, zemljišnih posjeda i zanatstva.

Plemićki stalež je bio sastavljen od starih i uglednih obitelji uglavnom latinskog i bizantskog porijekla, među koje postepeno ulaze i slavenske porodice; oni čine *communitas* i iz njihovih redova se biraju članovi Velikog i Malog vijeća i Vijeća umoljenih. Suživot i saradnja dva najvažnija staleža su „i pored povremenih sukoba bili od esencijalnog značaja za grad, pogotovo u ovom nestabilnom i opasnom periodu".[12]

Naslov Statuta je na latinskom jeziku *Liber fraternitatis divi Nicolai marinarorum d*e *Catharo*, a zatim je dat prevod na italijanski u mletačkom dijalektu *Qua comenca la matricola de la congregation de miser san Nicolo di marinai de Catharo* (*Statut Bartovštine Svetog Nikole Mornara iz Kotora*). Osim prologa na latinskom, kojim se saziva milost Duha Svetoga, tekst je napisan na italijanskom jeziku, gotičkim slovima

M. Milošević i J. Antović smatraju, s pravom, da je „ogromna većina pomoraca slavenskog porijekla uticala da se Statut ne piše na latinskom, koji im je bio nepoznat ili malo poznat, nego na italijanskom"[13]. Manuskript Statuta ima 72 pergamentna lista, a minijatura koja predstavlja obojeni lik Svetog Nikole u inicijalu na prvom listu pripisuje se kotorskom slikaru Lovru Marinovu Dobričeviću.[14]

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[10] „Don Anton Belan o Statutu kotorske Bratovštine bičevalaca iz 1298. na Međunarodnom naučnom skupu Stare i rijetke knjige, dokumenta i umjetnine na papiru", *Hrvatski glasnik* 174, Kotor, 2020, str. 21.

[11] J. Martinović, *Socijalno-ekonomska struktura društva u Kotoru prve polovine XIV vijeka*, Kotor, 2017, str. 137.

[12] A. Sbutega, *Bokeljska mornarica, nematerijalna kulturna baština čovječanstva*, Kotor, 2022, str. 56.

[13] *Statut Bratovštine svetog Nikole mornara iz1463. godine sa alegatima do 1807. godine*, prir. M. Milošević i J. Antović, Kotor, 2009, str. 159.

[14] R. Vujičić, „Jedna minijatura Lovra Dobričevića u Kotoru", *Uvijek na istom putu,* Zbornik biskupa Iva Gugića, Perast, 1996, str. 183.

Statut ima XXVI glava. U prvoj se određuje da se gastald, sindici i prokuratori biraju tajnim glasanjem na Skupštini koja se saziva sa tri otkucaja zvona, a kojoj mora prisustvovati najmanje 25 članova.

U glavi II se određuje da se o svim važnim pitanjima odlučuje tajnim glasanjem većinom glasova.

U glavi III se određuje da se gastald bira svake godine na skupštini koja se saziva na dan Uznesenja. Gastald se mora zakleti da će „povećati, uzdići i održavati sa svom svojom vlašću stanje naše bratovštine“[15]. On čuva Statut, križ i sve predmete od vrijednosti, kao i kasu sa novcem, koji moraju biti na raspolaganju Skupštini i službenicima Bratovštine.

Glava IV precizira da se izbor tri prokuratora koji vrše dužnost blagajnika vrši tajnim glasanjem na Skupštini na godinu dana. Oni raspolažu sa dva ključa od kase koju čuva gastald i moraju u prisustvu svjedoka staviti u kasu prihode, od kojih dobijaju tri posto. Ono što ne budu sakupili u toku svoga mandata platiti će od vlastitog novca. Ukoliko daju ostavku, biti će izbačeni iz Skupštine i platiti kaznu.

Glava V se odnosi na dvojicu sindika koji se biraju na skupštini tajnim glasanjem na dvije godine. Oni imaju zadatak da zajedno sa gastaldom i prokuratorima, jedan do tri puta godišnje ili više, u potpunoj slobodi „utvrde i ocijene razloge postojanja naše bratovštine“.

Glava VI se odnosi na izbor četiri svećenika-kapelana, koje bira Skupština tajnim glasanjem. Njihova dužnost je da svakog dana, smjenjujući se svake sedmice, služe misu u Crkvi Sv. Nikole uz platu od 40 perpera godišnje i da prate križ Bratovštine na svečanim procesijama i za to imaju naknadu od 4 groša.

Glava VII propisuje da se svečanost Sv. Nikole svetkuje sa dvije pjevane večernje službe i misom.

Glava VIII predviđa da Skupština imenuje jednog gvardijana crkve (ckrvenjaka).

Glava IX se odnosi na članstvo i određuje da se svi patruni nava, malih nava, brodova, barkozija i malih barkozija koji žele da budu članovi moraju upisati sa svojim brodovima i zakleti se da će čuvati odredbe Statuta i sve buduće odluke. Moraju prijaviti svaki teret svojih brodova i platiti jedan kotorski groš po „karu“. Termin patrun je označavao brodovlasnika i zapovjednika, koji su često bili ista osoba.

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15 *Statut Bratovštine svetog Nikole mornara iz1463. godine sa alegatima do 1807. godine*, prir. M. Milošević i J. Antović, Kotor, 2009, str. 156.

Glava X se odnosi na obavezu rukovodioca Bratovštine da svake tri godine provjerava spisak upisanih patruna i njihovih brodova i ažurira ga.

Glava XI predviđa da patruni koji idu iz Kotora na putovanje u pravcu Pulje, Marke, Romanije (Peloponez) ili drugdje, a od tamo za Veneciju, Dalmaciju, Albaniju ili drugdje, ne vraćajući se u Kotor, moraju po povratku u Kotor prijaviti svoja putovanja i izmiriti dugovanja Bratovštini, te da ako neki zapovjednik koji plovi van Boke ukrca strane pomorce, mora za njih odgovarati Bratovštini.

Glava XII se odnosi na pomoć siromašnim članovima.

Glava XIII se takođe odnosi na pomoć siromašnim članovima koji nemaju mogućnosti da opreme svoje kćerke za udaju.

U glavi XIV stoji odredba da suvlasnici brodova ne mogu biti birani u važne službe Bratovštine već samo patruni brodova.

U glavi XV se ovlašćuje gastald da naredi nekom patrunu da prenese tijelo umrlog člana sahranjenog van zaliva u Kotor, gdje će biti časno sahranjeno u grobnici Bratovštine.

Glava XVI predviđa posmrtni vjerski obred za članove Bratovštine i članove njihovih obitelji.

Glava XVII predviđa da se svake godine za Duhove održi večernja misa sa pjevanjem za duše svih preminulih članova.

Glava XVIII određuje da troškove sahrane povodom smrti člana, ako ih obitelj ne može pokriti, to učini Bratovština.

Glava XIX takođe predviđa da Bratovština pokrije troškove bdjenja trećeg dana prilikom smrti siromašnog člana uz misu sa pjevanjem.

Glava XX određuje da će strani pomorac koji umre u Kotoru, bez sredstva za ukop, biti sahranjen u grobu Bratovštine, o njenom trošku, a pratiti će ga dva svijećnjaka.

Glava XXI određuje da se prilikom svečanih procesija u gradu, u kojima učestvuju i druge bratovštine, nosi križ Bratovštine pomoraca sa četiri svijećnjaka i svijećama.

Glava XXII predviđa da se redovno vodi evidencija prihoda i rashoda u „velikoj svesci“ koju će verifikovati sindici.

Glavom XXIII se određuje da prokurator vodi još jednu pisanu evidenciju o prihodima, tzv. malu svesku.

Glava XXIV se odnosi na troškove o kojima treba da vode brigu prokuratori, a koje oni moraju pravdati kada se to od njih traži.

Glava XXV predviđa kazne za članove, posebno službenike koji bi obmanjivali ili vršili krađu imovine Bratovštine.

Posljednja XXVI glava određuje da se izradi inventar na pergameni svih pokretnih stvari koje pripadaju Bratovštini, koji jednom godišnje treba da ispitaju prokuratori i sindici prilikom izbora novog gastalda.

Za svaki prekršaj, odnosno neizvršavanje predviđenih obaveza predviđene su kazne, zavisno od ozbiljnosti prekršaja.

Pored navedenih glava na marginama je upisano još odredbi donesenih prije 1514. godine, koje su sastavni dio Statuta.

Prva se odnosi na odluku Skupštine da sindici mogu trošiti u korist Bratovštine, a da prokuratori bez sindika mogu primati i trošiti novac u njenu korist.

Druga utvrđuje dodatak za kapelane od pet perpera.

Treća se odnosi na obavezu kapelana da svakog 14. novembra povodom svete mise održe molitvu Svetom Nikoli i za pomorce.

Četvrta se takođe odnosi na obavezu kapelana da svakog ponedjeljka održe pomen za mrtve.

Peta navodi odluku Skupštine da svako ko uvrijedi službenika crkve plati kaznu, a ako je ne plati, da se isključi iz Bratovštine.

Šesta zabranjuje prokuratorima da kreću na put, a da ne predaju novac u kasu, uz prijetnju kaznom.

Sedma određuje da nijedan brod ne može krenuti a da ne uplati predviđenu svotu Bratovštini ili ne preda zalog, uz kaznu koja će se odrediti.

Osma zabranjuje pozajmicu novca Bratovštini bez sigurnog zaloga, uz prijetnju kaznom.

Deveta predviđa da na poziv zvona na Skupštinu ili procesiju oko grada moraju doći svi članovi, uz prijetnju kaznom.

Deseta se odnosi na odluku Skupštine da karake plaćaju lučke takse (*arboragi*) kako je uobičajeno, manji brodovi od 500 do 400 stara pet dukata, a još manji od 200 do 300 stara četiri dukata, a svi plaćaju dva solda za jedan kar. Taksa *arboragi* se odnosi na veličinu broda, odnosno njegovu nosivost, na što „upućuje i etimologija riječi, od 'arbore' tj. jarbol, što znači katarka, odnosno broj jedara. Tu se pominje da je za karake iznos već 'ranije' bio utvrđen, ali se ne kaže o kolikom se iznosu radi. Posebno je zanimljivo da to 'ranije' može značiti samo prije 1463, dakle u nekoj ranijoj organizaciji, ili Statutu“[16].

[16] Ibid., str. 174.

Jedanaesta zabranjuje da službenici Bratovštine donose odluke o davanju u najam nekretnina Bratovštine bez Skupštine, kako bi se izbjegle neracionalne odluke i zloupotrebe.

Dvanaesta insistira na tome da se ne smije pričiniti šteta Bratovštini, te precizira način naplate predviđenih kazni.

Trinaestom odlukom, koja je donesena na Skupštini uz prisustvo 36 članova, zabranjuje se članstvo u Bratovštini brodograditeljima (drvodjelcima i kalafatima), te se isključuju oni koji su tada bili članovi, a predviđena je kazna za članove koji se zalažu za brodograditelje. Odnos između brodograditelja i Bratovštine je kompleksan i on se mijenjao, tako da su brodograditelji povremeno bili članovi, a povremeno bili isključivani.

Četrnaesta odluka predviđa kaznu za članove koji ne dođu na ispraćaj umrlih sinova ili kćeri nekog člana.

Petnaesta predviđa da stranac koji izvuče brod na zemlju (radi popravke) i koristi sredstva Bratovštine mora platiti četiri venecijanska groša. To svjedoči da je Bratovština posjedovala ako ne brodogradilišta, onda opremu za remontnu brodogradnju.

Šesnaestom odlukom Skupština naređuje majstoru Radelji (Radeglia, brodograditelju) da izvlači brodove na suho i da za tu uslugu naplaćuje za veće brodove 4 groša, a za manje 2 groša. Obavezuju se svi patruni da moraju koristiti usluge Radelje, koji se naziva odanim članom Bratovštine, a u suprotnom će morati da mu plate dnevnicu. Ako se Radelja ne odazove, treba da plati četiri groša. Ova odredba pokazuje da su i dalje, i pored ranije zabrane, brodograditelji bili članovi Bratovštine. Mijušković to tumači time da je Radelja, kao i neki drugi brodograditelji, bio ranije pomorac i kao takav član, a da se poslije posvetio brodogradnji.[17]

Skupština od 23. aprila 1514, na kojoj je učestvovalo 30 članova, odlučuje da se majstor Radelja otpusti i zamijeni gospodinom Nikolom Martegatom (Nicolò Martegato), koji će upravljati magacinom i za to biti plaćen. Očito se radi o magacinu sa brodograđevnim alatom i opremom.

Odluke koje su donesene na Skupštini poslije 1514. uvrštene su kao prilozi, alegati Statuta i ima ih previše da bi ovdje mogle biti analizirane. Važno je spomenuti odluku iz 1631. godine da sve osobe nastanjene u gradu i okolini koje plove ili namjeravaju da to rade, osim Perasta, neće moći da se bave ovom djelatnošću ako se ne učlane u Bratovštinu Svetog Nikole Mornara. Svi koji se bave pomorskom trgovinom moraju plaćati 4 solda za jedan miljar

[17] S. Mijušković, *Kotorska mornarica*, Podgorica, 1994, str. 63.

bilo koje robe koja se izvozi iz Boke i drugih krajeva.[18] To ne znači da i ranije nije važilo ovo pravilo, već se ono izričito naglašava zato što nije striktno poštovano. Iz prakse drugih bratovština koje su bile udruženja određenih profesija u srednjem vijeku znamo da se niko nije mogao baviti tom profesijom ko nije bio član bratovštine. To potvrđuje i odluka donesena na Skupštini Bratovštine pomoraca Svetog Nikole Mornara 12. jula 1649. godine, na kojoj je odlučeno da se svi oni koji se bave pomorstvom u gradu i okolini, izuzev Perasta, moraju u roku od 8 dana upisati u Bratovštinu. Kazna za nepoštovanje ove odluke bila je 50 perpera.

Izuzimanje Perasta ovom odlukom je neosporna potvrda da teritorija peraške komune, koja je osnovana oko 1585. i administrativno odvojena od Kotora, nije više bila u kompetenciji bratovštine iz Kotora. No već 1580. godine postoje podaci da je Perast imao svoju Bratovštinu pomoraca[19] i do ponovnog ujedinjena sa Bratovštinom u Kotoru će doći tek u XX stoljeću.

U poređenju sa statutima bratovština pomoraca u Zadru i Splitu iz približno istog perioda Statut Bratovštine pomoraca iz Kotora je znatno precizniji i detaljniji, „pa možemo bez ikakvog ustručavanja izvesti zaključak da je Bratovština kotorskih pomoraca u svakom slučaju starija od ostalih dviju, čiji se datumi osnivanja takođe ne mogu odrediti“[20].

U toku skoro 377 godina mletačke vladavine Bratovština je imala brojne funkcije koje nijesu pomenute u Statutu iz 1463, već u kasnijim dopunama i alegatima, bilo da su te funkcije postojale ranijih stoljeća bilo da su nastale tokom mletačke vladavine. Za razliku od ostalih pomorskih bratovština na Istočnom Jadranu Bratovština u Kotoru je imala i vojnu funkciju, koja je najvjerovatnije postojala tokom stoljeća koji su prethodili mletačkoj vladavini, a mletačke vlasti su stimulisale njeno jačanje. Tako 1430. godine mletačke vlasti potvrđuju Bratovštini privilegiju da opremi državnu galiju.[21] Registar pomoraca i brodova koji je vodila Bratovština je bio dragocjen za mletačke vlasti koje su ove pomorce i brodove po potrebi angažovale u vojne svrhe. Najzad, 1493. godine Alegreto Nigro ujedinjuje funkciju admirala kotorske luke (lučkog kapetana) i gastalda Bratovštine, preuzimajući upra-vljanje lukom, borbenim pomorskim odredom i Bratovštinom pomoraca. „S obzirom na njegovu vezu sa Bratovštinom, ili bolje s obzirom na njegovo inkorporira-

[18] *Statut Bratovštine svetog Nikole mornara iz 1463. godine sa alegatima do 1807. godine*, prir. M. Milošević i J. Antović, Kotor, 2009, str. 66.
[19] P. Butorac, *Kulturna povijest grada Perasta*, Perast, 1999, str. 78–79.
[20] S. Mijušković, *Kotorska mornarica*, Podgorica, 1994, str. 45.
[21] Državni Arhiv Crne Gore (DACG), Istorijski Arhiv Kotor (IAK) OK CI–161 i 161/1t.

nje u istoj, a naročito držanjem njenih odgovornih, a kasnije i najodgovornijeg položaja (gastalda), shvatljivo je što je kotorski admiral bio ne samo 'ammiraglio del porto', već i 'ammiraglio della Marinarezza di Cattaro'."[22] Prema J. Paralu, admiral je zajedno sa rektorom Kotora (funkcija koju je ustanovila Venecija od 1420, a kasnije sa vanrednim providurom) „bio prva i najvažnija ličnost Boke i kao takav imao izvanredna ovlaštenja"[23].

Bratovština je imala i zadatke da se brine o pomorskoj sanitetskoj službi i o organizaciji pomorskog prevoza državne pošte između Kotora i Venecije. Ta pošta je išla kopnenim putem preko Crne Gore do Kotora (odnosno iz Kotora do Carigrada), a brodovima između Kotora i Venecije. U početku su pomorski prevoz te pošte organizovali plemići iz Kotora, a kasnije su za to bili zaduženi Prčanjani.[24]

Kao i druge srednjovjekovne bratovštine i Bratovština pomoraca je obrazovala svoje članove, što je bilo posebno značajno jer u Boki prije 1849. godine nije bilo javnih pomorskih škola.[25] Članovi Bratovštine, a posebno časnici, bili su najbolji stručnjaci za sve oblasti pomorstva, pa ih je vlast pozivala da daju stručno mišljenje u raznim sudskim sporovima i drugim prilikama.

Interesantno je da Statut grada Kotora ima veoma malo odredbi koje se odnose na pomorstvo, iako je pomorstvo bilo od vitalnog značaja za grad tokom cijele njegove povijesti, a posebno u periodu vladavine Mletačke Republike. Mletačke vlasti su pri rješavanju sporova u pomorstvu koristile običajno pravo, služeći se pri tome uslugama lokalnih eksperata koji su to dobro poznavali, koji su bili članovi, posebno časnici, Bratovštine pomoraca: „Oni, će, kao i ostali članovi Bratovštine, prilikom svojih sastanaka često razgovarati o raznim situacijama iz pomorskih sporova i o riješavanju istih, evocirajući pri tom iste i slične tretmane i odluke iz prošlosti, na kojima će zasnivati i nove presude u takvim arbitražnim procedurama itd. i ti razgovori će ići i prenositi se sa generacije na generaciju. I tu, u sjedištu Bratovštine kotorskih pomoraca, stalno će se voditi briga o pravilnom rješavanju pomorskih sporova, isto onako kao što se vodila briga o svim drugim pitanjima od interesa za pomorstvo uopšte."[26]

[22] S. Mijušković, „Kotorski admirali", GPMK XV, Kotor, 1967, str. 7.
[23] J. Parall, *La Marinarezza Bocchese e la Festa di San Trifone*, Cattaro, 1899, str. 11.
[24] N. Luković, *Prčanj*, Kotor, 2010, str. 33–34.
[25] A. Sbutega, „Doprinos Bokeljske mornarice obrazovanju pomoraca", Zbornik Pomorskog fakulteta, Kotor, 2019.
[26] S. Mijušković, *Kotorska mornarica*, Podgorica, 1994, str. 87–88.

Bratovština pomoraca je, kao i druge bratovštine, bila institucija građana čiji članovi nijesu bili plemići. Na taj način su bratovštine, predstavljajući *universitas*, odnosno građanski stalež, nasuprot *communitasu*, koga je činilo plemstvo, imale značajnu društvenu i političku ulogu u životu grada i komune. „Svaki od ova dva elementa je štitio i promovirao svoje staleške interese, ali istovremeno morao biti spreman na kompromis u zajedničkom interesu svih. U tom smislu poseban značaj je imala Bratovština pomoraca, najvjerovatnije najstarija a svakako najmoćnija institucija građanskog društva."[27]

Bratovština pomoraca je imala i bitnu direktnu i indirektnu ulogu u stvaranju materijalne i nematerijalne kulture Kotora i Boke, zbog koje je Kotor sa okolinom po više osnova upisan na UNESCO-vu listu kulturne baštine čovječanstva. „U Boki je na neobično jasan i sugestivan način pri-mjetna najuža veza između porasta pomorskog prosperiteta i umjetničkih realizacija."[28] „Sa svojom plodnom aktivnošću Bokeljska mornarica je bila od bitne važnosti za javni život, koji je tada u Boki zavisio gotovo isključivo od pomorstva."[29]

Imajući u vidu višestruki značaj Bratovštine pomoraca za Mletačku Republiku, a posebno njenu vojnu funkciju, te izuzetnu hrabrost njenih članova ispoljenu u brojnim ratovima i bitkama, među kojima je najpoznatija Lepantska bitka 1571. godine,[30] Republika je odobravala brojne privilegije Bratovštini, od kojih su posebno bile značajne one trgovačke, kao i one vezane za preuzimanje trodnevne vlasti u gradu za vrijeme Tripundanskih svečanosti, te pomilovanje osuđenika tom prilikom.

Statut Plemenitog tijela Bokeljske mornarice iz 1873. godine

Statut iz 1463. je bio na snazi do 1873. godine, kada je donesen novi Statut, dakle, punih 410 godina. On je dopunjavan novim odredbama i omogućio je efikasno funkcionisanje Bratovštine do kraja Mletačke Republike 1797. godine. Poslije toga, u toku Napoleonovih ratova, Boka je prošla kroz buran i dramatičan period: prva austrijska vladavina 1797–1805, kratka ruska vlast 1806–1807. i francuska vladavina 1807–1814. godine.[31] U toku ovog

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[27] A. Sbutega, *Bokeljska mornarica, nematerijalna kulturna baština čovječanstva*, Kotor, 2022, str. 81.

[28] M. Milošević, „Neki aspekti pomorske privrede Boke Kotorske", *Pomorski zbornik* II, Zagreb, 1962, str. 1793.

[29] J. Parall, *La Marinarezza Bocchese e la Festa di San Trifone*, Cattaro, 1899, str. 9.

[30] A Sbutega, „Kotor, Boka i Bratovština kotorskih pomoraca u Kiparskom ratu i bici kod Lepanta", GPMK LXVI–LXVII–LXVIII, Kotor, 2021.

[31] P. Butorac, *Boka Kotorska nakon pada Mletačke republike do bečkog Kongresa (1797–1815*), Zagreb, 1938; I. Zloković, „Bokeljsko pomorstvo u Napoleonovo doba", *Pomorski zbornik* II, Zagreb, 1962.

perioda Boka je ne samo često mijenjala vladaoce već je bila pogođena ratovima, razvojem gusarstva i ekonomskim ograničenjima, što je posebno pogodilo pomorstvo i trgovinu. To je imalo negativne posledice i na Bratovštinu pomoraca, koju su Francuzi ukinuli 1811. godine i zaplijenili joj imovinu.[32]

Druga austrijska vladavina Bokom, koja je na osnovu dogovora ruskog i austrijskog cara, potvrđenog odlukom Bečkog kongresa, počela 1814. i trajala do 1918. godine, bila je period značajnih promjena u Bratovštini. Ona je bila obnovljena 1833, a zatim ponovo ukinuta 1848. (ili 1849) godine. Angažovanjem kotorskog biskupa Marka Kalođere i pomorskog kapetana i pjesnika Pava Kamenarovića obnovljena je 1859. kao Plemenito tijelo Bokeljske mornarice. U međuvremenu je izgubila funkcije iz mletačkog perioda i pretvorena je u memorijalnu organizaciju, što je normirano novim Statutom 1873. godine.

Komisija za izradu Statuta je formirana 1871. godine i imala je trideset članova, a činili su je, pored članova Mornarice, i načelnici općina Kotor, Dobrota, Prčanj, Muo, Lastva i Stoliv.[33] Komisija kojom je rukovodio admiral Nikola de Matei izradila je Statut koji je usvojen na sjednici 6. oktobra 1873. godine.[34]

Statut iz 1873. godine ostao je sačuvan u rukopisu na italijanskom jeziku (danas se čuva u Pomorskom muzeju Crne Gore u Kotoru) i sastoji se od uvoda i 11 poglavlja sa 64 člana. U uvodu se ističe da se osnivanje Bokeljske mornarice vezuje za godinu donošenja tijela Sv. Tripuna u Kotor (809), ali se navodi da ima i mišljenja o njenom kasnijem porijeklu. Pominje se Statut iz XV stoljeća, koji je proistekao iz tradicionalnih običaja, a na kraju uvoda se navodi kao najdraže geslo Bokeljske mornarice *Fides et honor – Vjera i čast*, koje joj je podario austrijski nadvojvoda Albreht Habzburški. Novo ime Bratovštine je Nobile corpo della Marinerezza bocchese – Plemenito tijelo Bokeljske mornarice.

Član 1 Statuta utvrđuje kao sjedište Mornarice grad Kotor.

Član 2 precizira da je cilj Mornarice da „Bokelji sačuvaju uspomene na slavna djela svojih predaka, okupljajući se u dane proslave Sv. Tripuna".

[32] DACG IAK, DEBOF XXXV, 279t–281t, *Bokeljska mornarica u arhivskim dokumentima. Zbornik dokumenata od najstarije sačuvanih do danas*, Kotor, 2021, str. 272.
[33] DACG IAK, OK XLIII, 72, 72t, 72/1, 72/1t; *Bokeljska mornarica u arhivskim dokumentima. Zbornik dokumenata od najstarije sačuvanih do danas*, Kotor, 2021, str. 299–300.
[34] DACG IAK OD XXXIX–419.

Član 3 predviđa učešće Mornarice prilikom dočeka austrijskog cara ili nekog člana njegove porodice, kao i drugih monarha i prinčeva-nasljednika.

Član 4 određuje da Mornarica prilikom nastupa prima od političke vlasti državnu, a od kotorske općine gradsku zastavu sa likom Sv. Tripuna.

Član 5 definiše odoru Mornarice kao bokeljsku narodnu nošnju sa odgovarajućim oružjem, pri čemu se odore i šeširi časnika razlikuju od odore mornara.

Član 6 određuje da članovi mogu biti svi Bokelji, stanovnici bokeljskih općina, a u izuzetnom slučaju svaki austrijski građanin nastanjen u Boki.

Član 7 određuje da članovi moraju imati najmanje 16 godina.

Članovi 8–63 odnose se na: regulisanje prava i obaveza članova; izbor i dužnosti oficira; održavanje skupština; regulisanje svečanih nastupa; održavanje loda, koje mali admiral izgovara na narodnom jeziku; igranje kola Mornarice; dužnosti kapelana; zastave; fond koji se sastoji od pomoći koju daje car i od „pobožnih" priloga i zaviještanja; komisiju koja će njime rukovoditi; opšte odredbe u kojima se govori: o sastavljanju pravilnika za internu upotrebu Glavnog štaba i pravilnika za regulisanje rada komisije za administriranje fonda; o obavezi prisustvovanja Glavnog štaba i ađutanta u uniformama na državnim svečanostima, prilikom carevog rođendana i Spasovdana; o pečatu koji treba da nosi grb grada Kotora, bez krune i orla, nad kojim će se nalaziti lovorov vijenac koji će podržavati dvije zastave, a između zastavnih kopalja nalaziće se natpis „Fides et honor"; o mogućnosti modificiranja Statuta odlukom 3/4 glasova Opšte skupštine i uz saglasnost dalmatinskog Namjesništva.

Član 64 (posljednji) propisuje da Statut mora biti podnesen Namjesništvu na odobrenje, a zatim preveden na slavenski jezik i objavljen u službenim novinama na oba jezika, koji se upotrebljavaju u Kotoru.

Original Statuta su potpisali: admiral Niko vitez de Matei (Nicolò de Mattei), major Mato conte Ivanović (Matteo Ivanovich), prvi kapetan Frederiko Brambila (Frederico Brambilla), drugi kapetan Luka Sablić (Luca Sablich), natporučnik Ferdinand Petović (Ferdinando Petovich), poručnik Luka Dabović (Luca Dabovich), poručnik Ilija Gasparini i ađutant Urban Vida.

Ovim Statutom Bokeljska mornarica je pretvorena u memorijalnu instituciju, čije su najvažnije aktivnosti bile učešće na proslavi Svetog Tripuna i u dočeku austrijskih i drugih velikodostojnika. Ona više nije bila udruženje pomoraca i nije isključivala plemiće, već je bila otvorena za osobe svih zanimanja i društvenih staleža.

Statut iz 1873. ostao je na snazi do donošenja Statuta 1934. godine, dakle 61 godinu.

U ovom periodu je ustaljen običaj imenovanja malog admirala, dječaka od 7 do 12 godina koji je 27. januara izgovarao tekst pohvala – loda Svetom Tripunu. Riječ je o drevnom običaju da dječak toga uzrasta, koji još nije grešan i zato je dostojan, obučen u narodno odijelo izgovori pohvale svecu. Nastupe Mornarice i plesanje kola pratila je Gradska muzika, a Pavo Kamenarović je napisao *Pjesan,* poetski tekst usklađen sa muzikom koja prati Kolo, u kome ističe ideju narodnog i vjerskog zajedništva:

Svi zajedno – svi u kolo
Rukama ruke stisnimo
Potvrdimo svim okolo
Da slogu bratsku ljubimo;
Nasljedujmo to načelo
što daše nama djedovi,
A Bog će dat – da veselo
Sl'jedit nas budu sinovi.

Mornarica se finansirala iz doprinosa Općine Kotor, priloga članova i sponzora, dobijala je i finansijsku pomoć od cara, a imala je svoje prostorije na Pjaci Svetoga Tripuna. Formirala je zbirku muzejskih eksponata i dokumenata koji svjedoče o njenoj povijesti i povijesti pomorstva Boke. Krajem XIX stoljeća imala je oko 300 članova, od čega je oko 150 učestvovalo na Tripundanskim svečanostima, a prvi put je nastupila van Kotora 1908. godine prilikom proslave 60 godina vladavine cara Franja Josipa u Beču.

U toku XIX stoljeća više autora je proučavalo bogatu povijest Mornarice i objavljeno je više djela sa ovom temom.

Statut iz 1934. godine

Plemenito tijelo Bokeljske mornarice je nastavilo svoje aktivnosti poslije Prvog svjetskog rata u novoj Kraljevini Srba, Hrvata i Slovenaca (od 1929. Kraljevini Jugoslaviji) i kralj Aleksandar Karađorđević ga je odlikovao Ordenom Svetog Save. U skladu sa Statutom i dalje su glavne funkcije bili nastupi na Tripundanskim svečanostima, valorizovanje drevnih tradicija i povijesnih memorija, te učešće u dočeku u Kotoru kralja, članova kraljevske dinastije i stranih suverena.

Promjena političkog, pravnog i administrativnog konteksta zahtijevala je donošenje novog statuta.

Na sjednici Mornarice 19. novembra 1933. konstatovani su brojni problemi i formiran je jedan odbor sa zadatkom da sagleda ukupno stanje i predloži mjere za prevazilaženje problema i revitalizaciju Mornarice.[35]

Posebno su bili aktivni Ćiro Kamenarović i Rudolf Đunio (Giunio), koji su imali značajnu ulogu u elaboraciji novog Statuta koji je usvojen 27. decembra 1934. godine i štampan sljedeće godine. Sastojao se od 8 poglavlja i 116 članova i bio je znatno precizniji i širi od prethodnog. U opširnom predgovoru je detaljno objašnjena prethodna povijest Mornarice i njene tradicije, uz navođenje važnih pisanih izvora. „Historija grada Kotora usko je povezana sa historijom crkve sv. Tripuna i sa historijom Bokeljske mornarice. Teško se može zamisliti život i razvoj grada Kotora odvojeno od života i razvoja crkve sv. Tripuna i Bokeljske mornarice. Gradska vlast, crkva sv. Tripuna i Bokeljska mornarica bile su tri glavne i moćne komponente one rezultante koja je za dugi niz vjekova bila uglavnom mjerodavna i odlučujuća za unutrašnji život i razvoj grada Kotora. Njihovi utjecaji su se međusobno isprepletali, pa nije čudo što ih je život za trajanja tolikih vjekova slio skoro u jedno te nam sada u historijskoj perspektivi često izgledaju jedna nerazdvojiva cjelina."[36]

Prvo poglavlje određuje sjedište, zadatak, nošnju, okupljanje, obilježja i zastave.

Član 1 određuje da je sjedište Bokeljske mornarice Kotor. U članu 2 se određuju njeni sljedeći zadaci:

„Da održavajući neprekidno svoj vlastiti kontinuitet očuva vjeru otaca i učvrsti u srcima Bokelja živu uspomenu na slavnu prošlost Mornarice, na velika i sjajna djela pradjedova, i da slaveći njihove vrline: viteštvo, junaštvo, čovječnost i domovinsku ljubav, prenosi ih iz generacije u generaciju pod drevnim geslom Mornarice 'Fides et honor' (Vjera i čast);

Da čuvajući svoje najsvjetlije tradicije neizostavno svake godine obnovi starodrevne običaje i svečanosti prilikom proslave pokrovitelja grada i Mornarice, Mučenika sv. Tripuna okupljajući tom prigodom svoje članove u tradicionalnoj nošnji i pod oružjem, i da vrši sve običaje, dužnosti i funkcije koje su tradicionalno vezane sa obredima crkve sv. Tripuna;

Da prikuplja historijsku građu o svojoj prošlosti, o slavnim djelima Bokelja uopće, a Mornarice napose, o svemu što je u vezi sa pomorstvom Boke Kotorske, sakupljajući i obnavljajući istovremeno staru nošnju i oružje, te izgrađujući biblioteku i muzej Bokeljske mornarice;

[35] Pomorski muzej Crne Gore Kotor, Knjiga zapisnika, sig. XVI–14.
[36] *Statut Plemenitog Tijela Bokeljske mornarice*, Kotor, 1935, str. 1.

Da obnovi prastaru i visoko razvijenu svijest čovječnosti svojih članova, njihovu dobrotvornost, i to obnavljajući staru Bratovštinu koja će pomagati siromašne članove Mornarice u slučajevima oskudice, bolesti i smrti, njihove udovice i siročad, pa i mornare, tuđe pripadnike, u slučaju da ih se u Kotoru (bez sredstava) snađe kakva nesreća ili smrt."

Članom 3 je predviđeno da se „Bokeljska mornarica okuplja u narodnoj nošnji, pod oružjem i pod zastavama; za vrijeme proslave sv. Tripuna Mučenika, pokrovitelja grada, Biskupije i Mornarice; prigodom dolaska u Kotor NJ. V. Kralja i Kraljice, Nj. Vis. Prijestolonasljednika ili ma kojeg člana Vladajućeg Doma; prigodom dočeka u Kotoru kojeg drugog poglavara stranih država ili njihovih prijestolonasljednika, drugim važnim prigodama, kada o tome odluku donosi Glavna Skupština; prigodom smrti Admirala".

Član 4 propisuje da „nošnju, oružje i obilježja Bokeljske mornarice mogu nositi samo njeni članovi isključivo u slučajevima predviđenim članom 3 Statuta". Kada je riječ o nošnji, unosi se jedna inovaciju u odnosu na prethodni Statut; umjesto dvorogog šešira za časnike se propisuje krzneni kalpak sa perom.

Poglavlje II detaljno opisuje učešće Mornarice na Tripundanskim svečanostima.

Poglavlje III propisuje počasne službe, postrojavanje, zapovjednike i Komandu Bokeljske mornarice.

Poglavlje IV se bavi članovima, njihovim pravima i dužnostima.

„Član Bokeljske mornarice može biti svaki državljanin Kraljevine Jugoslavije, koji je dobra društvena glasa i ponašanja, a kojeg primi Uprava Bratovštine. Član Mornarice može biti i svaki Bokelj ili koji potječe iz bokeljske obitelji, pa i tuđi državljanin, ako je dobra glasa i ponašanja i ako ga primi Uprava Bratovštine." Postoje sljedeće kategorije članova: počasni, dobročinitelji, osnivači, redovni, pomagači i mornari.

Tema poglavlja V su časnici, barjaktari, kolovođe i Uprava Mornarice.

Propisuje se da se admiral bira na pet godina, a ne kao ranije doživotno, a uvodi se čin podadmirala (viceadmirala). Mornaricom upravljaju Glavni štab (Admiralat) i Upravni odbor. Na čelu Mornarice je admiral koji rukovodi Admiralatom, a član je i Upravnog odbora, kojim rukovodi domaćin (gastald). Pored njih, Upravni odbor čine zamjenik domaćina, 5 skrbnika i gvardijani, kao i kapelani (najviše 4), te kotorski biskup i gradonačelnik ili njihovi predstavnici.

Poglavlje VI ima za temu finansiranje. Mornarica se finansira iz sljedećih izvora: redovnog visokog prihoda kralja; skrbnika, državnih, samoupravnih

i crkvenih vlasti; prinosa članova; ostavština i legata; darova i drugih fondova.

Član 94 predviđa osnivanje sljedećih fondova:

1. Administrativnog fonda – za pokriće administrativnih troškova i troškova vezanih za tradicionalne svečanosti povodom proslave Sv. Tripuna;

2. Historijsko-kulturnog fonda – za pokriće troškova za uređenje i održavanje muzeja, arhiva i biblioteke Mornarice, kao i za prikupljanje, sređivanje, čuvanje i nabavku historijske građe o Boki, Bokeljima i pomorstvu Boke;

3. Socijalno-humanitarnog fonda – za pokriće izdataka namijenjenih pomaganju siromašnih, bolesnih ili unesrećenih članova mornara i njihovih porodica, bez obzira na njihovu narodnost ili državnu pripadnost;

4. Fonda A – za finansiranje kupovine ili izgradnje Doma Bokeljske mornarice, kada to odluči Glavna skupština Mornarice;

5. Fonda B – za pokriće izdataka prema oporuci legatora čiji se legati ne mogu uvrstiti ni u jedan od gore spomenutih fondova.

Poglavlje VII ima za temu Glavnu skupštinu. Redovne skupštine se održavaju svake godine 13. januara u Općini, kada se biraju časnici i predsjedava im gradonačelnik, te na Spasovo, kada se raspravlja o važnim temama. Izvanredne skupštine sazivaju admiral, Uprava ili trećina članstva. Na svim skupštinama imaju pravo učešća i glasanja svi članovi, a glasanje je javno, osim ako četvrtina prisutnih članova ne zahtijeva da bude tajno.

Poglavlje VIII sadrži općenite odredbe i predviđa da je Admiralat dužan da izradi Nutarnji red Mornarice (pravilnik) sa detaljnim odredbama o nastupima.

Pečat Mornarice je grb Kotora sa natpisom *Plemenito tijelo Bokeljske mornarice* iznad njega i *Fides et honor* ispod.

Član 115 predviđa da „u slučaju raspusta Plemenitog tijela Bokeljske mornarice, sva će imovina odmah pripasti Crkvi Sv. Tripuna u Kotoru“ i ona će njom upravljati 50 godina. Ako se u tom periodu uspostavi ponovo Mornarica sa istom svrhom, crkva će joj vratiti imovinu, a u suprotnom prelazi u stalno vlasništvo crkve.

Formiran je Odbor dvanaestorice, kojim je predsjedavao Rudolf Đunio, sa zadatkom da Statut odobri vlast i da se sazove vanredna Glavna skupština.

Novi Statut, koji je vlast i odobrila, i druge inicijative dovele su do revitalizacije Mornarice, povećanja broja članova, osnivanja Muzeja Plemenitog tijela Bokeljske mornarice u Palati Grgurina (današnji Pomorski muzej Crne Gore) i izbora novog rukovodstva. Na izbornoj sjednici 13. januara 1935. za novog admirala je izabran prof. dr Karlo Radoničić. No, kako je on iste godine

umro, na Skupštini 13. janura 1936. za novog admirala izabran je kapetan Luka Matović, a za podadmrila Rudolf Đunio.[37] Admiral Matović je početkom 1941. godine dao ostavku, pa je 13. januara 1941. za admirala izabran Rudolf Đunio.[38]

Statuti Bokeljske mornarice iz 1964. i 1976. godine

U toku italijanske i njemačke okupacije u Drugom svjetskom ratu Bokeljska mornarica je bila ukinuta, a njeni najistaknutiji članovi admiral Rudolf Đunio i Ćiro Kamenarović bili su internirani u Italiju. Kamenarovića su po povratku iz italijanskog zarobljeništva 1944. ubili četnici. Mnogi članovi Mornarice su učestvovali u borbi protiv okupatora, a neki su u toku rata plovili na brodovima zapadnih saveznika.

Odmah poslije oslobođenja Kotora i Boke u novembru 1944. Bokeljska mornarica je obnovila svoje aktivnosti i učešće u proslavi Svetog Tripuna 1945. i 1946. godine uz podršku i učešće nove komunističke vlasti. No, pošto se učvrstio, komunistički režim je ubrzo promovisao agresivni ateizam i uspio da odvoji Mornaricu od njenih vjerskih tradicija, čemu se suprotstavio admiral Đunio, koji je dao ostavku. Iako njegova ostavka nije prihvaćena i on je formalno ostao admiral sve do smrti 1959. godine, nije učestvovao u aktivnostima i nastupima. Za Dan Mornarice je proglašen 10. septembar, dan Jugoslavenske ratne mornarice i pomorstva, mali admirali nijesu više izgovarali Lode, a odred Mornarice je nastupao na nekim folklornim smotrama i državnim proslavama, a ne na proslavi Svetog Tripuna. Iako je Statut iz 1934. bio na snazi, on nije poštovan i pokrenuta je inicijativa za reformu Mornarice i izradu novog Statuta.

Na Skupštini održanoj 30. avgusta 1964. usvojen je novi Statut, 30 godina poslije usvajanja prethodnog, a umjesto imena Plemenito tijelo Bokeljske mornarice usvojeno je ime Bokeljska mornarica. Ovim Statutom je djelatnost Mornarice usklađena sa novim društveno-političkim sistemom.

U uvodu se izlaže povijest Mornarice i piše da je „prije više od jedne decenije bila pokrenuta akcija za oživljavanje Bokeljske mornarice kako bi ona uporedno sa ostalim pomorskim ustanovama uzela udjela na unapređenju

[37] DACG IAK, OK CCXXIII, 154–154/2, *Bokeljska mornarica u arhivskim dokumentima. Zbornik dokumenata od najstarije sačuvanih do danas*, Kotor, 2021, str. 541–543.

[38] DACG IAK OK CCXLI – 62 do 62/1t, *Bokeljska mornarica u arhivskim dokumentima. Zbornik dokumenata od najstarije sačuvanih do danas*, Kotor, 2021, str. 562–565.

pomorstva Boke i čuvanju velikog kulturnog nasljeđa, čija je baza uglavnom bila pomorstvo“[39].

Za Dan Bokeljske mornarice u članu 4 Statuta utvrđen je isti datum kao i za Dan Jugoslavenske ratne mornarice i pomorstva – 10. septembar, ali je zadržan grb sa likom Svetog Tripuna i geslo *Fides et honor*, koje je samo prevedeno sa latinskog kao *Ponos i čast*, a ne *Vjera i čast.*

Članom 5 određeni su zadaci Bokeljske mornarice: „da njeguje svijetle tradicije našeg pomorstva i slavnu istoriju Bokeljske mornarice; da čuva i unapređuje bratstvo i jedinstvo Jugoslavije i da učvršćuje tekovine stvorene kroz Narodnooslobodilačku borbu i socijalističku revoluciju, budući da se u svojoj dugoj istoriji temeljila na idejama bratstva i ujedinjenja naših naroda; da sarađuje sa državnim organima, ustanovama i drugim organizacijama, koje u svojim programima imaju zadatke iz oblasti pomorstva; da održava veze sa srodnim organizacijama u zemlji i van nje.“

U članu 6 definisan je način ostvarivanja tih zadataka: „okupljanjem članova, fizičkih i pravnih lica, u organizaciji Bokeljske mornarice; organizovanjem i potpomaganjem svih inicijativa usmjerenih na unapređenje pomorstva; pomaganjem i organizovanjem naučno-istraživačkih radova iz oblasti pomorstva; objavljivanjem povremenih publikacija s tematikom pomorstva; vanrednim stipendiranjem ljudi koji se izuzetno bave usavršavanjem u oblasti pomorstva; prikupljanjem i obrađivanjem arhivske građe o pomorstvu, posebno one koja se odnosi na Bokeljsku mornaricu; prikupljanjem navigacionih uređaja, kako iz prošlosti, tako i iz savremenog doba, koji su od interesa za Bokeljsku mornaricu; aktivnim učešćem u radu na ostvarivanju zadataka društveno-političkih organizacija; saradnjom sa sindikalnim organizacijama i državnim organima u rješavanju materijalnog položaja pomoraca; ukazivanjem materijalne pomoći članovima Bokeljske mornarice u naročito opravdanim slučajevima; priredbama manifestacionog karaktera u tradicionalnoj nošnji bokeljskih mornara; prikupljanjem i obnavljanjem nošnje i oružja bokeljskih mornara; Bokeljska mornarica može za ostvarivanje svojih zadataka imati i osnivati institute, muzeje, zbirke i slične institucije.“

Član 7 određuje da Bokeljska mornarica radi ostvarivanja svojih zadataka može biti član drugih pomorskih organizacija u SFRJ, kojima je cilj i zadatak jačanje i unapređenje pomorstva Jugoslavije i njegovanje naših pomorskih tradicija.

Ostali članovi Statuta, kojih ima ukupno 31, govore o članovima Bokeljske mornarice, koji mogu biti utemeljivači, pomagači, redovni članovi i mor-

[39] *Statut Bokeljske mornarice*, Kotor, 1964, str. 7.

nari – aktivni sastav; o materijalnim sredstvima; o organima Bokeljske mornarice, koji su: Skupština, Predsjedništvo, Admiralat, Aktivni sastav sa svojim časništvom i Nadzorni odbor.

Član 24 prvi put predviđa mogućnost osnivanja podružnica Bokeljske mornarice; „Bokeljska mornarica, radi ostvarenja svojih ciljeva i izvršenja zadataka, ima podružnice za okupljanje članstva po raznim mjestima Jugoslavije. Podružnice moraju imati najmanje 10 članova".

Mornarica je trebalo da bude ne samo memorijalna institucija koja gaji drevne tradicije u novim uslovima već i da stimuliše razvoj pomorstva Jugoslavije i sarađuje sa drugim institucijama u toj oblasti.

Mornarica je odvojena od svojih religioznih tradicija i vrijednosti, te nije učestvovala na Tripundanskim svečanostima,

Na istoj Skupštini je izabrano novo rukovodstvo, na čelu sa admiralom prof. dr Vladislavom Brajkovićem i viceadmiralom dr Slavkom Mijuškovićem, koji je kasnije postao akademik.

„Novi Statut je bio rezultat kompromisa između želje najvećeg dijela članstva Mornarice da očuva kontinuitet i tradicije, s jedne strane, i vlasti koja je željela da drevnoj instituciji dâ nove ideološke sadržaje, sa druge. Pri tome su članovi Mornarice koji su bili vjernici i nijesu pripadali Komunističkoj partiji, uključujući tu i novog admirala, pristali da se Mornarica odvoji od crkve, a time i od svoje najvažnije tradicije, veze sa kultom svetog Tripuna i učešća na Tripundanskim svečanostima, jer su bili svjesni da je taj ustupak nužan da Mornarica ne bi bila ukinuta, odnosno svedena na obično folklorno društvo. S druge strane, vlast je pristala da valorizira stoljetne tradicije Mornarice, zadrži isti grb i geslo, jer je imala interesa da jednu ovako drevnu i značajnu instituciju razvija kako bi pokazala da tek tadašnja 'narodna' vlast omogućava punu slobodu i razvoj drevnih institucija i narodnih tradicija. Iako Mornarica više nije nastupala na vanjskoj proslavi svetog Tripuna, njeni članovi vjernici su mogli da nesmetano učestvuju na toj i drugim vjerskim svečanostima, što su mnogi od njih i praktikovali. Tako su u Kotoru u ovom periodu na misama u katedrali na dan svetog Tripuna, učestvovali i neki članovi Mornarice u odorama a od 1985. godine lode je čitao, uz prisutnost jednog dječaka iz obitelji Mirošević obučenog u narodnu bokeljsku nošnju, rektor katedrale don Anton Belan."[40] Poslije 1946. nijesu redovno birani mali admirali jer nijesu više imali svoju osnovnu funkciju – izgovaranje pohvala svetom Tripunu: međutim, mali admirali su ipak imenovani 1957, 1976, 1977. i 1985. i imali su samo folklornu funkciju.

[40] A. Belan, „Lode – laudes – pohvale", *Hrvatska revija* 2, 2018.

Novi statut i novo rukovodstvo, puna podrška vlasti, ukupni razvoj pomorstva u Boki, kulturnih i obrazovnih institucija vezanih za pomorstvo imali su za posljedicu da je Mornarica doživjela veoma dinamičan razvoj, da je imala članstvo brojnije nego ikada i razvila brojne kulturne aktivnosti.[41] Osnovane su podružnice Bokeljske mornarice u Hrvatskoj (Zagreb, Rijeka i Split) i Srbiji (Beograd), a zatim i u Boki (Tivat, Herceg Novi i Perast). Mornarica je odlikovana Ordenom bratstva i jedinstva sa zlatnim vijencem. Pored brojnih kulturnih inicijativa izdala je i monografiju *12 vjekova Bokeljske mornarice*.

Budući da je u SFR Jugoslaviji došlo do promjena Ustava, 1976. godine je donesen novi Statut, koji je prilagođen novom pravnom i administrativnom sistemu. Radilo se o manjim promjenama u odnosu na prethodni Statut. Tako član 7 predviđa učlanjenje Mornarice u Socijalistički savez radnog naroda i njeno djelovanje u skladu sa ciljevima i statutom te organizacije. Član 29 predviđa da podružnice Mornarice postaju „konstitutivni dio opštinskih konferencija Socijalističkog saveza radnog naroda". U Statutu se pominju podružnice u Tivtu, Perastu i Herceg Novom, a ne pominju se podružnice u Hrvatskoj i Srbiji, koje su prethodno pretvorene u udruženja Bokeljske mornarice koja ne daju delegate za Skupštinu Mornarice.

Statut predviđa da glavni odred Mornarice nastupa, osim na Dan Bokeljske mornarice, 10. septembra, koji je i Dan Jugoslavenske ratne mornarice i pomorstva, i „prilikom dočeka Predsjednika Socijalističke Federativne Republike Jugoslavije, visokih predstavnika stranih zemalja koji dolaze u posjetu Boki Kotorskoj i u naročito svečanim prilikama na teritoriji Socijalističke Federativne Republike Jugoslavije po odluci Predsjedništva, a prema Pravilniku o nošnji, činovima i nastupima aktivnog sastava Bokeljske mornarice; nastupanjem prilikom proslave državnih praznika i značajnih istorijskih datuma i drugim svečanostima, a u duhu Pravilnika o nošnji, činovima i nastupima aktivnog sastava Bokeljske mornarice" (član 8). Podružnice pored proslave 10. septembra proslavljaju svoj Dan i druge značajne datume koje odredi Skupština podružnice (član 19).

Podružnice sada moraju imati najmanje 20 članova i mogu se osnovati za pojedino naselje ili za područje opštine.

U članu 14 Statuta navode se članovi utemeljitelji Bokeljske mornarice, odnosno „društveno-političke zajednice, organizacije udruženog rada, društvene organizacije, naučna i stručna društva i udruženja koji svojim radom doprinose njenim ciljevima i zadacima".

[41] A. Sbutega, *Bokeljska mornarica, nematerijalna kulturna baština čovječanstva*, Kotor, 2022, str. 305–306.

Članom 17 postaje sastavni dio Statuta ranije donesena odluka od 5. januara 1973. godine, kojom je za doživotnog počasnog admirala Bokeljske mornarice proglašen predsjednik Socijalističke Federativne Republike Jugoslavije Josip Broz Tito.

Zemljotres 1979. godine, koji je nanio velike ljudske žrtve i materijalne štete u Boki, a zatim ekonomska i politička kriza Jugoslavije poslije smrti J. B. Tita 1980. godine, negativno su uticali i na Mornaricu .

Statuti od 1991. do 2011. godine

Politička, ideološka i ekonomska kriza Jugoslavije se produbljivala, da bi 1991. došlo do raspada federalne države i početka tragičnih ratova koji su trajali čitavu posljednju deceniju XX stoljeća. Iako u Crnoj Gori nije bilo oružanih sukoba i etničkih čišćenja poput onih u drugim republikama, i ona je direktno i indirektno bila uvučena u ove dramatične događaje. Crna Gora je bila jedina republika koja je ostala u federaciji sa Srbijom koja je 1992. godine nazvana Socijalistička Republika Jugoslavija i bila izložena oštrim sankcijama OUN zbog rata u Bosni i Hercegovini. Rat i sankcije su izazvale ekonomsku krizu i jednu od najvećih inflacija u povijesti. Poslije ratova u Sloveniji, Hrvatskoj, Bosni i Hercegovini, izbio je i rat na Kosovu, koji je završen vojnom intervencijom NATO-a 1999. godine. Crna Gora, koja se 1997. suprotstavila autokratskom režimu srpskog predsjednika Slobodana Miloševića, postepeno je trasirala put prema nezavisnosti, pod kontrolom međunarodne zajednice. Država je 2002. transformisana u Državnu zajednicu Srbije i Crne Gore, a na referendumu 2006. godine građani Crne Gore su se opredijelili za nezavisnost i odvajanje od Srbije.

Ove promjene su imale uticaj i na Bokeljsku mornaricu, koja je i pored brojnih iskušenja, problema i pritisaka od raznih ekstremista i nacionalista uspjela da odoli svim iskušenjima i izazovima, slijedeći svoje stoljetne moralne i duhovne tradicije i vrijednosti, te zahvaljujući mudrosti svoga rukovodstva. Jedna od posljedica raspada Jugoslavije i rata bilo je odvajanje bivših podružnica u Hrvatskoj, koje su promijenile ime i statute i nijesu više bile u zajedništvu sa maticom u Kotoru, a istovremeno se ugasila i podružnica u Beogradu. U toku ovog perioda veoma često su mijenjani statuti, što je bilo potrebno da bi se normativnim aktima Mornarica prilagodila promjenama u okruženju, čuvajući tradicionalne vrijednosti i obezbjeđujući kontinuitet.

Kriza komunizma je omogućila da Mornarica od 1990. godine ponovo učestvuje na proslavi Svetog Tripuna, zaštitnika Kotora, Kotorske biskupije i Bokeljske mornarice, i tako se vratila svojim izvornim stoljetnim tradicijama poslije pauze od 1946. godine.

Donesen je novi Staut 1991. godine sa malim, ali veoma važnim promjenama u odnosu na prethodni. Bokeljska mornarica se definiše u članu 1 kao „staleška bratovština u kojoj se kontinuirano čuva tradicija jedne od najstarijih profesionalnih organizacija pomoraca na svijetu, nastale 13. januara 809. godine".

U članu 4 kaže se da „Bokeljska mornarica ima svoju svečanu pjesmu čija prva strofa glasi:

Uljezimo svi u kolo
Rukama ruke pružimo,
Pokažimo svim okolo
Da slogu bratsku vriježimo,

čime se za himnu Bokeljske mornarice proglašava *Pjesan*, pjesma koju je napisao Pavo B. Kamenarović u XIX stoljeću.

Članom 6 se određuje da Glavni odred Mornarice nastupa na Dan Bokeljske mornarice (10. septembra) i na gradskim svečanostima Svetog Tripuna u Kotoru, a „može nastupiti i u svečanim prilikama, po pozivu organizatora svečanosti, a na osnovu odluke Admiralata".

U poglavlju VII (članovi 21–40) utvrđuje se struktura organa Bokeljske mornarice, koja je zadržana i u kasnijim statutima. Članom 20 utvrđeni su organi Mornarice: Skupština, Admiralat, Upravni odbor, aktivni sastav, Nadzorni odbor, ostali odbori i Sud sedmorice. Ostalim članovima u ovom poglavlju se regulišu sastav, izbor i zadaci svakog organa, kao i trajanje mandata njegovih članova. „Skupština je najviši organ Bokeljske mornarice, a sačinjavaju je: Admiralat (11 članova), po dvadeset predstavnika svake Podružnice Bokeljske mornarice i po jedan predstavnik članova pomagača". Član 30 određuje da „Upravni odbor Bokeljske mornarice sastoji se od 19 članova i to: predsjednika, dva potpredsjednika, sekretara, admirala, viceadmirala, predsjednika podružnice Kotor, Tivat i Herceg Novi, predstavnika društava Bokeljske mornarice van Boke Kotorske, *Jugooceanije* Kotor, predstavnika MTRZ *Savo Kovačević* Tivat, predstavnika Brodogradilišta Bijela, predstavnika Fakulteta za pomorstvo Kotor, predstavnika Istorijskog arhiva i predstavnika Pomorskog muzeja Kotor, predstavnika opština Kotor, Tivat i Herceg Novi".

Članovima 41–47 u VIII poglavlju Statuta regulisana je materija podružnica Bokeljske mornarice, koje postoje samo na teritoriji opština Boke Kotorske i određuje se da je za formiranje odreda podružnice potrebno najmanje 10 mornara (član 43).

Na Skupštini 5. septembra 1991. izabrano je novo rukovodstvo, uključujući admirala dr Miloša Miloševića i viceadmirala kapetana Nenada Želalića.

Sljedeći Statut je usvojen 24. februara 1996. godine, koji se vrlo malo razlikovao od prethodnog, a najvažnija inovacija bila je odluka kojom se za Dan Bokeljske mornarice umjesto 10. septembra proglašava 26. jun, dan usvajanja prvog sačuvanog statuta Bratovštine iz 1463. godine.

Statut od 24. juna 2000. godine imao je samo jednu važnu izmjenu: Bokeljska mornarica prestaje da bude društvena i postaje nevladina organizacija sa svojstvom pravnog lica u skladu sa zakonskim promjenama. Bokeljska mornarica je iste godine upisana u spisak nevladinih organizacija Crne Gore, u skladu sa zakonom.[42]

I Statut od 13. novembra 2004. unosi minimalne promjene u odnosu na prethodni. Popravlja grešku u numerisanju članova u prethodnom Statutu (broj 36 greškom je bio upotrebljen za dva uzastopna člana, tako da su redni brojevi svih članova, počev od člana 37, umanjeni za jedan) i uvodi dopunu koja se tiče područja osnivanja podružnica. Članom 43 proširuje područje osnivanja podružnica Mornarice, koje je do tada bilo ograničeno samo na opštine Boke Kotorske, na teritoriju „državne zajednice SCG i izuzetno van njenih granica, kako je i predviđeno u Zakonu o NVO, a po saglasnosti Bokeljske mornarice".

Crna Gora je 2006. obnovila svoju nezavisnost, a Bokeljska mornarica je nastavila svoje aktivnosti u novim uslovima i 2009. godine proslavila 12 stoljeća od osnivanja nizom kulturnih manifestacija, a predsjednik Crne Gore odlikovao ju je Ordenom crnogorske zastave. Tim povodom Mornarica je objavila značajna izdanja *Dvanaest vjekova Bokeljske mornarice*, *Statut Bratovštine svetog Nikole mornara iz 1463. godine sa alegatima do 1807. godine*, *Zbornik radova za međunarodnog naučnog skupa u Kotoru Dvanaest vjekova Bokeljske mornarice* i monografiju *Katedrala Svetog Tripuna u Kotoru* autora M. Čanak Medić i Z. Čubrović.

Obnova nezavisnosti Crne Gore, donošenje novog ustava i promjene u društvenom okruženju uslovile su donošenje novog Statuta 2011. godine. U uvodnom dijelu je prenesen tekst o povijesti Mornarice iz Statuta iz 1934. godine. U novom Statutu nema mnogo inovacija u odnosu na prethodni iz 2004, ali su one veoma značajne. Tako je naziv Bokeljska mornarica dopunjen tradicionalnom godinom njenog osnivanja „809.", tako da glasi „Bokeljska mornarica 809.". Članom 1 Statuta Mornarica se definiše kao „nevladina organizacija koju osnivaju pravna lica: Podružnica Kotor, Podružnica Tivat,

[42] DACG IAK KOM nesređena arhivska građa, *Bokeljska mornarica u arhivskim dokumentima. Zbornik dokumenata od najstarije sačuvanih do danas*, Kotor, 2021, str. 721.

Podružnica Herceg Novi i pridružena Podružnica Beograd“[43]. Podružnica u Beogradu, ugašena 1991, obnovljena je 2009. godine.

Ovim je napravljen pravni presedan po kome matičnu organizaciju osnivaju podružnice umjesto da bude obrnuto i organizacija tada zapravo postoji tek kao zbir podružnica. Taj i drugi unutrašnji problemi u Mornarici, nastali poslije smrti admirala Miloševića 2012, zahtijevali su nekoliko godina pripreme i pregovora za donošenje novog Statuta i izbor novog rukovodstva.

Statut iz 2016. godine

Na izbornoj skupštini Mornarice 20. juna 2016. usvojen je novi Statut i izabrano novo rukovodstvo. Statut ima 57 članova i u preambuli se poziva na povijesne tradicije:

„Baštineći vjekovne pomorske tradicije grada Kotora i Boke Kotorske, želeći da se svijest o staroj slavi i veličini prenese u nasljeđe novim naraštajima, a ističući sljedeće činjenice:

– da je početkom IX vijeka organizovani odred mornara Kotora preuzeo i donio u grad relikvije patrona grada svetog Tripuna;

– da se sredinom XIV vijeka u Kotoru pominje ’Pobožna družina pomoraca Kotora’ (Pia sodalitas naviculorum Catharensium);

– da je sredinom XV vijeka napisan najstariji sačuvani statut ’Bratovštine mornara Svetog Nikole iz Kotora’ (Fraternitas divi Nicolai marinariorum da Catharo);

– da je tokom proteklih vjekova bratovština ’Kotorska mornarica’ (Marinarezza di Cattaro) bila temelj na kome se zasnivala egzistencija, kultura i blagostanje ovoga kraja;

– da je sredinom XIX vijeka postala memorijalna organizacija ’Plemenito tijelo Bokeljske mornarice’ Kotor;

– da je sredinom XX vijeka obnovila svoju djelatnost u novim uslovima, sa osnivanjem podružnica van Kotora;

– da je tokom dvanaest vjekova svoga postojanja bila vezana za crkvu i svoje patrone Sv. Nikolu i Sv. Tripuna;

– da je tokom svih dvanaest vjekova svoga postojanja njegovala solidarnost i bratsku uzajamnost, a sve pod drevnim geslom ’Fides et honor’ (Vjera i čast);

[43] *Statut Bokeljske mornarice 809*, Kotor, 2011, str. 17.

– da je „Bokeljska mornarica Kotor“ proglašena organizacijom od nacionalnog značaja za državu Crnu Goru i da je predložena za upis na listu svjetske nematerijalne kulturne baštine UNESCO.“[44]

U članu 1 se navodi: „Bokeljska mornarica Kotor je matična organizacija sa svojstvom pravnog lica, koja u svom sastavu ima i podružnice Tivat, Herceg Novi i Beograd“, čime je Kotoru vraćen status matice. Članom 3 ime je promijenjeno u Bokeljska mornarica Kotor, a članom 4 određeno da je njeno sjedište u Kotoru na Pjaci od kina br. 372.

Članom 9 se utvrđuje da je „cilj Bokeljske mornarice da nastavi viševjekovni kontinuitet svojih istorijskih tradicija i što bolje ih usaglasi sa savremenim potrebama. Bokeljska mornarica Kotor može se povezivati i učlanjivati u saveze ili druge odgovarajuće asocijacije u zemlji i inostranstvu, o čemu odgovarajuću odluku donosi Skupština“.

Član 10 određuje da „Bokeljska mornarica Kotor, u skladu sa Pravilnikom, održava javne nastupe odreda aktivnog sastava u odorama, sa barjacima, starinskim oružjem, uz drevne komande, preuzima ključeve gra-da i pleše kolo.

Prikuplja, obrađuje i objavljuje istorijsku građu i radove iz istorije pomorstva, posebno one koje se odnose na Bokeljsku mornaricu. Osim strogo naučnih domena, simpozijuma i izdavanja stručnih edicija, radi na popularizaciji tih saznanja u školske, muzeološke i turističke svrhe (posebna izdanja, CD-ovi, vodiči, suveniri, bedževi, značke, organizacija predavanja u školama, na tribinama Bokeljske mornarice i sl.).

U okviru humanitarnih tradicija Bratovštine brine se posebno za svoje bolesne, ostarjele ili siromašne članove.

Sarađuje sa preduzećima, ustanovama i organizacijama pomorske privrede, kao i školskim, društvenim i naučnim organizacijama koje se bave odgojem i obrazovanjem kadrova za pomorstvo ili djelatnostima vezanim za pomorstvo. Organizuje kurseve, seminare, predavanja, konsultacije, gostovanja, izlete, okrugle stolove, izradu odora i suvenira.

Cjelokupna djelatnost Bokeljske mornarice Kotor vezana je za grad Kotor, Boku Kotorsku i patrona Sv. Tripuna u cilju očuvanja i nastavljanja tradicije nastale u ovom gradu i odvija se u tradicionalnom duhu zasnovanom na nacionalnom i vjerskom uvažavanju i zajedništvu.“

Statut određuje razne kategorije članstva: redovni član, član aktivnog sastava, član pomagač, zaslužni član, počasni član i počasni oficir ili podoficir.

[44] http://www.bokeljskamornarica.com/-rubrika Opšta akta

Poglavlje V se odnosi na prava i dužnosti članova, a poglavlje VI na organe Mornarice koji su: Skupština, Admiralat, Upravni odbor, Nadzorni odbor i Sud sedmorice. Skupština je najviši organ odlučivanja Bokeljske mornarice Kotor, a sačinjavaju je: 20 članova matične organizacije Bokeljske mornarice Kotor, 20 članova Bokeljske mornarice Kotor – podružnica Tivat; 20 članova Bokeljske mornarice Kotor – podružnica Herceg Novi; članovi Admiralata i Upravnog odbora.

Admiralat sačinjavaju: admiral, viceadmiral, predsjednik Upravnog odbora, majori; kapetani, koji su istovremeno i komandiri odreda matice i podružnica, ađutant admirala, kolovođa Glavnog odreda, ceremonijal majstor, domaćin. Upravni odbor sačinjavaju: predsjednik, tri pot-predsjednika (2 potpredsjednika su iz sastava podružnica) koji mijenjaju predsjednika u njegovom odsustvu, sekretar, predsjednici podružnica, admiral, domaćin, blagajnik. Statut propisuje da „za admirala Bokeljske mornarice Kotor može biti imenovana ličnost visokih moralnih i kulturnih kvaliteta koja je svojom djelatnošću povezana sa pomorskom djelatnošću, kao i sa kulturom i tradicijama Bokeljske mornarice".

U periodu od 2016. do 2022. godine unesene su neke manje izmjene u postojeći Statut, kao što je brisanje podružnice u Beogradu koja se svojom odlukom 2017. godine odvojila od Bokeljske mornarice Kotor i ugasila. To, kao i prethodno odvajanje bivših podružnica u Hrvatskoj, pokazuje da je ideja osnivanja podružnica Mornarice van Boke neuspješna, budući da je tokom stoljeća ona postojala samo u Boki i da je samo tu duboko ukorijenjena.

Na istoj Skupštini 2016. izabrano je novo rukovodstvo na čelu sa admiralom prof. dr Antunom Sbutegom i predsjednikom Upravnog odbora dipl. arh. Aleksandrom Denderom, a reizabran je viceadmiral kap. Ilija Radović. Usvojen je ambiciozni program rada i sve to je dalo novu energiju i vitalitet drevnoj instituciji. Sljedećih godina, uprkos problemima koje je izazvala pandemija 2020–2022, postignuti su značajni rezultati: usvojen je Pravilnik o odorama, činovima i nastupima, nabavljene su nove odore i replike starih pušaka, uspostavljena je saradnja sa školama i fakultetima (Pomorskim fakultetom i Fakultetom za hotelijerstvo i turizam u Kotoru), povećan je broj članova, posebno mladih, znatno su uvećana redovna i vanredna sredstva koje je Mornarica dobila od institucija države, opština i sponzora, intenzivirana je saradnja sa kulturnim institucijama (Pomorski muzej Crne Gore, JU Muzeji Kotor, Istorijski arhiv, Kotor Art i dr.), sa Biskupijom Kotor, sa resornim ministarstvima i Opštinom Kotor; uspostavljena je saradnja sa pomorskim udruženjima, objavljeno je više značajnih izdanja, od kojih su posebno važni *Historija pomorstva Crne Gore u kontekstu jadranskog, mediteranskog i svjetskog pomorstva* (2019), čiji je autor Antun Sbutega i *Bokeljska mornarica u arhivskim dokumentima. Zbornik dokumenata od najstarije sačuvanih do*

danas (2021). Organizovano je više izložbi od kojih je bila posebno značajna izložba na Cetinju 2019. godine *Bokeljska mornarica Kotor – 1210 godina istorije, duhovnosti i kulture.* Mornarica je gostovala u Piranu, Trstu i Beču, imala je veliku promociju u domaćim i stranim medijima, ima i svoj sajt koji redovno prati sve njene aktivnosti.

Primarni cilj plana rada iz 2016. godine bio je upis Mornarice na Reprezentativnu listu nematerijalne kulturne baštine čovječanstva UNESCO-a i rukovodstvo Mornarice je za to dobilo podršku svih članova, građana i relevantnih institucija Kotora i Boke, predsjednika i Vlade Crne Gore, a posebno Ministarstva kulture. Izrada Nominacionog dosjea za kandidaturu je počela 2017, da bi dosje bio predan 31. marta 2018. godine. Radilo se o prvom nematerijalnom dobru koje je Crna Gora kandidovala za upis na Listu UNESCO-a, pa je proces kandidature bio otežan i produžen zbog neiskustva, kao i zbog neočekivane agresivne političke i medijske kampanje iz Hrvatske i nekih hrvatskih udruženja u Crnoj Gori, koji su pokušali da onemoguće ovu kandidaturu tvrdeći da je Mornarica kulturno dobro Hrvata i da Crna Gora nema pravo da je samostalno kandiduje. Najzad, na konferenciji Međuvladinog komiteta za očuvanje nematerijalne baštine UNESCO-a 16. decembra 2021. donijeta je odluka da se Mornarica upiše na Reprezentativnu listu nematerijalne kulturne baštine čovječanstva.

Zaključak

Kotor i njegova okolina su od početka svoje povijesti bili integrirani u evropsku civilizaciju i imali politički, društveni i kulturni razvoj analogan onome u drugim djelovima kontinenta, posebno na njegovim mediteranskim obalama. Bitan element te civilizacija je pravna regulativa. Najvažnije države koje su stoljećima vladale Bokom bile su pravne države, počev od Rimskog Carstva, preko Mletačke Republike do Austrije. Tako su se Kotor i kasnije osnovane bokeljske komune razvijale kao pravno utemeljeno društvo, sa svojim komunalnim statutima, te statutima bratovština. Najvažnija srednjovjekovna bratovština Kotora i Boke je bila Bratovština Svetog Nikole Mornara, današnja Bokeljska mornarica, i njen najstariji sačuvani statut datira iz 1463. godine. Kako je Bratovština pomoraca u Kotoru prema tradiciji osnovna 809. godine i svakako je postojala stoljećima prije XV stoljeća, sigurno je imala statut i ranije, koji nije sačuvan. Statut iz 1463. godine je bio veoma detaljan, a dopunjavan je i ažuriran novim odredbama u sljedećim stoljećima i bio je na snazi 410 godina. Poslije propasti Mletačke Republike 1797. godine, koja je 377 godina vladala Kotorom i Bokom, došlo je do velikih promjena u funkcijama i značaju Bratovštine pomoraca, kao i u društveno-političkom i pravnom okruženju. Zato je u toku vladavine Austrije Bratovština reformisana i donesen je 1873. novi Statut kojim je promijenjen njen naziv u Plemenito

tijelo Bokeljske mornarice, kao i funkcije, tako da je postala memorijalna organizacija. Ovaj Statut je bio na snazi znatno kraće nego prethodni, 61 godinu, a naredni statuti su bili na snazi sve kraće, budući da je u toku posljednjih 150 godina na ovom prostoru bilo mnogo političkih i drugih promjena koji su to uslovili. Novi Statut je donesen 1934. godine u Kraljevini Jugoslaviji, a poslije 30 godina donesen je Statut Bokeljske mornarice 1964. godine u Socijalističkoj Federativnoj Republici Jugoslaviji. Ustavne promjene su zahtijevale donošenje Statuta 1976. godine, a nestabilni i dramatični period koji je uslijedio poslije raspada Jugoslavije 1991. godine, praćen ratovima i političkim promjenama, uslovio je i česte promjene statuta Bokeljske mornarice – 1991, 1996, 2000. i 2004. godine. Mornarica je doživjela novu transformaciju u nezavisnoj Crnoj Gori poslije 2006. i 2009. godine je proslavila jubilej 1200 godina od osnivanja. Novi Statut je usvojen 2011. i konačno, sadašnji, 2016. godine. Bokeljska mornarica je tako pokazala sposobnost da se prilagođava promjenama u svome okruženju, a da istovremeno sačuva svoje najvažnije tradicije, kulturne, duhovne i moralne vrijednosti, stečene tokom duge povijesti. Te vrijednosti je valorizovao i UNESCO, koji je 2021. upisao Bokeljsku mornaricu na Reprezentativnu listu nematerijalne kulturne baštine čovječanstva. Statuti, počev od onoga iz 1463, do sadašnjeg iz 2016. godine, predstavljaju važan dio vrijednog kulturnog nasljeđa i povijesti Bokeljske mornarice.

STATUTI BOKELJSKE MORNARICE KOTOR OD 1436 DO 2016 GODINE

Apstrakt: U toku više od 12 stoljeća svoje povijesti Bokeljska mornarica je više puta mijenjala ime, funkcije i statute, zadržavajući kontinuitet baziran na temeljnim vrijednostima. Otpočetka je imala statute koji su regulisali njenu djelatnost, ciljeve, prava i obaveze članova, način i organe upravljanja. Najstariji sačuvani statut datira iz 1463. i bio je na snazi do 1873. godine, punih 410 godina. Kasnije su statuti više puta mijenjani zbog čestih promjena država u čijem se sastavu nalazila Boka Kotorska, pa time i promjena administrativnih i pravnih sistema. Ovaj rad koncizno analizira sve poznate statute, od najstarijeg iz 1463. do sadašnjeg iz 2016. godine, a pored toga prati i promjene same Mornarice, od srednjovjekovne bratovštine pomoraca do sadašnje nevladine organizacije. Bokeljska mornarica Kotor 2021. godine upisana je na UNESCO-vu Reprezentativnu listu nematerijalne kulturne baštine čovječanstva.

Ključne riječi: statut, srednjovjekovne bratovštine, Bokeljska mornarica

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Assessment of Energy Efficiency for the Existing Cargo Ships*

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Abstract: In order to address the decarbonization policy, International Maritime Organization (IMO) has been dealing with energy efficiency of ships for more than a decade. Firstly, procedures for energy efficiency assessment are introduced through the regulative, but only for new ships. Consequently, IMO also introduced energy efficiency criterion for already built ships that is set to be applicable starting from 2023. Regulative is already having an impact on ship design. While the new ships can be adapted in design phase, built ones will not have so many options. So far, almost all the solutions include reduction of the speed, i.e., slow steaming. Nevertheless, there are numerous technical and operational measures. The paper presents the calculation of energy efficiency performed for the fleet of existing 11 cargo ships categorized into four different ship classes. Calculation is based on the current IMO regulations covering the evaluation of energy efficiency of existing ships index (*EEXI*). Input parameters for analysis are obtained using two approaches: technical files (design parameters of the ship) & sea-trial reports and statistical method (when technical files & sea-trail reports are not available). Authors examined if the difference in two input approaches and potential class notation change could lead to different energy efficiency evaluation results. Moreover, the main goal of the research was to investigate on how the present conventionally designed cargo ships compare to the novel regulations.

Keywords: EEXI, EEDI, Energy efficiency, Energy efficiency existing ships.

1. Introduction

Following the emerging decarbonization policies in various industries, the Marine Environment Protection Committee (MEPC), working under the framework of the International Maritime Organization (IMO), introduced a procedure for the evaluation of energy efficiency of new ships. The regulations started to apply in 2013 while its requirements have been strengthened over every five years, starting from 2015. Procedure asked for the calculation of attained (*attained EEDI*) and required energy efficiency designed

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index (*required EEDI*), as shown in [1]. In order to satisfy the criterion, ship's *attained EEDI* had to be lower than its *required EEDI*. If not, ship has to make design changes in order to meet the regulative. To large extent, this pushed the investigations towards the energy saving devices. However, the major and most obvious change over the years appears to be the speed and power reduction.

Already built ships have not been neglected since the corresponding regulative is introduced in IMO's strategy for the short- and long-term decarbonization of shipping [2, 3, 4]. Thus, Intersessional Working Group (ISWG) of the IMO delivered a procedure for the evaluation of energy efficiency of existing ships, see [5]. The procedure includes methods for the calculation of attained (*attained EEXI*) and required energy efficiency existing ship index (*required EEXI*). *EEXI* is largely based on *EEDI* concept. Therefore, a*ttained EEXI* should be lower than *required EEXI* for the ship to comply with the regulative. *EEXI* requirements are set to start applying from 2023 and are obligatory for ships having GT above 400 and while satisfying MARPOL Annex VI.

Authors of this paper have been studying the influence of novel environmental policies on existing ships. This was the case, particularly, for multipurpose fleet of sea-going ships [6] and furthermore, for similar ships in size but different regarding their class [7]. Hence, this paper is an extension of the paper presented in [7]. Here, energy efficiency evaluation is performed on 11 cargo ships that falls into four classes whereas in [7] only four ships are included. In the following sections, the various built ships are presented along with their particulars. Besides, authors presented the procedure and results for the calculation of *EEXI* for each of the ship, followed by the sensitivity assessment for various input variations. Finally, authors discussed potential solutions for energy efficiency improvement. More on energy efficiency considerations for cargo ships one can find in literature, see [8] and [9].

2. Database of ships

Energy efficiency existing ship index (*EEXI*) is calculated for the 11 cargo ships for which authors have obtained reliable data from design documentation and sea-trial reports. All ships are falling into four different classes, namely: two general cargo ships, three bulk carriers, three tankers and three containerships. The main particulars are presented graphically, see Figs. 1 and 2. Each is represented by 11 columns that denote to 11 ships. Going from left to the right of each column respective ships with their classes (and years of built) are illustrated in the following order: 1 – general cargo (2001), 2 – general cargo (2007), 3 – bulk carrier (2010), 4 - bulk carrier (2017), 5 - bulk carrier (2011), 6 – tanker (2010), 7 - tanker (2007), 8 - tanker (2007), 9 –

container ship (2006), 10 - container ship (2008), 11 - container ship (2017). This notation is used as an agenda in diagrams. For some of particulars there are no full list of data for each ship. For instance, first two ships (1 and 2) have no data on design *DWT*, so the corresponding column values starts from ship no. 3, see Fig. 2.

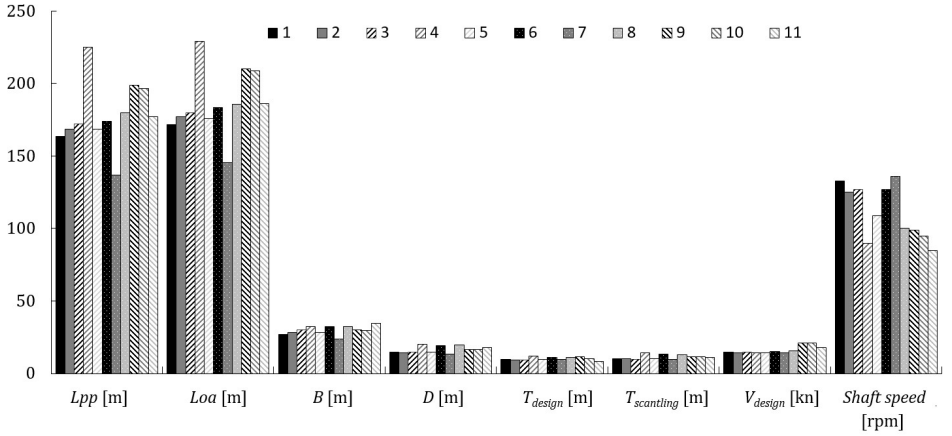

Fig. 1 – *Ship particulars.*

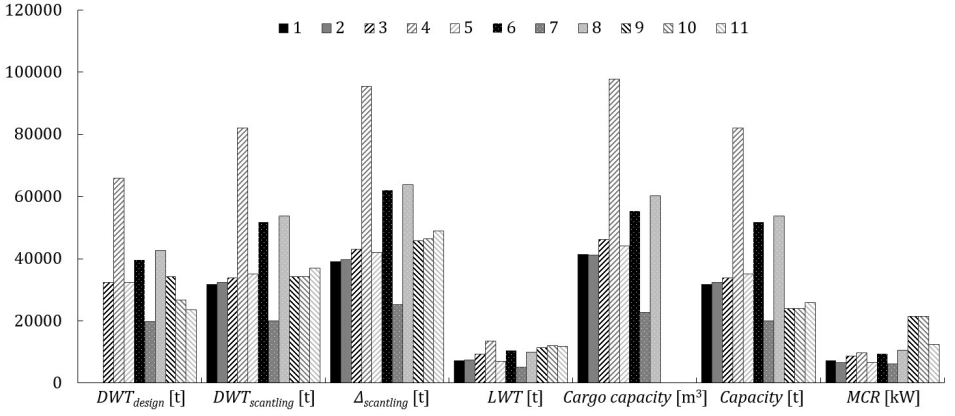

Fig. 2 – *Ship particulars.*

3. *Required EEXI* calculation

Required EEXI is a criterion for energy efficiency evaluation. Therefore, *attained EEXI* must be lower that *required EEXI* so that ship can be regarded as energy efficient according to IMO. ISWG [10] provided the *required EEXI* calculation procedure for built ships as the same as in case of *required EEDI* for new ships, see eq. (1). *Y* is a reduction factor and is chosen based on ships class and *DWT*. *Y* and other coefficients used are given in Table 1. Consequently, a diagram of *required EEXI* depending on *DWT* is plotted in Fig. 3.

$$Required\ EEXI = \left(1 - \frac{Y}{100}\right) \cdot Reference\ line\ value \qquad (1)$$

$$Reference\ line\ value = a \cdot b^{-c}$$

Table 1 – *Coefficients for the calculation of required EEXI.*

	Ship No.	*Y*	*a*	*b=DWT*	*c*	*Req. EEXI*
General cargo ships	1	30	107.48	31659	0.216	8.023
	2			32286		7.989
Bulk carriers	3	20	961.79	33762	0.477	5.322
	4			82049		3.485
	5			35009		5.231
Tankers	6	20	1218.8	51672	0.488	4.886
	7			19996		7.765
	8			53815		4.790
Container ships	9	20	174.22	34254	0.201	17.089
	10			34331		17.081
	11			36946		16.831

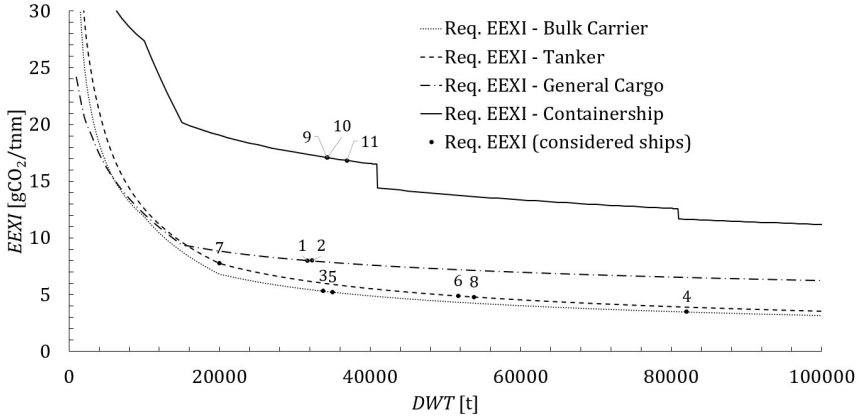

Fig. 3 – *Required EEXI.*

4. *Attained EEXI* calculation

Attained EEXI calculation procedure for built ships corresponds to the *EEDI* for new ships. Hence, according to IMO regulative, ships that were newly built at the time when only *EEDI* regulative for new ships were available can use their already calculated *attained EEDI* instead of calculating *attained EEXI*. Nevertheless, *attained EEXI* is calculated according to [5], as in eq. (2). Label "*" in eq. (2) means that if part of the normal maximum sea load is provided by shaft generators, SFC_{ME} and C_{FME} may, for that part of the

power, be used instead of SFC_{AE} and C_{FAE}. Moreover, label "**" states that, in case of $P_{PTI(i)} > 0$, the average weighted value of ($SFC_{ME} \cdot C_{FME}$) and ($SFC_{AE} \cdot C_{FAE}$) is to be used for calculation of P_{eff}.

$$\left[\left(\prod_{j=1}^{n} f_j\right)\left(\sum_{i=1}^{nME} P_{ME(i)} \cdot C_{FME(i)} \cdot SFC_{ME(i)}\right) + (P_{AE} \cdot C_{FAE} \cdot SFC_{AE}\,*)\right.$$
$$+$$
$$+\left(\left(\prod_{j=1}^{n} f_j \cdot \sum_{i=1}^{nPTI} P_{PTI(i)} - \sum_{i=1}^{neff} f_{eff(i)} \cdot P_{AEeff(i)}\right) C_{FAE} \cdot SFC_{AE}\right) \qquad (2)$$
$$-$$
$$\left.-\left(\sum_{i=1}^{neff} f_{eff(i)} \cdot P_{eff(i)} \cdot C_{FME} \cdot SFC_{ME}\,**\right)\cdot\right.$$
$$\left.\cdot \frac{1}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref} \cdot f_m}\right.$$

Note that in this paper the following assumptions are made: shaft motors are not installed (P_{PTI}=0) on these ships, nor innovative mechanical energy efficient technologies on main or auxiliary engine (P_{eff} = 0, P_{AEeff} = 0). Furthermore, two approaches are performed for inputs. In the first one (case 1), statistically obtained data are used as an input. In the second one (case 2), semi-statistical data are applied, which were based on available documentation and sea-trail report for the particular ship. Nonetheless, no ship from the database has engine power limiter installed so the eq. (2) can be simplified to the level of eq. (3).

$$Attained\ EEXI = \frac{P_{ME} \cdot C_{FME} \cdot SFC_{ME} + P_{AE} \cdot C_{FAE} \cdot SFC_{AE}}{f_i \cdot f_c \cdot f_l \cdot Capacity \cdot f_w \cdot V_{ref} \cdot f_m} \qquad (3)$$

All parameters used in eq. (3) are determined using guidelines from [4] and presented in Tables 2-4. Still, some of them need clarification. Power of main engine (P_{ME}) corresponds to the 75% of the installed power (MCR). P_{AE} is auxiliary engine power required to supply normal maximum sea load also taking into account power for propulsion of machinery/systems and accommodation. C_F is a conversion factor between fuel consumption and CO_2 emissions. Subscript "*ME*"refers to the main and subscript "*AE*" to the auxiliary engine.

Table 2 – *Input parameters.*

	Ship no.	P_{ME} [kW]	P_{AE} [kW]	Fuel type ME	Fuel type AE	C_{FME} [tCO2/tFuel]	C_{FAE} [tCO2/tFuel]	SFC_{ME} [g/kWh]	SFC_{AE} [g/kWh]
General cargo ships	1	5369	358.0	Diesel	Diesel	3.206	3.206	167.9	204.7
	2	4965	331.0	Diesel	HFO	3.206	3.114	168.1	215.0
Bulk carriers	3	6435	429.0	Diesel	Diesel	3.206	3.206	171.5	218.3
	4	7350	490.0	Diesel	Diesel	3.206	3.206	163.1	235.3
	5	4992	332.8	Diesel	HFO	3.206	3.114	183.8	215.0
Tankers	6	7110	474.0	Diesel	HFO	3.206	3.114	175.4	215.0
	7	4613	307.5	Diesel	Diesel	3.206	3.206	180.7	208.2
	8	7965	515.5	Diesel	HFO	3.206	3.114	171.0	215.0
Cont. ships	9	16170	789.0	Diesel	Diesel	3.206	3.206	174.9	208.6
	10	16118	787.3	Diesel	HFO	3.206	3.114	169.8	215.0
	11	9375	562.5	Diesel	Diesel	3.206	3.206	165.6	209.2

Table 3 –*f factors.*

	Ship no.	f_c [-]	f_l [-]	f_m [-]	f_w [-]	f_i [-]
General cargo ships	1	1.000	1.009	1.000	1.000	1.000
	2	1.000	1.009	1.000	1.000	1.000
Bulk carriers	3	1.000	1.000	1.000	1.000	1.022
	4	1.000	1.000	1.000	1.000	1.013
	5	1.000	1.000	1.000	1.000	1.000
Tankers	6	1.035	1.000	1.000	1.000	1.000
	7	1.077	1.000	1.000	1.000	1.000
	8	1.000	1.000	1.000	1.000	1.000
Container ships	9	1.000	1.000	1.000	1.000	1.000
	10	1.000	1.000	1.000	1.000	1.000
	11	1.000	1.000	1.000	1.000	1.000

Table 4 – *Reference speeds and power.*

	Ship no.	$V_{ref,avg}$ [kn]	$V_{ref,app}$ [kn]	V_{ref} [kn]	MCR_{avg} [kW]	MCR [kW]
General cargo ships	1	17.27	13.72	14.14	12246	7159
	2	17.34	13.34	13.74	12468	6620
Bulk carriers	3	14.13	14.59	12.88	6683	8580
	4	14.48	13.31	13.51	10803	9800
	5	14.15	13.33	13.62	6815	6656
Tankers	6	14.59	13.72	13.62	9771	9480
	7	13.87	13.47	14.63	5751	6150
	8	14.62	14.18	15.70	9995	10620
Container ships	9	21.88	20.22	20.84	23738	21560
	10	21.89	20.19	19.92	23793	21490
	11	22.19	16.67	15.95	25662	12500

4.1. *Attained EEXI* – Case 1

Case 1 here represents the approach in which the inputs for the *EEXI* evaluation are determined according to statistics of similar ships taken from in IMO guidelines. This approach can be used when no speed-power curve nor sea-trail report are available. Therefore, according to [5] ship speed is determined by eq. (4) using mean distribution of ship speed and engine power for the corresponding *DWT* and ship type. Moreover, considering [5], specific fuel consumptions are assumed as: $SFC_{ME,app}$ = 190 g/kWh and $SFC_{AE,app}$ = 215 g/kWh.

$$V_{ref,app} = \left(V_{ref,avg} - m_v\right) \cdot \left[\frac{P_{ME}}{0.75 \cdot MCR_{avg}}\right]^{\frac{1}{3}} \tag{4}$$

4.2. *Attained EEXI* – Case 2

When speed-power curve is available from sea-trail report and the actual specific fuel consumption data are available, then a semi-statistical approach can be used to obtain input data. Considering [5], reference speed is calculated for general cargo ships, see eq. (5) and for container ships, bulk carriers and tankers, see eq. (6).

$$V_{ref} = V_{S,EEDI} \cdot \left[\frac{P_{ME}}{P_{S,EEDI}}\right]^{\frac{1}{3}} \tag{5}$$

$$V_{ref} = k^{\frac{1}{3}} \cdot \left(\frac{DWT_{S,service}}{Capacity}\right)^{\frac{2}{9}} \cdot V_{S,service} \cdot \left[\frac{P_{ME}}{P_{S,service}}\right]^{\frac{1}{3}} \quad (6)$$

$V_{s,EEDI}$ is a service speed taken from sea-trails under the scantling draught. $P_{s,EEDI}$ is power of main engine that is matched to the service speed. Service power is equal to 85% of *MCR* and with no sea margin included. $DWT_{S,service}$ corresponds to deadweight, while $V_{S,service}$ is the sea-trial service speed under the design draught. $P_{S,service}$ is power of the main engine that matches the $V_{S,service}$ with no sea margin taken into account. Parameter k is the scale coefficient depending on the ship type and size. Furthermore, SFC_{ME} is obtained from the NOx technical file test report in case of 75% of *MCR* of the main engine, while SFC_{AE} is to be acquired from the same test report but for the auxiliary engine at 100% of power.

5. Results

In the following, the results are presented in a form of diagrams and include:

- *attained* vs. *required EEXI* evaluation (Fig. 4),
- difference between *attained* and *required EEXI* and EPL (Fig. 5),
- *MCR* reduction needed to comply with *EEXI* (Fig. 6).

Label "difference" is defined as a relative difference between *attained* and *required EEXI*, in percentages. Engine power limitation - EPL is the amount of main engine power reduction (in percentages) necessary in order to meet the *required EEXI*. When the relative difference is negative, the *attained EEXI* is lower than *required EEXI* and therefore, EPL is zero. Hence, there is no need for power reduction. *MCR* reduction (or MCR_{lim}) is new total power for which the *required EEXI* is satisfied.

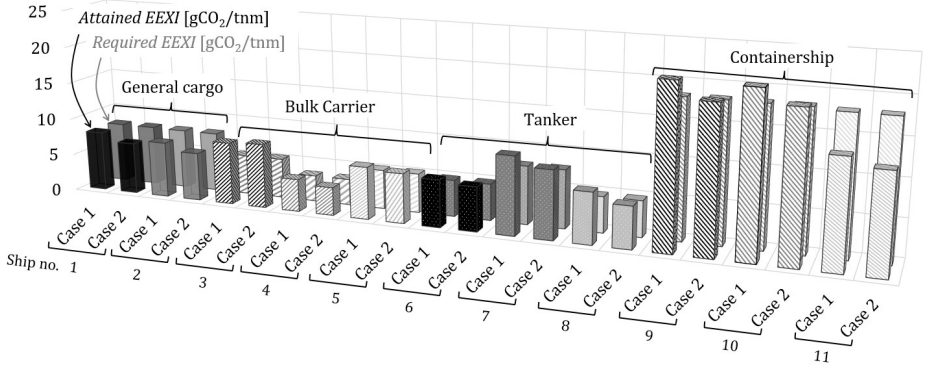

Fig. 4 – *Attained and required EEXI.*

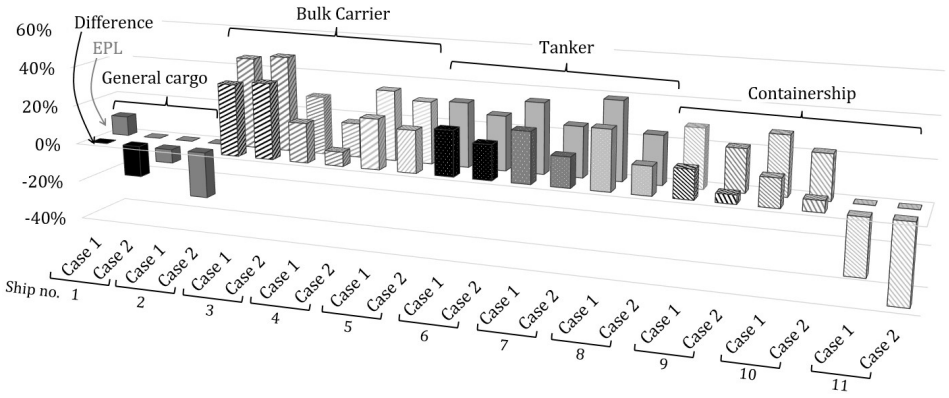

Fig. 5 – *Absolute and EPL power reduction.*

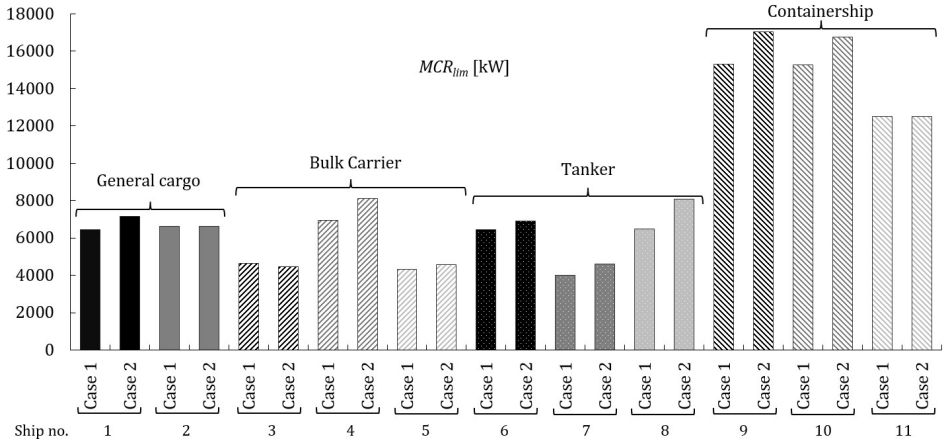

Fig. 6 – *MCR reduction.*

Study shows that 9 out of 11 ships are not satisfying present regulative in case 1, while 8 out of 11 are not passing the regulative in case 2, suggesting that those ships need energy efficiency improvement. However, depending on the input approach (case 1 vs. case 2) *attained EEXI* varies significantly, going from a few to more than 18%. This means that the same ship can satisfy the criterion using case 2 input approach and fall the criterion using case 1 approach (see the first general cargo ship in Fig. 4 and Fig. 5). Then again, if the same ship is not meeting the criterion in both input cases, the "margin" would not be the same so this could influence the future designer's choice on the application of energy saving devices. Consequently, EPL and *MCR* reduction necessary to meet the requirements differ between methods for the same ship. The total of 10 out of 11 ships have lower *attained EEXI* when case 2 is being applied. This means that the ship is more likely to meet the requirements when there is available sea-trial report and NOx technical file. Current calculation of energy efficiency and power reduction for existing

ships vastly depends on obtained particulars and therefore, needs to be addressed in regulative.

Nevertheless, there are ways to decrease *attained EEXI*: for instance, the reduction of P_{ME} using mechanical or electronical engine power limiter in main engine, see Fig. 6. The second method could be the reduction of SFC_{ME} since such data are included in NOx technical files. Therefore, an actual data from main engine tests can be used instead of proposed statistical values and may lead to reduced *attained EEXI* value. Third method is to increase ship's capacity, i.e., deadweight for the same size. Moreover, one can increase reference speed by installing energy saving devices (ESD) such as: air lubrication, wind propulsion system, stern adjustments, etc.

An alternative fuel solution (such as LNG, methanol, hydrogen, biofuels, etc.) can also be used to reduce the emissions. They generally require larger storage and pose additional safety issues. Furthermore, propeller efficiency can be increased by more proper maintenance (cleaning, polishing, coating). Nonetheless, overall efficiency can be increased by implementing a variety of operational methods, for instance, operation planning in order to minimize the time spent on berth.

To end, although appears as trivial, a change of ship's class notation could result in reduction of *attained EEXI* since the procedures for its calculation slightly differs depending on the ship type. This possibility is applied and analyzed in the following section.

6. Class notation

As shown in Fig. 3, the criterion of *EEXI* for bulk carriers is stricter than for general cargo ships. Both classes are very similar in design characteristics and it is not unusual that a bulk carrier is classed as general cargo ship and vice versa. Here, authors investigated the effect of such "minor" change on energy efficiency of the same vessel.

6.1. *Inputs for the calculation*

Input parameters are determined according to case 1 and case 2 approach. Moreover, additional case no. 3 is defined as an optimal combination of input parameters (from case 1 and case 2 inputs) which can lead to the lowest *attained EEXI*. Case 3 assumes that the both statistical data and sea-trial reports are available and one can choose from which source shell obtain each parameter. The ship no. 3 has been chosen for this investigation, for which the statistical method (case 1) provided the lower *attained EEXI*. Input parameters are presented in Table 5.

Table 5 – *Input parameters.*

	Bulk carrier			General cargo ship		
Method	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
$SFC_{ME,APP}$	190.00	171.45	171.45	190.00	171.45	171.45
$SFC_{AE,APP}$	215.00	218.30	215.00	215.00	218.30	215.00
$V_{ref,avg}$	14.13	N/A	14.13	17.48	N/A	17.48
$V_{ref,app}$	14.59	N/A	14.59	14.46	N/A	14.46
V_{ref}	14.13	12.88	14.13	17.48	13.14	17.48
MCR_{avg}	6683	N/A	6683	12993	N/A	12993
MCR	8580	8580	8580	8580	8580	8580

6.2. *Effect of class notation change*

Effect of the class notation change of bulk carrier to general cargo ship is shown in Table 6.

Table 6 – *Results.*

	Bulk carrier			General cargo ship		
Method	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
Attained EEXI	8.371	8.633	7.611	8.445	8.462	7.678
Required EEXI	5.32			7.91		
Difference	36.42%	38.35%	30.07%	6.31%	6.50%	-3.04%
EPL	46%	48%	40%	16%	17%	0%
MCR_{lim}	4633	4462	5148	7207	7121	8580

Changing the class notation from bulk carrier to general cargo ship, according to the investigation presented in case of specific ship, can have a vast influence on the energy efficiency existing ship index. The main difference is addressed to the *required EEXI* since for the bulk carriers the proposed criterion is very strict. Therefore, the EPL could drop from 48% (the worst-case scenario) to 0% (the best-case scenario) for ship to meet the requirements by just changing the class notation. In this paper, the class change example is not considered as a measure for energy efficiency improvement. It is rather examined as a lack of current regulative to properly address the result variations due to this change.

7. Conclusion

IMO's most recent regulative on energy efficiency for already built ships is presented. Moreover, the energy efficiency is evaluated for the cargo fleet consisting of 11 ships that falls into the scope of four different classes: general cargo, bulk carrier, tanker and container ship. The performed analyses showed that 8 out of 11 ships are not satisfying the current regulative. For

those ships a potential power reduction is calculated, with respect to the engine power limitation level and *MCR*, so that they can comply the criteria. Moreover, authors showed that different methods to determine input parameters can significantly affect the results. For instance, statistically obtained inputs led to two ships that met the requirements. Still, using sea-trail report data, energy efficiency was satisfied in case of three ships from the database. Moreover, 10 out of 11 ships have lower attained *EEXI*, if sea-trials are conducted and NOx technical file is available. Furthermore, possibilities for the reduction of *attained EEXI* are explored. One of those, a class notation change from bulk carrier to general cargo, showed that such change has a significant influence on *EEXI*.

The paper showed that the present regulative based calculation of energy efficiency of existing ships is very sensitive to input methods and class notation. Regulations have impact on ship design. However, most of the solutions to improve energy efficiency are still related to reduction of speed and power.

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Nomenclature

B – Breadth [m];
$Capacity$ – equals to DWT at scantling draught, except for containerships where it is equal to $0.7DWT$ [t];
C_{FAE}, C_{FME} – Conversion factor between fuel consumption and CO_2 emission for auxiliary and main engine [tCO_2/tFuel];
D – Depth [m];
EEDI – energy efficiency design index (*attained EEDI*, *required EEDI*) [gCO_2,/tnm]
EEXI - energy efficiency existing ship index (*attained EEXI*, *required EEXI*) [gCO_2,/tnm]
f_c – Cubic capacity correction factor [/];
f_i – Capacity correction factor [/];
f_l – Factor for general cargo ships equipped with cranes and other cargo-related gear [/];
f_m – Factor for ice-classed ships having IA Super and IA [/];
f_w – Factor for speed reduction at sea [/];
$DWT_{design}, DWT_{S,service}, DWT_{scantling}$ – Deadweight at design, service, scantling draught [t];

k – Scale coefficient [/];
L_{oa}, L_{pp}– Length overall, between perpendiculars [m];
LWT – Lightweight [t];
MCR – Maximum continuous rating (maximum power of main engine) [kW];
MCR_{lim} – Maximum continuous rating after installing EPL [kW];
m_v – performance margin [kn];
P_{AE} – Power of auxiliary engine [kW];
$P_{AE,eff}, P_{eff}$ – Innovative mechanical energy efficient technology for auxiliary and main engine [kW];
P_{ME}, P_{PTI} – Power of main and shaft engine [kW];
$P_{S,EEDI}, P_{S,service}$ – Power of main engine corresponding to $V_{S,EEDI}, V_{S,service}$ [kW];
$SFC_{ME,}\ SFC_{AE}$– Specific fuel oil consumption for main engine and auxiliary engine [g/kWh];
$SFC_{ME,app}, SFC_{AE,app}$ – Approximated specific fuel oil consumption for main and auxiliary engine [g/kWh];
$T_{design}, T_{scantling}$ – Design, scantling draught [m];
V_{design} – Design speed [kn]
$V_{ref,}\ V_{ref,avg}, V_{ref,app}$ – Reference speed, average reference speed, approximated reference speed [kn];
$V_{S,EEDI,}\ V_{S,service}$ – Sea trial service speed under the *EEDI* and design load draught [kn];
Y – Reduction factor [-];
$\Delta_{scantling}$ – Displacement at scantling draught [m^3].

References

[1] IMO MEPC," Resolution MEPC.203(62) - Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the prevention of pollution from ships, 1973, as modified by the protocol of 1978 relating thereto.: IMO, 2011/07/15", 2011.
[2] IMO MEPC, "Resolution MEPC.304(72) - Initial IMO strategy on reduction of GHG emissions from ships.: IMO, 2018/04/13", 2018.
[3] IMO MEPC," Resolution MEPC.324(75) - Amendments to the Annex of the Protocol of 1997 to amend the International Convention fort the prevention of pollution from ships, 1973, as modified by the protocol of 1978 relating thereto. -: IMO, 2020/11/20", 2020.
[4] IMO MEPC, "Resolution MEPC.308(73) - 2018 Guidelines on the Method of Calculation of the attained Energy Efficiency Design Index (EEDI) for new ships: IMO, 2018/10/26", 2018.

[5] Intersessional Working Group," Draft report of the eight meeting of the Intersessional Working Group on Reduction of GHG Emissions from Ships (ISWG-GHG 8). Norway: IMO, 2021/05/28.", 2021.
[6] M. Kalajdžić and N. Momčilović, "A Step Toward the Preliminary Design of Seagoing Multi-Purpose Cargo Vessels", Brodogradnja/Shipbuilding, Vol.71, No. 2, 2020, pp. 75-89.
[7] M. Kalajdžić, M. Vasilev and N. Momčilović, "Exploring an Effect of Novel IMO Policies on Energy Efficiency of Existing Ships", 1st Kotor International Maritime Conference (KIMC 2021), Kotor, Montenegro, 2021.
[8] I. Ancic, G. Theotokatos and N. Vladimir, "Towards improving energy efficiency regulations of bulk carriers", Ocean Engineering, Vol. 148, 2018., pp. 193-201.
[9] N. Vladimir, I. Ancic, A. Šestan: Effect of ship size on EEDI requirements for large container ships, Journal of Marine Science and Technology, Vol. 23, No. 1, 2018., pp. 42-51.
[10] Intersessional Working Group, "Final report of the seventh meeting of the Intersessional Working Group on Reduction of GHG Emissions from Ships (ISWG-GHG 7). Norway: IMO, 2020/11/10.", 2020.

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Solutions to Minimize Sediment Resuspension in Ports*

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Abstract: Sediment resuspension has, among other things, negative consequences for marine flora and fauna. A solution to this problem could lie in alternative ship manoeuvres, automated mooring systems and bottom protection techniques. The paper deals with the methodology for determining sediment resuspension, which consists of real-time kinematic measurements and in-situ measurements with (PNS-RTK) sensors. Real-time data from the manoeuvring vessel is used to determine the critical vessel rate per minute (RPM) or propeller jet velocity on the seabed and to identify the most common critical vessel manoeuvres on approach to port and departure. The Full Mission Bridge Simulator (FMBS) can be an excellent simulation tool for the analysis of real-time and on-site measurements, which is proposed for further research.

Keywords: Sediment Resuspension, Real Time In-Situ Measurements, Alternative Ship Manoeuvres, Full Mission Bridge Simulator.

1. Introduction

Sediment resuspension has become a major concern for marine biologists and port authorities. Marine biologists are concerned about the marine ecosystem and port authorities are concerned about the impact of resuspended material on the seabed caused by the rotation of ship propellers [1] [2]. The solution lies in the implementation of structural measures and new procedures for manoeuvring ships. The latter solution is based on analytical criteria for determining sediment resuspension (SR), which are applied to most ships that have the greatest impact on SR in the port of Koper, taking into account the frequency of their calls. The ships and their manoeuvres are analysed to find the least interaction between ship and seabed. Each port is specific from a global point of view in terms of its geographical location, type of operating costs and available manoeuvring space, type of seabed and ba-

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thymetry, prevailing weather conditions, waves, winds and currents. Nevertheless, some of these manoeuvring procedures are applicable to similar ports.

2. Methods and tools for determining sediment resuspension

The real-time data of the manoeuvring vessel is obtained from the following sources: Automatic Identification System (AIS), Pilot Navigation System (PNS) in conjunction with Real Time Kinematic (RTK) GNSS receivers and records of vessel course, heading, speed, telegraph status, rates per minute (RPM) recorded on board. An assessment of the real ship is made: type, size, draft, propeller type and diameter. All the above parameters are used to determine the critical ship RPM or propeller jet speed on the seabed. Previous research methods for calculating propeller jet velocity are being investigated to find the most suitable method. The Full Mission Bridge Simulator (FMBS) is used to replicate a real ship manoeuvre. A similar type of ship is selected for the FMBS. The chosen propeller jet speed method is used to compare the real and simulated ship manoeuvres and determine the agreement of the results and any discrepancies. The next step is to perform optimal ship manoeuvres with experienced local pilots and tugs on the FMBS. The aim is to use less engine power, give telegraphic commands, use the tugs optimally and adjust their positioning to the vessel's requirements. The test manoeuvres are repeated to achieve satisfactory results, depending on how the jet speed affects the seabed.

2.1. Tools

The AIS is a widely used tool for monitoring ship movements while underway and manoeuvring. It provides information such as: course, direction, speed, position, vessel type and vessel track. This data is important to identify the most common critical ship manoeuvres when approaching and leaving port. The PNS is normally used when the vessel enters port. As it presets the desired personal settings, it simultaneously enables the recording of all dynamic data on the ship's manoeuvres. Researchers and pilots can also set up RTK sensors that provide more accurate information about the vessel's position, movement and acceleration.

Collaboration between master, pilot and researcher can lead to safer harbour manoeuvres and reduced sediment stir-up by sharing best practises and records of vessel speed, course, heading and Under Keel Clearance (UKC). The FMBS is a useful tool to recreate a real ship manoeuvre and obtain all desired dynamic parameters for ship movement. Alternative Ship Manoeuvres (ASM) are performed to obtain the least sediment stir-up due to propeller rotation. The ship motion parameters are processed with a suitable method to determine the velocity of the jet on the seabed.

An important tool for determining the interaction between the ship's propeller and the seabed is also the bathymetry map of the port of Koper. It should be inserted into FMBS as an overlay to obtain realistic ship motion data.

2.2. Methods

The methods for calculating the volume of sediment resuspension are based on theoretical equations with hypotheses that are not reliable and on experimental studies with scaled propeller systems in test basins. The jet outflow velocity (V_0) is the most important parameter for the analysis of sediment resuspension, as all theoretical equations developed so far use it as a dependent variable. Fig. 1 shows the propagation of the propeller jet in axial (x) and radial (r) directions.

The outflow velocity (V_0) is the maximum velocity at the front of the propeller [3] which is shown in (1).

$$V_0 = 1.59 n D_p \sqrt{C_T} \tag{1}$$

In equation (1) n is the rotational speed of the propeller in revolutions per second, D_p is the propeller diameter in metres and C_T is the thrust coefficient of the propeller. This equation does not take into account the propeller geometry [3].

Other researchers introduce equations with the propeller geometry; one of them is Hashmi [4] who proposed (2) and (3).

$$V_0 = E_0 n D_p \sqrt{C_T} \tag{2}$$

$$E_0 = \left(\frac{D_p}{D_h}\right)^{-0.403} C_t^{-1.79} \beta^{0.744} \tag{3}$$

He improved this equation by not dimensioning the propeller diameter (D_p) but dividing it by the hub diameter (D_h) with value 14.92 mm; the blade area ratio (β) is the projected area of the blades relative to the propeller disc area.

In many cases, there are no parameters derived from the area of the propeller disc and the number of revolutions per second. The authors [6] solved this problem by establishing the following equation (4).

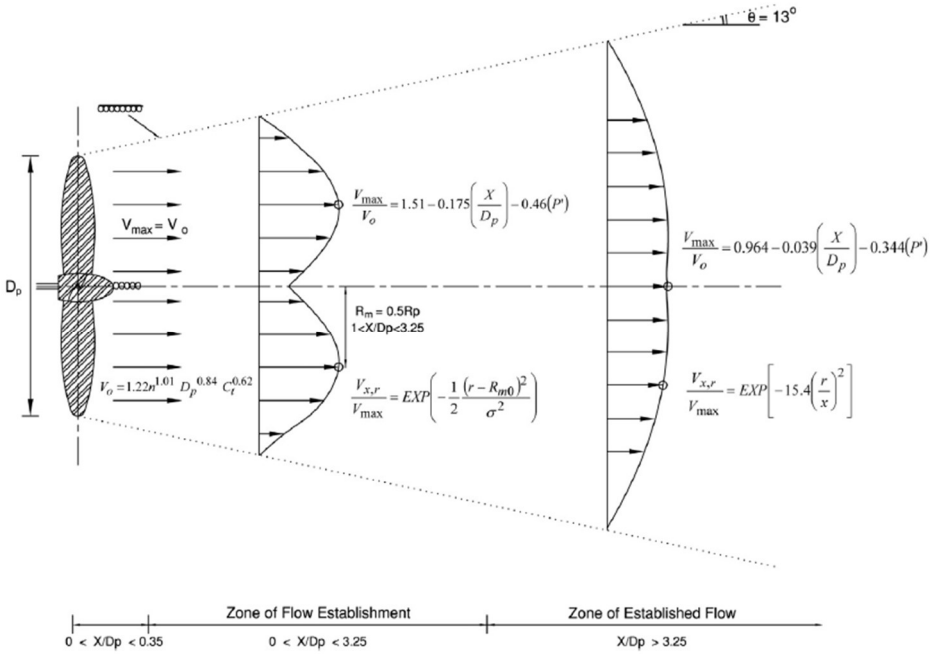

Fig.1 - *Definitions for jet of the main propulsion system (without rudder) [6].*

$$V_0 = C_2 \left(\frac{f_p P_{Max}}{\rho_W D_p^2} \right)^{\frac{1}{3}} \tag{4}$$

Here, the coefficient C_2 has a value of 1.17 for propellers with air ducts and of 1.48 for propellers without air ducts; f_p is the expected average engine power (which can be 0.15 or 0.4 according to [7]) due to arrival and departure manoeuvres; P_{Max} is the maximum installed engine power; and ρ_w is the media density in which the ship is sailing.

The next step is to calculate the jet speed along the centreline of the propeller (x-axis). The German method with equation (5) is presented.

$$V_{ax} = AV_O \left(\frac{D_p}{x} \right)^a \tag{5}$$

This equation can be used for range from x/Dp>2.6. Value A is presented below (6), (7), (8).

$$A = 1.88 \times exp\left(-0.092 \times \left(\frac{h_t}{D_p}\right)\right) propeller\ without\ rudder,$$

$$0.9 \leq \frac{h_t}{D_p} \leq 9 \tag{6}$$

$$A = 1.88 \times exp\left(-0.0161 \times \left(\frac{h_t}{D_p}\right)\right) propeller\ with\ rudder\ on\ centerline,$$

$$0.9 \leq \frac{h_t}{D_p} \leq 9 \tag{7}$$

$$A = 0.92 - 0.018 \times exp\left(\frac{h_t}{D_p}\right) for\ ships\ with\ two\ propellers,$$

$$0.9 \leq \frac{h_t}{D_p} \leq 9 \tag{8}$$

where:

A = 0.9 twin screw

a = 0.6 influence of bottom and water surface only

a = 0.3 extra influence for lateral quay wall (A is not applicable then, but the equation below should be used with r=0).

$$h_t = C + \frac{D_p}{2} \tag{9}$$

Here the parameter h_t is the distance between the propeller axis and the seabed and the parameter C is the distance between the propeller tip and the seabed.

The following is a simplified equation (10) for determining the velocity of the propeller jet at a certain distance (x) and radius (r) from the propeller plane.

$$V_{(x,r)} = V_{ax} exp\left[-22.2\left(\frac{r}{x}\right)^2\right] \tag{10}$$

Equation (11) predicts maximal bottom velocity produced by propeller jet.

$$V_{b,max} = EV_0\left(\frac{D_p}{h_t}\right)^b \tag{11}$$

Where E = 0.71, b = 1.0 for seagoing ships with rudder; E = 0.42, b = 0.275 for sea-going ships without rudder; E = 0.52, b = 0.275 for sea-going ships with twin propeller and double rudder [6].

3. Recommended solutions to minimise sediment resuspension

The most important solution for further research is alternative ship manoeuvres [8] and manoeuvers using tugs [9]. Another solution is active docking fenders. Various techniques are used in ports around the world to overlap the harbour floor to prevent re-suspension, which have advantages and disadvantages [10].

3.1. Alternative ship manoeuvres

The most important principle for minimising sediment resuspension is to use a lower propulsive power or speed per minute (RPM). Reducing the propulsive power results in a lower speed of the propeller jet hitting the harbour bottom. The use of propulsive power on board a vessel depends not only on the pilot/captain and tug master, but also on the experience, personalities and communication between them. The type of manoeuvre (departure, arrival) also has a major influence. The departure manoeuvre requires more power to get the vessel moving. Environmental conditions such as: visibility, wind and current direction, water density, traffic in the port and its approach, approach and composition of berths. The above factors play an important role in the difficulty of the manoeuvre and indicate that more force is required to perform a safe manoeuvre.

The arrival manoeuvre starts with a predefined entry speed and a position course towards a conspicuous object at the berth. The speed and course will vary depending on weather conditions. The involvement of the tugs in the manoeuvring process must be carefully planned. Up to what point in the approach channel should the tugs be connected to the vessel and where will they be too fast in relation to the vessel. There must be close cooperation between the ship's master/port pilot and the tug master regarding the manoeuvrability of the ship (ship's master/port pilot) and the desired angle and tow of the connected tugs (pilot/tug master). Tugs also stir up sediments, but they disturb less due to their shallower draught. The tug's pull/push is also used in determining alternative vessel manoeuvres in terms of "optimal tug deployment".

The outbound manoeuvre is again influenced by all the parameters from the previous paragraph. Statistically, it leads to more sediment stirring, comparable to the arrival manoeuvre, while more propulsive power is needed to get the vessel moving. The solution lies in the "optimal use of tugs" and the non-aggressive kick-ahead mode (gradual increase of RPM).

3.2. Automated mooring system

The Automated Mooring System (AMS) was developed with efficiency, economy and environmental friendliness in mind. The system comprises an extendable hydraulic arm with vacuum cushion, controlled via monitoring and control interfaces. The system was primarily developed to speed up the berthing process, resulting in a faster turnaround time in port and consequently having a positive impact on reducing sediment stir-up. Less propulsion power and tug assistance is required to align the vessel at berth. The hydraulic extension arm is able to push the vessel between 600 and 2500 mm away from the pier (depending on the AMS model), resulting in a moment of inertia of the vessel and requiring less propulsion power and tug assistance.

Source: https://tekointerface.com.ua/wp-content/uploads/2019/12/112.pdf, Available 23.11.2021.

Fig. 2 - *Automated mooring system (QuaySailor 40)*

3.3. Techniques to prevent scouring of the harbour bottom

There are various scour protection techniques (SPT) to reduce the sediment stirring up from the propeller jet. The type of scour protection depends on: the sediment size, the bathymetry of the harbour bottom, the economic perspective and the time needed to set up this system (interference with shipping traffic and economic losses due to construction works).

The most common types of scour protection are: Riprap (basalt, granite, syenite, quartzite, limestone); riprap impregnated with asphalt primer; riprap impregnated with underwater concrete; cabled concrete block mats; concrete slabs; concrete-filled fabric mattresses; stone-filled fibre-reinforced bitumen mattresses; geosynthetic bags, mattresses, tubes and containers filled with sand, gravel or a combination thereof [10].

The rock size for the riprap system is determined according to the German method (12).

$$V_{b,max} = B_{cr}\sqrt{D_{50} g \Delta} \tag{12}$$

$$\Delta = \frac{\rho_s - \rho_w}{\rho_w}$$

Coefficient B_{cr} is ranging from 0.9 to 1.25, D_{50} indicates the sediment size such that 50 % of the sediment particles are smaller than this size; g is the acceleration due to gravity, Δ is the relative density, ρ_s is the density of the sediment and ρ_w is the water density. The thickness of the mattresses or concrete slabs is determined with (13).

$$D > \frac{C_L V_{b,max}^2}{2g\Delta} \tag{13}$$

Coefficient C_L is ranging from 0.50 to 0.75 [9]. Figure 3 shows concrete-filled fabric mattresses lay-up and structure design.

Source: https://proserveltd.co.uk/. Avaliable 23.11.2021.

Fig. 3 - *Concrete-filled fabric mattresses on harbour bottom.*

Scouring of the harbour bottom also has a negative impact on the environment (on flora and fauna). Future dredging (global trends in shipping indicate a continuous increase in ship size and thus deeper draught) will require the removal of the concrete-filled fabric mattress prior to dredging.

4. Conclusion

The paper reviews the existing literature on tools and methods for assessing the impact of ship scour caused by propeller jets and presents exist-

ing techniques that use the new ASM approach to avoid sediment resuspension. The main ship manoeuvres are analysed (collection of voyage data recorders, PNS movement data from pilots and records from AIS). The data will be used to determine the velocities of the propeller jets and their impact on the harbour bottom. A similar type of vessel will be used on the FMBS to accurately track the manoeuvring of vessels in real time. The real-time and FMBS manoeuvres will be compared and the data variance will be evaluated to determine possible and expected deviations. The following technique will also show whether FMBS is a suitable tool for reconstructing "real" ship manoeuvres. When performing ASM, the deviations of time/location and FMBS manoeuvres are taken into account. Several ship manoeuvres will be tested with FMBS to find guidelines and recommendations to reduce ship scour.

Automated mooring systems may also help to reduce ship scour, but are not expected to significantly improve ship scour. Techniques to protect the harbour bottom from scour are already in use and are very effective. Their negative impact on the environment and future dredging is highlighted.

Further research should consider a holistic approach to a truly sustainable system of global maritime trade, because the costs and environmental damage caused by global maritime transport are primarily caused by profit-driven large shipping companies in collusion with construction companies that profit from port expansion contracts. At some point there will either come a time when actual sustainability is achieved, which would only be possible with a far more egalitarian economic system, or current trends will carry an abused environment beyond a point of no return.

References

[1] M. Perkovič, M. Batista, V. Malačič, D. Žagar, S. Jankowski, L. Gucma, M. Gucma, D. Rostopshin, 'Bottom wash assessment using a full mission ship handling simulator', MARSIM 2012 Conference, Singapore Maritime Academy, 2012, p. 11.

[2] A. Mujal-Colilles, T. Llull, et al., 'Ship manoeuvring effects on propeller induced erosion', in International Conference on the Application of Physical Modelling to Port and Coastal Protection, pp. 1-7, 2018.

[3] M. Fuehrer, and K. Romisch, "Effects on Modern Ship Traffic on Inland and Ocean Waterways," 24th International Navigation Congress, PIANC, Leningrad – Russia, 1977, pp. 236-244.

[4] H. N. Hashmi, "Erosion of a granular bed at a guay wall by ship's screw wash", Ph.D. thesis, Queen's University, Belfast, 1993.

[5] H. G. Blaauw, and E. J. Van de Kaa, "Erosion of Bottom and Sloping Banks Caused by the Screw Race of Manoeuvring Ships", Publication N.202', 7 th International Harbour Congress, Antwerp, Belgium, 202, 1978.
[6] G. A. Hamill, and C. Kee, "Predicting axial velocity profiles within a diffusing marine propeller jet," Ocean Engineering, vol. 124, pp. 104-112, September, 2016.
[7] PIANC Guidelines for Protecting berthing structures from caused by ships. Report n0180. The World Association for Waterborne Transportation Infrastructure, 2015.
[8] M. Castells, A. Mujal-Colilles, T. Llull, X Gironella, F. X. Martinez de Oses, A. Martin, and A. Sanchez-Arcilla, 'Ship Manoeuvre Patterns to prevent Eropeller Scouring Effects.' PIANC-World Congress Panama City, Panama 2018.
[9] L. Absalonsen, "Pacific Northwest LNG Jetty Propeller Scour Analysis", Hatch, 2014.
[10] N. D. Belyaev and V.I. Klimovich, "State of the art in protection of bottom against scour caused by marine propulsors", Power technology and Engineering, vol. 53, pp. 159-165, July, 2019.

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Distance Measurement Sensors – A Comparative Case Study with Example from Education*

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Abstract: A modern approach to active learning is a technique called "learning by doing". It is usually the most wanted approach. As an example of this technique, this paper presents a student learning process about sensors and their properties by performing experiments and learning from sensors' manuals. In order to compare distance sensors in industry applications, an experiment was conducted. Experimental results leads to conclusion which of the available sensors showed the most accurate results in relation to the results given by the manufacturer. Finally, conclusions have been made about reasons for the deviation of individual sensors from the predicted values.

Keywords: Distance measuring sensors, Photoelectric sensor, Capacitive sensor, Inductive sensor, Marine engineering education.

1. Introduction

It could be expected that distance sensors will play important role in future autonomous traffic in ports, and in land traffic as well. Furthermore, it is important in robots, which could operate both indoor and outdoor. Hence, it is important that students get in touch with such sensors to be better prepared for future needs.

Inductive proximity switches were already considered for Industry 4.0 [1]. Implementation [2] and a structure [3] of the inductive proximity switches were considered as an introduction to energy efficiency research. Except for proximity sensing [4], capacitance proximity sensors were used even for identification of the materials [5], which also has interesting implications in maritime industry. Reed switches design was considered in [6]. The design and implementation of photoelectric sensor for color fault detection is an interesting additional use of distance sensors [7]. Mentioned examples shows that sensors of interest in this paper can be widely used in many applications. Hence, it is important to students to learn of them.

*An earlier version of this paper was presented at the 1st Kotor International Maritime Conference – KIMC 2021, Kotor, Montenegro.

The paper is organized as follows. The second section provides details about equipment and experimental setup. The third section presents results. Finally, conclusions are given.

2. Experimental Data

2.1. Experimental equipment

The IA 120 Principles of industrial sensor technology unit allows experimental investigation of the functioning of various industrial sensors, including both non-contact (capacitive proximity switch, inductive proximity switch, reed contacts, reflex photoelectric proximity switch, reflex photoelectric barriers, and one-way photoelectric barriers) and contact sensors (limit switches).

Technical data for reflex photoelectric barrier are:

– Range limit S_n = 4.0 m,
– Operating range S_b = 3.2 m,
– Light source / wavelength - pulsed red light diode / 660 nm,
– Operating voltage: 10-30 VDC,
– Average current consumption: 22 mA,
– Current consumption max: 35 mA,
– Max. switching current: 200 mA,
– Voltage drop: 1.8 VDC, and
– Working temperature: -25...+55 °C.

Light guide (one-way photoelectric barrier) has characteristics:

– Operating range S_b = 800 mm,
– Scanning range T_w = 150 mm,
– Light source / wavelength - Pulsed IR diode / 880 nm,
– Operating voltage: 10-30 VDC,
– Average current consumption: 40 mA,
– Max. current consumption: 55 mA,
– Max. switching current: 200 mA,
– Voltage drop: 1.8 VDC,
– Working temperature: -25...+55 °C.

Reflex photoelectric proximity switch (red light) has characteristics:

– Scanning range T_w = 5...200 mm,
– Light source / wavelength - Pulsed red light diode / 660 nm,
– Operating voltage: 10-30 VDC,

– Average current consumption: 20 mA,
– Max. current consumption: 30 mA,
– Max. switching current: 100 mA,
– Voltage drop: 1.8 VDC,
– Working temperature: -25...+65 °C.

Reflex photoelectric proximity switch (infrared) have technical characteristics:

– Scanning range T_w = 20...150 mm,
– Light source / wavelength - Pulsed IR diode / 880 nm,
– Operating voltage: 10-30 VDC,
– Average current consumption: 30 mA,
– Current consumption max: 45 mA,
– Max. switching current: 200 mA,
– Voltage drop: 1.8 VDC,
– Working temperature: -25...+55 °C.

Technical data for capacitive proximity switch are:

– Nominal switching distance S_n = 5 mm,
– Min. switching distance S_{min} = 0.5 mm,
– Max. switching distance S_{max} = 10 mm,
– Operating voltage: 10-35 VDC,
– Idle current: 15 mA,
– Max. switching current: 400 mA,
– Voltage drop: 2.0 VDC,
– Working temperature: -25...+70 °C.

Inductive proximity switch has characteristics:

– Nominal switching distance S_n = 5 mm,
– Operating voltage: 10-35 VDC,
– Idle current: 15 mA,
– Max. switching current: 250 mA,
– Voltage drop: 2.5 VDC,
– Working temperature: -25...+70 °C.

Reed contact has maximum switching voltage: 24 V, maximum switching current: 0.1 A, breaking capacity of maximum 1 W, and operates at ambient temperatures between -30 and +85 °C.

2.2. Experimental setup

Experimental setup consists of a reflector, which represents sensor's platform, e.g. car, and a barrier, which represents e.g. wall, IA 120 unit, and plate with meter. It is shown in Fig. 1.

The reflector part is moving away from the stationary part. At marked distances (150, 250, 360 mm), the moving part (reflector) is stopped. If the signal is detected, the operator (e.g. student) writes "yes", and otherwise "no" (see tables in the Results section).

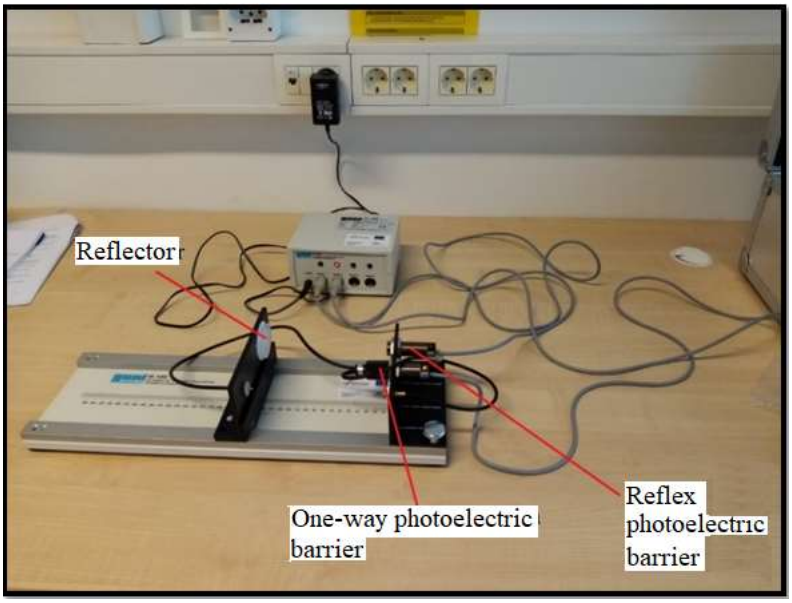

Fig. 1 – *Experimental setup.*

By changing types of plates, students can learn about reflexive properties of various materials by actually performing the experiment. Hence, they learn by doing.

3. Results

Experimental results are shown in Table 1 for one-way photoelectric barrier and reflex photoelectric barrier. To correctly compare results, the same distances were marked and used in experiment with both one-way and reflex photoelectric barrier. If there is a switch at some distance, "Yes" is circled. Experiment is repeated for three distances and five plates.

Table 1 – *Switching distances for one-way and reflex photoelectric barrier - results.*

Sensor	Experimental plate					
	Sensor distance (mm)	Aluminum sheet	Steel sheet, textured, matt black	Steel sheet, smooth, silver	Plexiglass, Transparent	Plastic, smooth, white
One-way photoelectric barrier: switches	360	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
	250	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
	150	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
Reflex photoelectric barrier: switches	360	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
	250	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No
	150	Yes/No	Yes/No	Yes/No	Yes/No	Yes/No

As it can be seen from the results, the white sheet provides the best detection by photoelectric sensors. It is obvious, because white surface reflects all light.

Another observation from the results is that transparent sheets are less detectable by reflex methods. Silver and aluminum are similar colors. Hence, the results are the same.

Table 2 shows measured switching distances for inductive, capacitive, reflex photoelectric IR, and red light proximity switches. Three measurement were carried out for every plate and switch. N/A means that this case is not possible for the declared setup. Since, setup is such that there is no setup for distances greater than 360 mm, "360+" means that the switch detects marked plate at higher distance than 360 mm.

Table 2 – *Measured switching distances.*

Sensor	Experimental plate				
	Aluminum sheet	Steel sheet, textured, matt black	Steel sheet, smooth, silver	Plexiglass, transparent	Plastic, smooth, white
Inductive proximity switch [mm]	4.8	5.2	5.7	N/A	N/A
	4.75	4.95	5.45	N/A	N/A
	4.35	5.1	5.47	N/A	N/A
Capacitive proximity switch [mm]	7.5	6.6	7.55	4.47	5.49
	7.49	6.95	7.65	4.89	4.9
	7.48	6.9	7.49	4.1	4.8
Reflex photoelectric proximity switch (IR) [mm]	157	64	248	105	101
	156	65	250	106	104
	157	65	249	106	105
Reflex photoelectric proximity switch (red light) [mm]	124	128	360+	211	230
	123	129	360+	211	228
	123	128	360+	213	231

4. Conclusions

The equipment obtained by the EU project (see Acknowledgment) can be used for education of marine engineers. It can be useful to get in touch

with sensors which are widely used. This papers presents experimental data, which is obtained by "learning by doing" technique by student of marine engineering.

Experimentally used sensors can be applied in many usages in maritime industry, but also in advanced applications, such as robotics, Internet of Things, etc.

5. Acknowledgments

The equipment used was obtained by the project "Functional integration of the University of Split, PMF / PFST / KTF through the development of scientific and research infrastructure in the three faculty (3F) building". The work is performed by the research group for application of new technologies in maritime affairs (https://brod.pfst.hr/~ivujovic/zn_grp.html). The results are obtained in the research for student's thesis (5 years, marine engineering, N. Rajković).

References

[1] I. de la Peña Zarzueloa, M. J. F. Soeanea, and B. López Bermúdez, "Industry 4.0 in the port and maritime industry: A literature review," J. Ind. Inf. Integr., vol. 20, 100173, December 2020.

[2] Y. Zhao, Y. Fang, J. Yang, W. Zhang, X. Ge, S. Cao, and X. Xia, "An Implementation Method for an Inductive Proximity Sensor with an Attenuation Coefficient of 1," Energies, vol. 13, 6482, 2020.

[3] Y.-X. Guo, C. Lai, Z.-B. Shao, K.-L. Xu, and T. Li, "Differential Structure of Inductive Proximity Sensor," Sensors, vol. 19, 2210, 2019.

[4] Y. Ye, C. Zhang, C. He, X. Wang, J. Huang, and J. Deng, "A Review on Applications of Capacitive Displacement Sensing for Capacitive Proximity Sensor," IEEE Access, vol. 8, pp. 45325-45342, 2020.

[5] I. Kabir Ahmad, M. Mukhlisin, and H. Basri, "Application of Capacitance Proximity Sensor for the Identification of Paper and Plastic from Recycling Materials," Res. J. Appl. Sci., vol. 12, 1221-1228, 2016.

[6] N. Ralbag, I. Felner, and D. Avnir, "New reed switch design based on magnetic silver," Mater. Res. Express, vol. 6, 126329, 2019.

[7] S. Fenhua, and C. Zujue, "The Design and Implementation of Photoelectric Sensor for Yarn Color Fault Detection," Int. J. Online Biomed. Eng. (iJOE), vol 12, 3824, 2016.

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Original scientific paper

Operational Limitations of Durres Container's Terminal

Osman Metalla, Eli Vyshka

Abstract: Albania is a maritime country, and maritime transport is the backbone of its economy. In 2021 maritime transport counted for about 59% of trading volumes, and Durres port handled more than 91% of all seaborne cargoes [1]. Durres Container's terminal is the only terminal handling containers in Albania. This terminal is operating under some limitations which are affecting its performance. These limitations are the lack of container storage area, increasing the container's dwell time and creating container congestion and the immediate need for more storage spaces, limited water depth at the access channel and port basin, lack of container handling cranes, and lack of railway connections, etc. This paper will focus on terminal needs for storage areas and aims to analyze the current situation and identify the space needed for the projected cargoes 15 years ahead based on historical data and using 2021 as the base year. A multi regression analysis [2] is used to identify the demand and consequently the space needed to handle the forecasted traffic. Based on the space requirements identified by this paper, it is evident that there is an urge to decide on terminal enlargement or terminal reallocation to a new site.

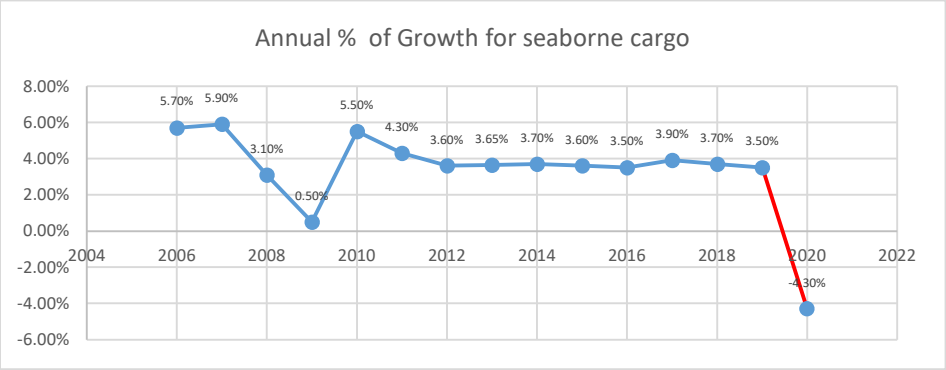
Keywords: Durres Port, Container's terminal, Congestion, Terminal space.

1. Introduction

In recent years the most technical development was the unitization of the liner shipping business. During 1960 the traditional system of the break-bulk become increasingly unable to cope with the escalating volume of world trade [3]. One of the principal benefits of containerization is that it allows bigger ships to be used, and the size of container ships has increased steadily, following much the same process of evolving into size segments we have already seen in the tanker and bulk carrier market.

Container traffic has always been growing. Even during the pandemic, due to the consumers' behavior change that was more oriented toward products than services, container traffic growth slowed down but remained optimistic. The world seaborne traffic was heavily hit by the pandemic [4]. The

following figure 1 shows the annual growth of the seaborne cargo volumes [5].



Source: Adopted by Review of maritime transport 2020 - UNCTAD

Fig. 1 – *Annual Growth of seaborne cargo*

Durres Port is relatively new in container handling. It started about 15 years ago, with the construction of a start-up container terminal. This terminal had a relatively small yard area of about 64000m^2, and the equipment available was limited. Initially, only one mobile crane, two reach stackers, and a few chassis to move the containers. Furthermore, the navigational parameters of the access channel and the quayside were 7,5m, not allowing bigger ships to be accommodated alongside the terminal.

2. Durres Container Terminal

Durres's container terminal is situated in wharf 6-7 of the port. It has a storage capacity of 7000 TEU. The terminal details are given in table 1 below.

Table 1 – *Terminal characteristics*

No	Description	units
1	Storage capacity	7000 TEU
2	Annual Terminal capacity	180000 TEU
3	Terminal area	64000m^2 +30000m^2 additional contract
4	Berth length	308m
5	Approach channel depth	8m
6	Terminal operation system	Solon Port
7	Quay crane productivity	45 containers/hour

Source: https://www.dct.al/terminal-information

Today, the terminal can handle up to 180000 TEU/year [6]. The overall length of the quay is 308 meters, and the water depth is 8m. The terminal is operating with the system Solon port. Two mobile cranes are operating at the terminal with a productivity of 45 Cont./hrs. Following table 2 shows the equipment available at the container's terminal:

Table 2 – *Durres terminal Equipment*

No	Description of equipment	Lift capacity	units
1	Fantuzzi MHC 130	100 T	1
2	Terex MHC 150	150 T	1
3	Reachstakers (Fantuzzi/Kal-mar		7
4	Forklift		1
5	Internal transfer vehicle		6
6	Reefer plugs		201
7	Empty container handling		1

Source: https://www.dct.al/terminal-information

The number of containers handled in this terminal is steadily growing from year to year. From a few hundred boxes in the first years of its operation, this terminal now is handling almost 150000 TEU/year. The following chart shows the number of TEUs handled during the years 2012 - 2019 [6].

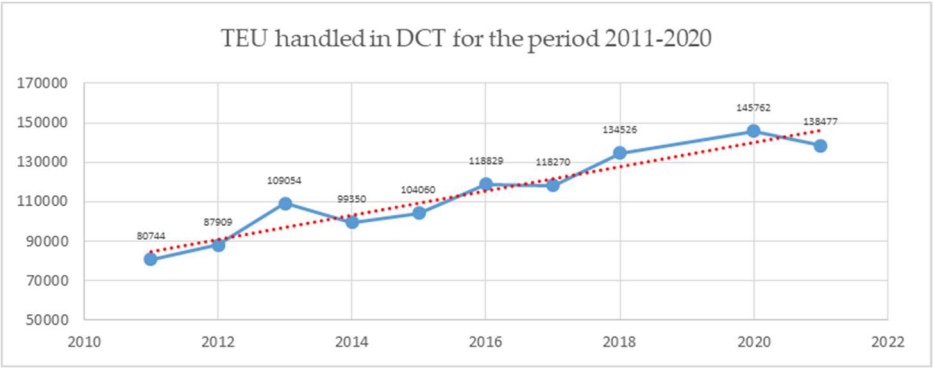
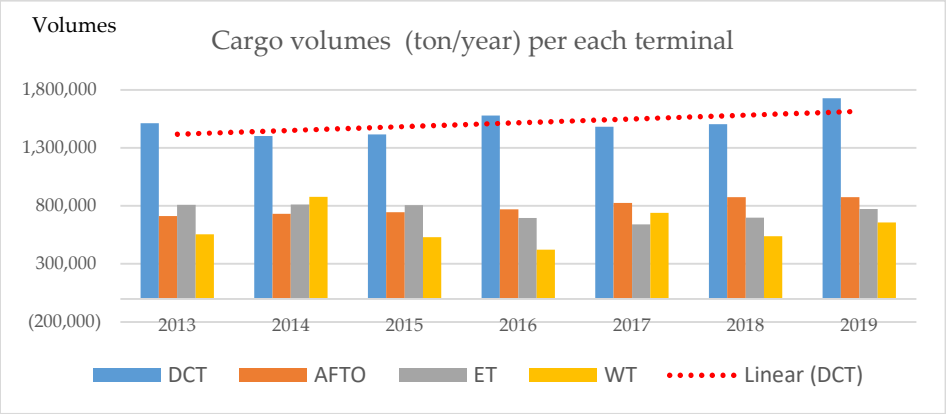


Fig. 2 – *Containers handled in DCT 2012-2019*

The trendline shows a steady growth of the container's demand. Regarding the volumes of cargoes (ton/year) handled in the port, the container terminal is the main terminal occupying the biggest share. The charts below show respectively the volumes of the cargo handled in Durres Container Terminal (DCT), Albanian Ferry Terminal Operator (AFTO), East Terminal (ET), and the West Terminal (WT) for the period 2013-2019.



Source: Durres Port Authority Statistics

Fig. 3 – *Volumes handled in Durres Port according to terminals*

The cargo share for the Containers Terminal is shown in figure No. 4:

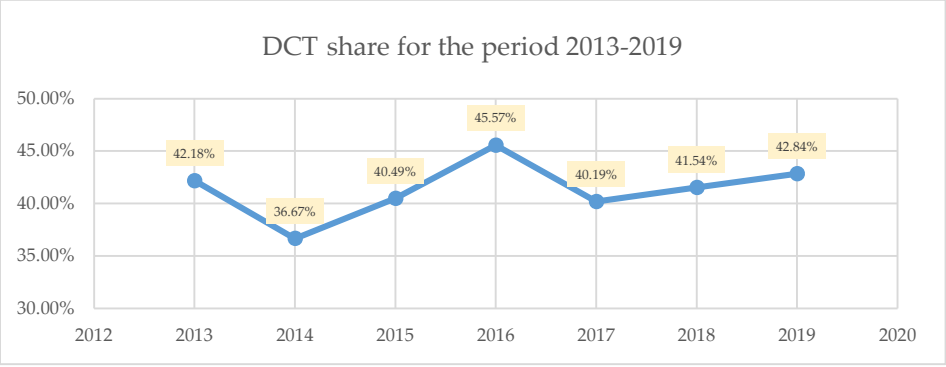
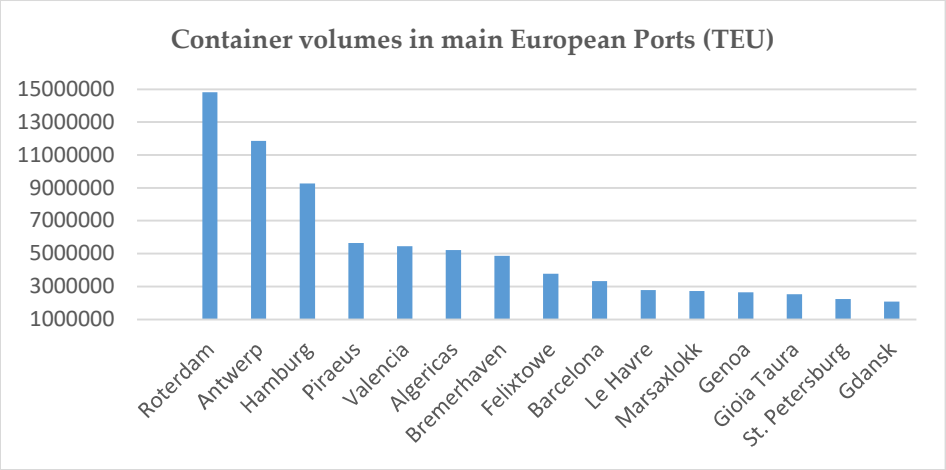


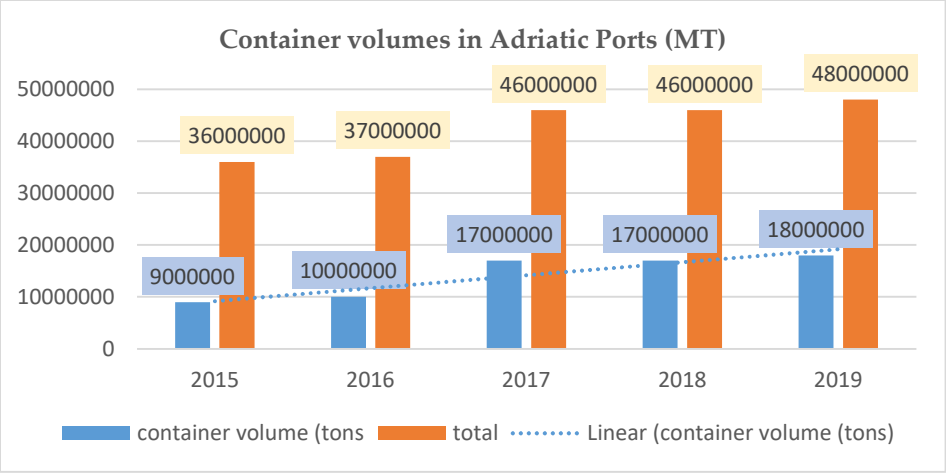
Fig. 4 – *Cargo share for container terminals*

Compared to other European ports, Durres has the same share of cargo, regarding container terminals. Figures 5 and 6 show the volume of the containers handled in the 15 biggest ports of Europe in 2019 and the share of containers in Adriatic Ports [7, 8].



Source: Port Economics retrieved from: https://www.porteconomics.eu/top-15-container-ports-in-europe-in-2019-teu-volumes-and-growth-rates/

Fig. 5 – *Top 15 container ports in Europe (2019)*



Source: https://www.statista.com/statistics/1183201/cargo-traffic-in-adriatic-sea-ports-by-type/

Fig. 6 – *Container volumes in Adriatic Ports*

It can easily be observed that the container share for the Adriatic ports is increasing respectively from 25% in 2015 to 37,5% in 2019 [8].

3. Methods and material

In this paper, we have used the quantitative method by using terminal data. To evaluate the handling capacity of the container's terminal several factors [9] need to be considered. Yard storage capacity is the dependent

variable of the number of ground slots (or otherwise the number of the containers footprint on the yard) stacking height and maximum utilization factor or coefficient. Yard maximum utilization factor varies from 60-80% in peak [10]. Other factors (independent variables) we must consider are dwell time which is the time the container stays in the yard from the day it arrives in and moves out of the yard. The longer container stays in the yard, the lower the yard capacity. Normally in Durres Containers' terminal dwell, time is about 8 days. The peak factor is the outcome of seasonal variations and the overall throughput of the terminal during a week. This factor varies from 1,2 to 1,5. In our case, we have considered the peak factor =1,2. Surge factor is observed during handling of loading/unloading operations. Normally the surge happens at the beginning of the unloading for the rate is higher and the terminal occupancy increases. It can be 1,5 - 1,2 depending on the unloading rate [11].

3.1. Discussion

Considering the volume of cargoes and the number of TEUs handled annually, Durre's container terminal is having steady growth. Because of this, terminal management decided to expand its original yard size, because the existing area of 64000m^2 was about to reach its limit. The terminal did not have enough storage space to face all the traffic. The handling capacity of the terminal with the original area size could be calculated by the following equation [12]:

$$\text{Yard Capacity} = \frac{TGS * MaxSTH * MaxUT}{Sf * Pf} * \frac{Days}{Dwt} \quad (1)$$

Where:
TGS = total ground slots
DWT = Dwell time of the containers
MaxSTH = maximum stacking height
MaxUt=maximum utilisation factor
Sf = surge factor
Pf = Peak factor
Days = working days of the year

In our case let's assume that dwell time is 8 days. The terminal is working 7/24 and there is no day off therefore the terminal works 365 days. There are 1234 TGS, max stacking height is 3,4 and average stacking is 0,8 the peak factor is 1,3, and surge factor is 1,2. [11]. If we make proper substitutions in the above equation (1), we have:

Observing annual volumes of the terminal [6], we realize that this value has been reached since 2013-2014, and ever since the annual overall TEU number handled by the terminal has been greater. Consequently, the terminal management has been forced to seek solutions for this area shortage. The terminal has hired additional areas from the adjacent terminal of the general cargoes. There are some 30000m^2 and that has made the TGS number to be

$$\text{Yard Capacity} = \frac{1234*3,4*0,8}{1,2*1,3} * \frac{365}{8} = 98166 \text{ TEU/year} \qquad (1)$$

increased and the maximum capacity the terminal can handle in the new conditions is about 180000 TEU/year.

Table 3 – *Regression statistics*

Regression Statistics				
R	0.95463	R-Squared	0.91131	Adjusted R-Squared
MSE	46,501,792.13911	S	6,819.22225	MAPE
Durbin-Watson (DW)	2.37265	Log likelihood	-101.34867	
Akaike inf. criterion (AIC)	20.66973	AICc	20.71973	
Schwarz criterion (BIC)	20.73025	Hannan-Quinn criterion (HQC)	20.60335	
PRESS	628,649,064.04527	PRESS RMSE	7,928.73927	Predicted R-Squared

ANOVA							
	d.f.	SS	MS	F	p-value		
Regression	1	3,822,482,049.7	3,822,482,049.1	82.20075	0.00002		
Residual	8	372,014,337.1	46,501,792.13				
Total	9	4,194,496,386.9					
	Coefficients	Std Err	LCL	UCL	t Stat	p-value	H0 (5%)
Intercept	-12,342,387.5	1,373,865.56	-15,510,527.1	-9,174,247.8	-8.98369	0.00002	Rejected
year	6,179.53347	681.58152	4,607.80366	7,751.26327	9.06646	0.00002	Rejected
T (5%)	2.30600						
LCL - Lower limit of the 95% confidence interval							
UCL - Upper limit of the 95% confidence interval							

This is a very temporary solution for the terminal because if we run a linear regression to make a simple forecast for the coming years it shows that the terminal is reaching this figure in less than three years (Figs. 7 and 8) [13]. Regression statistics show a strong correlation with an adjusted R square of 0.91131 which shows a very good correlation. The model is accepted because the p-value is 0,00002 and Ho is rejected.

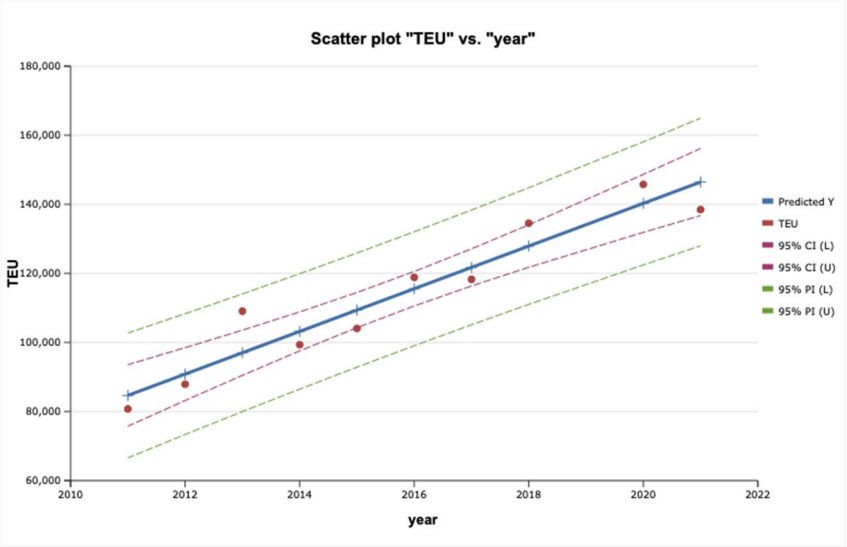


Fig. 7 – *Scatter plot*

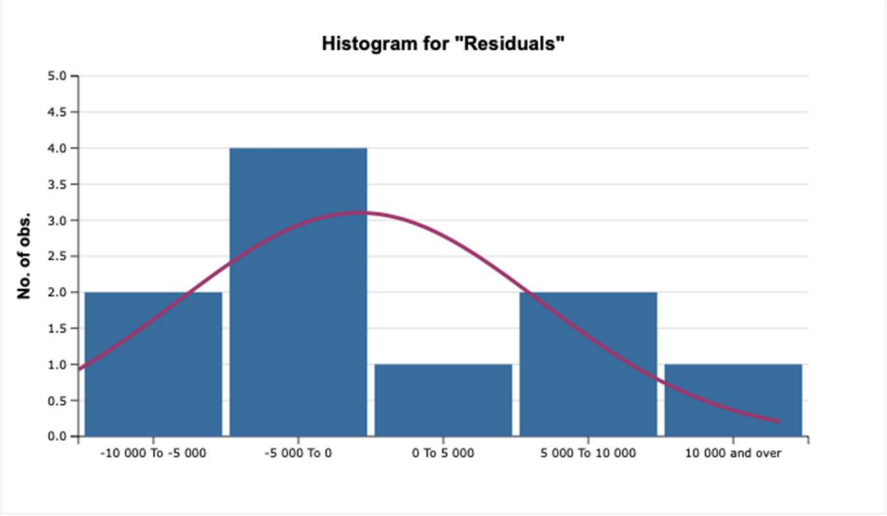


Fig. 8 – *Histogram for residuals*

The linear regression equation to calculate the volumes is as follows:

$$TEU = - 12\ 342\ 387{,}50849 + 6\ 179{,}53347 * year \quad (2)$$

Where - 12 342 387,50849 is the intercept, and 6 179,53347 is the slope and year is the period. According to this regression model [13], the output of 180000 TEU will be reached by the year 2025. The following Fig. 9 shows the actual and forecasted TEU volumes for the 15 coming years retrieved from the above regression:

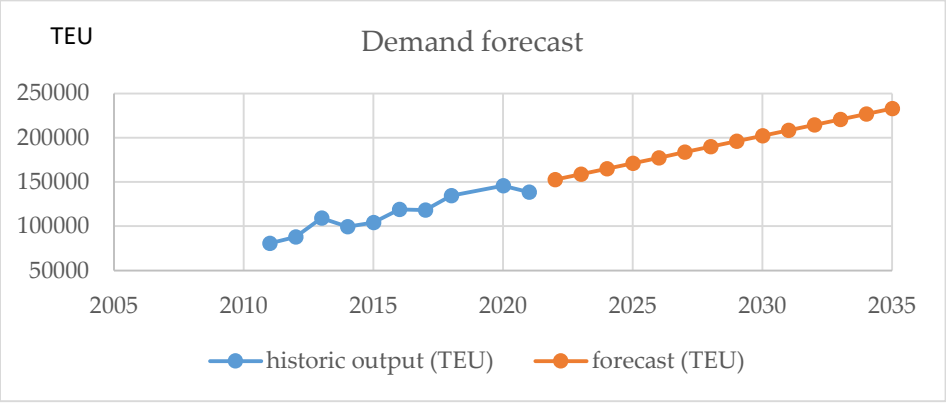


Fig. 9 – *Demand forecast*

4. Conclusions

This paper analyses the space issues of the Durres container terminal. This terminal is facing steady growing traffic and the terminal area is going to be insufficient to face the coming traffic. Investing in the same terminal is impossible for there is a lack of land for further expansion of the terminal [14]. Therefore, the terminal managers could think of dry terminals or distant yards to store the containers, but this will involve additional costs and will affect the productivity of the terminal because of the additional moves that the containers must undergo.

On the other hand, considering the navigational restrictions of that Durres's Bay, access channel, and port basin water depths, the expansion can go to a certain limit, and the terminal could not get the advantage of the economy of scale because bigger ships will have difficulties on getting in the port and berth. Therefore, it is recommended that terminal management should evaluate the alternative of building a new terminal, with a proper storage

area, sufficient water depth, and proper connections with the intended hinterland.

References

[1] INSTAT. Albania in figures 2020. Retrieved from: http://www.instat.gov.al/media/8988/albania-in-figures-2020.pdf

[2] Teknomo, K. (2012). *AHP Tutorial online edition*. Retrieved from www.revoledu.com

[3] Stophord, M. (1997). *Maritime economivs SECOND EDITION.*

[4] UNCTAD. (2020). *eview of maritime transport .* UNCTAD.

[5] UNCTAD. (n.d.). *Review of maritime transport .* 2019: UNCTAD.

[6] DPA. (2021). Durres Port Authority Statistics Office. DPA.

[7] Port Economics retrieved from https://www.porteconomics.eu/top-15 container-ports-in-europe-in-2019-teu-volumes-and-growth-rates/

[8] https://www.statista.com/statistics/1183201/cargo-traffic-in-adriatic-sea-ports-by-type/

[9] Metalla O, K. E. (2020). Durres container terminal cargo demand analyses and reallocationof terminal. *International journal of advanced research Engineering and Technilogy*, 2215-2223.

[10] A disclosure of MCDM. (2012). *International series in operation research & management science*. J.C, S. Y. (2015). Design of system and operations in container terminal maritime logisics. *Erasmus University Rotterdam, the Netherlands*.

[11] Syfaaruddin, D. S. (2015). Evaluation of container terminal efficiency performance. Erasmus University of Rotterdam.

[12] Metalla O, K. A. (2015). Land area limitation of Durres Port Container's Terminal. *Global Journal of management and Business research; business conomics and commerce*.

[13] W Lee, Z. (2012). Multicriteria decision making in maritime studies and logistics. *International series in operational research & management science*.

[14] Metalla O, K. A. (IJRD). Container terminal and associating infrastructure. *Interdisciplinary Journal for Research and Development*.

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Original scientific paper

Anti-Shock Foundation of Naval Engines for Naval Vessels*

Andrzej Grzadziela, Marcin Kluczyk

Abstract: The foundation of engines for naval vessels ensures multi-axis stiffness values and optimal isolation of harmonic vibrations on all axes. Another factor is the shock impulses caused by the battle actions of the ships. Dynamic impulse loads result from underwater or surface detonation of sea mines, a hit by a missile or an artillery shell. Such an impact is a high-energy step impulse. The paper presents the problem of selecting the physical parameters of materials used for shock absorbers. The presented models of material properties enable the presentation of physical and mathematical shock absorbers models for both impulse and harmonic interactions.

Keywords: Shock absorber, Impact loads, Simulations.

1. Introduction

The use of shock absorbers in ship structures has quite a long history. Publications on the effects of underwater explosions and the methodology of testing resistance to impulse impacts appeared after World War II. An additional factor that significantly supported the research was the tests of nuclear weapons used in open sea waters. The effects of underwater shock waves (UNDEX effects) were the primary impulse for computational and simulation research. Unfortunately, the current defense standards, as well as STANAG do not provide information about calculation procedures but only about verifying the impact resistance (1). Published papers and industrial studies mainly focus on the issues of vibration damping and reduction of the hydroacoustic field (2). The small number of scientific publications on shock resistance does not fill the projected gap. N. Klatka conducted the last marine research in Poland in detonation wave identification in 1982, and it was continued by A. Grządziela and Szturomski from 2012 to 2020(3–7). The preliminary research results were the main impetus for detailed research on the UNDEX effect, including research on materials on shock absorbers for naval vessels.

*An earlier version of this paper was presented at the 1st Kotor International Maritime Conference – KIMC 2021, Kotor, Montenegro.

An underwater explosion is a process of sequential and parallel physical phenomena, leading to an imbalance of the system, which initially consists of the explosive and the liquid medium surrounding it. The process is accompanied by chemical and physical reactions, the release of a significant amount of heat, the formation of gaseous products and the emission of energy in a relatively short time. The first stage of the explosion process is the combustion reaction of the explosive, which results in a detonation wave constituting the surface of the discontinuity and combustion products in the form of gas. The detonation wave created as a result of chemical reactions spreads from the detonation centre to the surface of the gas bladder and transfers energy to the adjacent water molecules. The gas takes the form of a bubble and moves upward at a certain speed. Thus, it is called a gas bladder or gas ball. The front of this wave moves in the initial period of about 2.5 microseconds, at the detonation speed (6000 - 8000 m / s), and after a few milliseconds, it reaches the speed of sound in seawater (approx. 1500 m / s)(8).

The hull's response to the shock wave caused by an underwater explosion depends on whether it is a surface ship or submarine hull. Under the influence of the shock wave, the surface ships will move upwards in the direction perpendicular to the surface of the body of water (there will also be slight displacements in other directions). Submarines will respond to the pressure pulse by moving in the direction of the shockwave(9).

When the shock wave hits the hull, it takes over some of its energy, which is then transferred to the remaining elements of the hull (frames, decks, stringers, etc.). This energy propagates through the fuselage at a specific relative speed, releasing in the form of vibrating energy. For durability reasons, the element of the ship that is most susceptible to shock loading is the propulsion system, mainly the main engines due to their enormous mass.

The literature analysis shows extensive knowledge in the foundation field for engines and machines for marine vessels. Specialist companies offer chocking materials to create permanent cast-in-place machinery supports for all sizes and types of main engines and auxiliary machines(10). Publications indicate the need to ensure the suppression of harmonic vibrations, and selecting the suitable grade depends on the machinery's alignment requirements and the chock's average operating temperature. The presented solutions refer to the tolerated requirements in terms of static stress on a chock. The sum of the engine deadweight and the tension on all bolts, hardener ratio guide, and sometimes the calculations are presented(11).

The vibrations generated by the machine lead to various problems such as shortening the service life of engines through wear of parts and the transmission of these vibrations to other uninsulated adjacent structures, causing problems of noise and vibration transmission as well faster destruction of

electronic components. The stiffness of a rubber anti-vibration mount is constant for harmonic excitation, but it changes when a dynamic force is applied to it. This parameter depends on the architecture, the rubber mixture used and even the frequency of excitation.

Proper mounting of the marine gear and propulsion engine in the vessel, once aligned, is critical to maintaining good alignment and consequent smooth, quiet operation and warrants close attention. The marine gear/engine foundation is that part of the boat's structure that supports the propulsion machinery and holds it properly. It generally consists of two longitudinal rails – with liberal transverse bracing – which carry the gear/engine's weight, thrust force, torque reaction, and inertial loads of the gear/engine. It is good design practice to make the foundation support structure as long as possible. This helps to limit hull deflection by distributing the loads over more of the hull length. The entire foundation must be strong enough to withstand operational forces due to torque, thrust, pitching, rolling, and occasional grounding. Since no structure is ideally rigid, the foundation must have greater rigidity than the shaft line so that none of the components of the driveline is stressed beyond their limits when flexing of the hull occurs. Depending on the vessel's hull composition, foundation structures may be of metal (steel or aluminium), wood, or fibreglass.

Generally speaking, dynamic stiffness is always greater than static stiffness, so calculations based on static stiffness may lead to wrong conclusions. However, in some cases, it is possible to reach limits of dynamic stiffness, which are two and even three times greater than the static stiffnesses.

The different stiffnesses of pads for each axis make it possible to offer significant flexibility in the direction perpendicular to the engine's crankshaft. This provides more effective isolation from vibrations of all types of engines.

The marine anti-vibration mounts work correctly when loaded at their 60% load capacity. This way, the vibration isolators offer correct stiffness properties and accept additional harmonic loads without premature deterioration(12).

The foundations of main engines for warships are considered a dynamic system consisting of a machine, parallel antishock pads, a foundation frame, and a floating ship's hull. The presented system indicates the need to analyse the materials' influence as elastic and damping elements. Several materials are used for antishock absorbers in marine applications. Below are the most commonly used materials and their brief characteristics:

1. Natural rubber provides high absorption of harmonic vibrations, resistance to fatigue and attractive elasticity. Therefore, it is often the most recommended material for insulating vibrations because it has the highest

modulus of elasticity (the ability to return to its original form). The disadvantage of natural rubber is the lack of resistance to temperatures above 50 ° C and the sensitivity of chemicals, including saturated hydrocarbons. Nevertheless, this material is one of the most cost-effective polymers to be used in a dry bilge and an effective ventilation system. Mainly applicable in shock absorbers for enclosure gas turbines. Another disadvantage is its high elasticity to impulse interactions, which results in flexible couplings between the motor and the gear.

2. Neoprene has high tensile strength and abrasion resistance. Thus, its main advantage is working in environments with constant exposure to lubricating oil and fuel. It should be noted, however, that continuous contact with saturated hydrocarbons over time degrades the elastomer and changes its physical properties.

3. EPDM (ethylene propylene diene monomer) polymer is sometimes used for foundations in small boats as EPDM resilient parts can have low-temperature requirements and tear resistance. In addition, EPDM is used in cases involving exposure to UV radiation, e.g. for elements directly attached to the open deck. An advantage of EPDM is that it can be manufactured over a wide tensile strength/stiffness range.

4. Silicone rubber is rarely used due to its low tear and abrasion resistance. However, research is currently underway on modifying silicone rubber to increase its damping coefficient, which will increase its attractiveness as a material for shock absorbers.

In conclusion, the most commonly used materials for shock absorbers are rubber materials, mixtures of rubber with polymeric materials, and more and more recently, specialized polymeric materials. The use of rubber as a material for shock absorbers brings many benefits, the most important of which are:

- Provides excellent damping and energy absorption of harmonic vibrations and pulse shock.
- Excellent noise and vibration damping and heat dissipation as dissipation of damping energy.
- Provides stability with appropriate hardness and initial deflection,
- A wide range of elastomers with different characteristics are available.
- Long service life even under constant pressure, vibration or vibration.
- Resistant to oil, water, ozone and other harmful factors.

This paper shows the importance of testing materials used for shock absorbers. At high deformation rates, catalogue physical properties may bring results far from those predicted in the calculations. Furthermore, due to the possible resonance effect during a UNDEX event, knowledge of the stiffness

and damping of materials on shock absorbers may be crucial for maintaining the technical efficiency of engines.

2. Materials physical properties

Rubber or metal-rubber Vibro-isolators are relatively cheap, and it is this fact makes the most common. Rubber has both advantages and disadvantages. The most crucial benefit of rubber is, as already mentioned, the relatively high damping factor γ, much more significant than the factor characteristic for steel springs (γ ~ 0.005). In the case of rubber, the value of the damping coefficient γ depends primarily on the hardness of the rubber. Although it also depends on the frequency of forced vibrations, the average values of this coefficient can be made dependent on the Shore hardness, as shown in Fig. 1. The spring constant of a rubber Vibro-isolator also depends on the hardness of the rubber, but it changes with the static load in a non-linear manner. It defines the constant of elasticity as.

$$k = \frac{dQ}{dy}\ \frac{N}{m}; \tag{1}$$

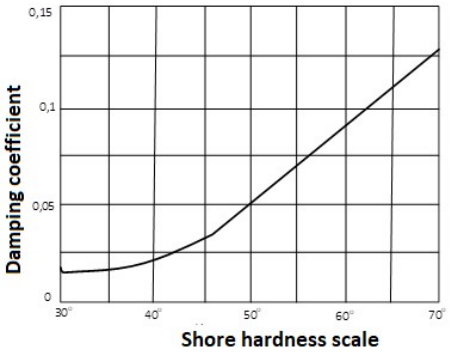

Fig. 1. *Diagram of dimensionless damping coefficient γ as a function of rubber hardness on the Shore scale*(13)

Figure 2 shows an example of the so-called complex characteristic, which consists of the fact that the value of k increases with increasing load. If the static load, expressed by the point Z0 or Z, does not exceed a specific value of Q, the characteristics of the Vibro-isolator can be treated as linear because k has a constant value in this load range.

But if the static load increases, e.g. to Q1, then the frequency of free vibrations of the system will be much higher because the value of k is then expressed as:

$$k' = \frac{Q_1}{\delta'}, \tag{2}$$

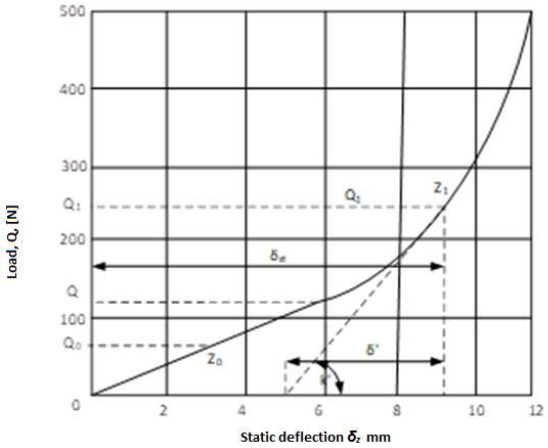

Fig. 2. *An example diagram of a nonlinear rubber characteristic*(13)

As the vibration amplitudes (dynamic displacements) are very small compared to the static deflection, changes in the dynamic load cause only a slight oscillation of the vibration isolator deflection in the vicinity of point Z1. The free vibration frequency of the system is then:

$$f' = \frac{0{,}5}{\sqrt{\delta'}} \text{ Hz} \tag{3}$$

and it is much greater than the ratio would suggest Q_1/δ_{st}.

Faultless calculation of the Vibro-isolator is possible only when the constructor has the appropriate experimental data. In general, the linear characteristic of a rubber Vibro-isolator can be assumed only when the static deflection δst is very small, i.e. it does not exceed 10% of the thickness (height) of the elastic element. Therefore, if not supported by relevant experimental data, the calculation of a rubber Vibro-isolator is only an approximate calculation. The biggest obstacle to obtaining accurate results is the discrepancy between the static and dynamic elastic modulus.

The dynamic modulus of rubber elasticity (and thus the active elasticity constant) is a function of the ingredients used in its production. For natural rubber, the dynamic to static modulus ratio varies within 1.2-1.4; for synthetic rubber, the ratio is 1.4-2.0. The free vibration frequency of the system, calculated taking into account the dynamic modulus, is, therefore, higher than the free vibration frequency calculated based on the static modulus. In

the calculations of Vibro-isolators, the ratio of static modules is assumed(14):

$$\frac{E_{st}}{G_{st}} \approx 6{,}5 \tag{4}$$

where: E_{st} - Young's modulus, i.e. the modulus of longitudinal elasticity, MPa,
G_{st} - Kirchhoff modulus, i.e. shear modulus, MPa.

The dependence of these modules on the hardness of the rubber is shown in Figures 3 and 4. However, it should be remembered that the actual values of the static modules may differ from the values read from the charts (up to ± 15%) because the properties of rubber are not uniform, even with the same hardness. The ratio of dynamic modulus to static v is usually taken as a constant value in practice; for soft rubbers with a hardness lower than 550 Sh, v - 1.25, and hard rubbers, i.e. above 550 Sh - v = 1.75, where:

$$v = \frac{G_d}{G_{st}} = \frac{E_d}{E_{st}} \tag{5}$$

The modulus ratio v varies almost linearly, as shown in Figure 5. Therefore, compliance with the measurement results obtained after installing the machine is possible only if the vibration isolators are mass-produced as standard elements, provided with appropriate characteristics; otherwise, verification by measurement is always necessary.

The most commonly used material for the construction of ship shock absorbers is rubber of various hardness. Rubber is one of the elastomers. The spring element for rubber should be connected to other shock absorber elements only on the load-bearing surfaces. In contrast, the remaining parts should be free so that the material can deform in different directions. Parts of a shock absorber made of rubber are most often combined with metal elements that enable correct assembly.

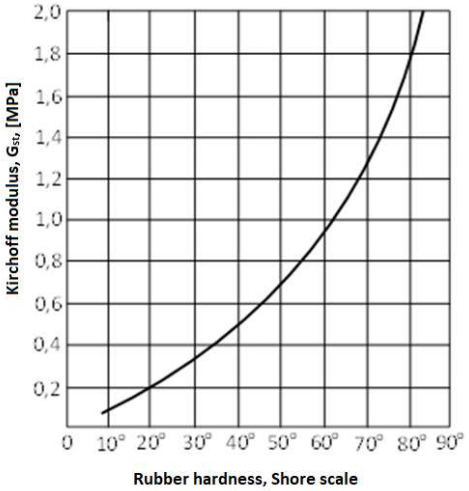

Fig. 3. *Diagram of the Kirchhoff static modulus as a function of rubber hardness*(13)

Such joints are made by the vulcanization method because the strength of the joint is practically equal to the strength of the rubber itself. The deflection of the shock absorber s under a statically loaded force F - see Figure 6, can be determined based on the formula:

$$s = \frac{4Fh}{E\pi d^2}\ ,m \tag{6}$$

To maintain the safety conditions concerning damage to the shock absorber and the correct functionality, shock absorber manufacturers use the following relationship:

$$s < 0{,}1h. \tag{7}$$

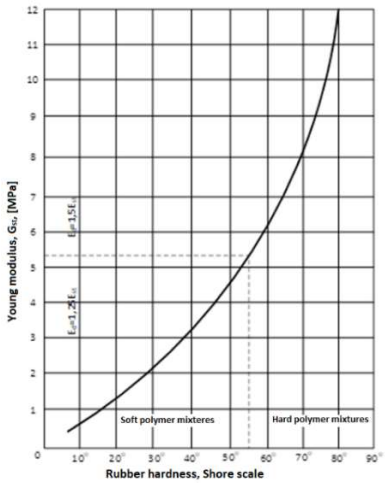

Fig. 4. *Diagram of the Young static modulus as a function of rubber hardness*(13)

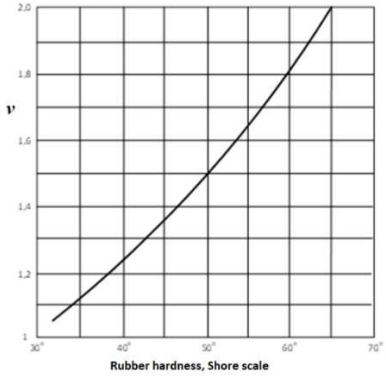

Fig. 5. *Diagram of the Ratio of dynamic to static modulus v as a function of rubber hardness* (13)

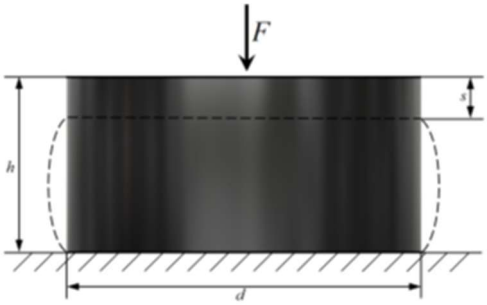

Fig. 6. *Shock absorber deflection under force F*(13).

For a given load is the maximum allowable force Fdop, the value of which should not be exceeded, also for safety reasons concerning damage. This force depends on the cross-sectional area of the shock absorber and the allowable stresses for the given rubber properties:

$$F_{dop} = \frac{\pi d^2}{4}\sigma_{dop}; \tag{8}$$

For a correct analytical solution of a rubber shock absorber, its shape coefficient k should be determined. This coefficient occurs where the dimension or shape of the loaded elements changes, where the stress distribution changes:

$$k = \frac{d}{4h_s}; \tag{9}$$

where: h_s - shock absorber height change in tension or compression.

As a result of the above analytical solutions for a rubber absorber, it is possible to determine the relationship between the calculated values - Young's Modulus, hardness according to the Shore scale and the shape factor.

3. Laboratory identification of the dynamic model forced with impulse load

Exemplary laboratory identification of a model of dynamic foundation of a ship engine loaded with an impulse from underwater detonation consists of three stages. The first part of the research on metal-rubber shock absorbers focused on four aspects, namely the measurement:

- deflection height,
- the height of the rebound.

The site's description is presented in Figure 7, and the research methodology is introduced in detail in the earlier publication of the Authors(13).

Two different shock absorbers were tested, all of them having the exact geometrical dimensions, i.e. cylinder diameter 20 mm and height 40 mm. In addition, five other materials were tested, each with three harnesses (55 Sha, 65 Sha, 75 Sha):

• NBR rubber, i.e. acrylonitrile-butadiene rubber.

• NR rubber (natural). Natural rubber is a flexible hydrocarbon polymer derived from latex. Latex is a milky colloid, the source of which is rubber trees.

The tests were carried out on the hammer drop machine shown in Figure 8. The mass of the falling element, including the mass of the shock absorber attached to it, was 2350 g. During the tests, vibration accelerations on the machine foundation were recorded using the BKSV 4514-B accelerometer. The analysis of vibration parameters was carried out in the Pulse Reflex environment. First, the height of deflections and rebound of shock absorbers were determined. Then, there were subjected to a free fall from a height of 300 and 450 mm. During the deflection distance and the height of reflection tests, a fast camera was used with automatic detection of the object in the frame and the image recording speed of 960 frames/second. Recorded movies were processed to obtain an image of the maximum deflection of the shock absorber or the full height of the reflection. A prepared measure was placed at the same distance from the camera lens as the falling shock absorber, which served as the distance standard for further processing. Thanks to the frame by frame processing of the images, it was also possible to determine the contact time of the shock absorber with the foundation of the drop hammer.

The next step in processing the images to determine the height of deflection and reflection was the cropping of the picture - Figure 9, to the width of the adopted distance standard for testing the deflection of shock absorbers, 100 mm was assumed, and for testing the height of rebound equal to 300 and 450 mm. In Autodesk Inventor, the prepared frame was inserted into the running sketch function as an image file.

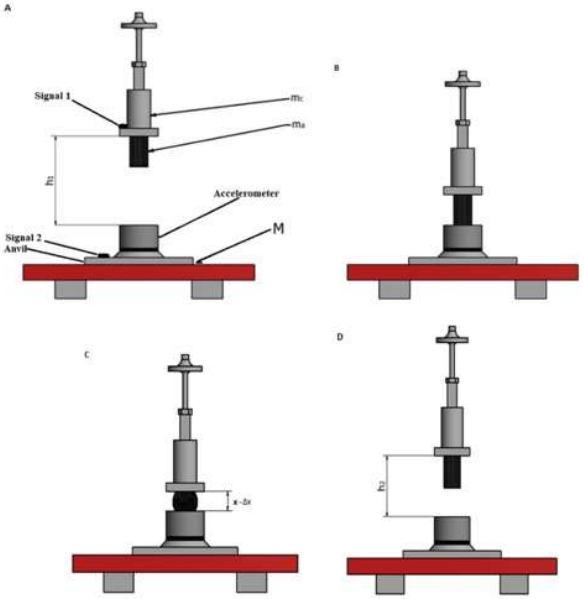

Fig. 7. *Diagrams of theoretical foundations for the conducted research*(13)

After giving it the assumed width of 100 mm, the scale 1: 1 was obtained, so the line drawn from the beginning to the end of the deflected shock absorber defined its deflection distance.

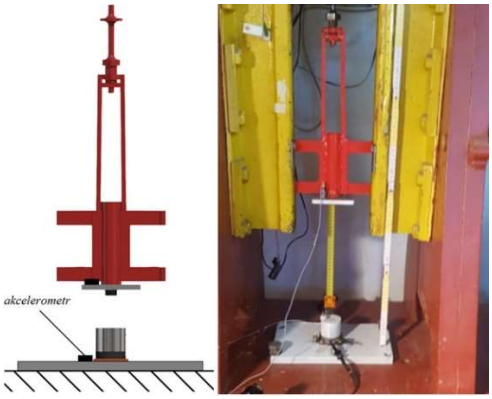

Fig. 8. *View of the drop hammer stand (right) and its virtual model (left).*

Fig. 9. *The maximum deflection of the shock absorber as read during post-processing*

The maximum deflection values of metal-rubber shock absorbers made of two different materials with three stiffnesses obtained during the tests are shown in Table 1.

Table 1. *The maximum values of deflection of shock absorbers were obtained during tests on the stand*

Material Sh A	***Test 1 : 300 mm Deflection [mm]***	***Test 2: 300 mm Deflection [mm]***	***Test 3 : 450 mm Deflection [mm]***	***Test 4: 450 mm Deflection [mm]***
NBR 55	25,4	25,7	22,8	23,1
NBR 65	27,6	26,7	24,3	24,2
NBR 75	31,9	32,0	30,9	27,1
NR 55	22,3	21,8	19,0	19,1
NR 65	22,6	22,8	20,5	20,4
NR 75	27,3	26,7	24,1	23,4

Tests were performed for both materials types. The dependence of more significant deflection in the case of lower stiffness expressed in the Shore A scale is visible here.

Table 2. *The maximum rebound values of shock absorbers were obtained during the tests.*

Material Sh A	***Free fall height [mm]***	***Rebound height [mm]***			***Average reflection height [mm]***
NBR 55	300	152	153	152	152
	450	214	213	217	215
NBR 65	300	125	124	126	125
	450	175	178	179	177
NBR 75	300	96	97	97	97
	450	130	139	141	137
NR 55	300	164	166	168	166
	450	213	247	251	237
NR 65	300	145	166	162	158
	450	230	234	245	236
NR 75	300	141	145	143	143
	450	175	202	209	195

This dependence occurs for all tested materials. The data collected in Table 1 also shows significant changes in the height of the shock absorber deflection depending on the material used.

The data presented in Table 2, shows a strong relationship between the stiffness of the material and the height of the rebound. The lower the stiffness of the material, the greater the rebound height, which clearly shows that the dissipation of the impact energy in the case of lower Shore stiffness of the material reaches smaller values.

The presented research results indicate the need for an individual adjustment of the shock absorber to dampen impulse loads. Catalogue selection of shock absorbers makes sense when the machine will be loaded only with harmonic interactions that require analysis in terms of fatigue and/or environmental wear.

4. Conclusion

The use of shock absorbers for the foundation of main engines on warships imposes additional technical requirements to suppress harmonics and shock loads. The conducted tests confirmed the necessity to carry out individual verification procedures of materials used in shock absorbers. The research results indicate that the essential factor for protecting against a shock impact is the damping factor, which determines the dissipated elastic energy. As a result, the main engine is not too displaced from the working position on the foundation. There is also a contradiction of the expected damping and deformation; hence the choice of shock absorbers is a computational process and the optimization of allowable deformations. However, selecting the shock absorber and its configuration in the foundation based on catalogues will result in a very high risk for the engines. It is caused in terms of resonance and the lack of resistance to the effects of UNDEX (Underwater Explosion).

The presented tests should be verified by SRS (Shock Response Spectrum) tests and the analysis of changes in physical parameters as a function of fatigue loads(15). The last two factors are currently being researched and analysed, which will be presented shortly in the following Authors publication.

Another factor confirming the need for a precise method of calculating shock absorbers is the need to reduce the physical fields by naval vessels. Warships in the design and operation phase are tested on test ranges to assess the hydroacoustic field emissions from the lower hemisphere to the marine environment. The primary source of emission is the ship's propeller, the emission of which has components from the propeller geometry and structure and vibration energy transmitted through the shaft line from the main engine. Correct installation of the engine also reduces the acoustic emission from the foundation through the hull to the water.

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References

1. Deshpande VS, Heaver A, Fleck NA. An underwater shock simulator. Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences. 2006;462(2067).
2. Cao L, Fei W, Grosshans H, Cao N. Simulation of Underwater Explosions initiated by high-pressure gas bubbles of various initial shapes. Applied Sciences (Switzerland). 2017;7(9).
3. Grządziela A. Model of impact underwater detonation. Journal of KONES Powertrain and Transport. 2015;19(2).
4. Grządziela A. Modeling the effects of underwater detonation wave. Vol. 588, Key Engineering Materials. 2014.
5. Grzadziela A, Muslewski Ł. High quality simulation of the effects of underwater detonation impact. Journal of Vibroengineering. 2013;15(1).
6. Grzadziela A, Szturomski B. Impact modeling of underwater explosion. In: Solid State Phenomena. 2013.
7. Grzadziela A, Szturomski B. Impact modeling of underwater explosion. Vol. 196, Solid State Phenomena. 2013.
8. Spence JH, Fischer RW. Requirements for Reducing Underwater Noise from Ships. Vol. 42, IEEE Journal of Oceanic Engineering. 2017.
9. Guiping C, Deping H, Guangji S. Underwater sound absorption property of porous aluminum. Colloids and Surfaces A: Physicochemical and Engineering Aspects. 2001;179(1–3).
10. Park IK, Kim JC, An CW, Cho DS. Measurement of naval ship responses to underwater explosion shock loadings. Shock and Vibration. 2003;10(5–6).
11. Cordes JA, Vo P, Lee JR, Geissler DW, Metz JD, Troast DC, et al. Comparison of shock response spectrum for different gun tests. Shock and Vibration. 2013;20(3).
12. Grządziela A, Kluczyk M. Preliminary calculations for minehunter's genset foundations. Transactions on Maritime Science. 2019;
13. Grzadziela A, Kluczyk M. Shock absorbers damping characteristics by lightweight drop hammer test for naval machines. Materials. 2021;14(4).
14. Grządziela A, Kluczyk M. The impact estimation of damping foundations in dynamics of the rotor system. Diagnostyka. 2017;18(3).

15. Snowdon JC, Jones DIG. Vibration and Shock in Damped Mechanical Systems. Journal of Applied Mechanics. 1969;36(2).

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A Discourse Analysis Approach to Email Communication on Ships*

Milena Dževerdanović-Pejović

Abstract: Emails have become an inevitable communication tool in a specific professional environment such as a ship. Changes that arose due to data digitalization, automatization and advances in communication systems have expanded the scope of internal and external ship business correspondence. Nevertheless, the structure of an email as a genre in seafaring has adapted to generic schemata in online communication and ship-specific communicative standards. Based on the genre analysis theories put forward by Swales and Bhatia, we analyse a corpus of emails collected from five foreign companies (100 pages of text). Then, the collected data were explained and interpreted concerning the contextual setting, primarily participants and their role in the given shipboard situation. The findings of this paper have pedagogical implications for creating teaching material for present and future ESP courses and introducing the concept of genre in establishing communication patterns in email correspondence on ships.

Keywords: Email communication, Ship, Genre analysis**,** Maritime discourse community

1. Introduction

Ship as an independent business unit has many genres related to correspondence which has been adapting to the changes in maritime affairs. The corpus of this paper comprises emails in the English language making 100 pages of text. These emails present external written communication, which was classified into two types: ingoing and outgoing correspondence. This kind of correspondence usually takes place between ship captains and other participants such as agents, charterers, port authorities or other parties. Keeping in mind the role of the master as the most responsible person on board the ship, we find that the corpus is representative and includes important aspects of the ship's commercial correspondence. The analysis of the structure and content of an email as a genre relies on the moves and step model set forward by Bhatia [1], Swales [2] and Lakić [3]. The aim of the

*An earlier version of this paper was presented at the 1st Kotor International Maritime Conference – KIMC 2021, Kotor, Montenegro.

paper is to point out how email reflects specific communicative purposes of the seafaring discourse community.

2. The concept of genre in a maritime setting

The need to identify recurrent language patterns, and the demand for specialized, professional and tailor-made courses in English for Specific Purposes (ESP), encouraged the research into language science through needs analysis, discourse and genre analysis. The concept of the genre has come from the study of literary genres to the studies of language, intending to study the recognizable structure and content of various types of communications used among members of a professional community. However, the study of genre in linguistics was heavily dependent on the context or pragmatic setting in which it is embedded. In order to know why specific texts are written in the way they are, we need to combine social, cultural and psychological aspects with linguistic knowledge [1]. The main feature of a genre is *its communicative purpose,* and the basic concept used in the language science regarding genres is a *discourse community*. *The discourse community* gathers the members that use a specific genre (be it a verbal or written genre) with the aim to obtain their *communicative goals* [2].

In the maritime discourse community, types of discourses and their genre features have been adapting to the communication needs of the shipping business. As the adjective 'maritime' refers to various marine and maritime-related activities, we assume that 'maritime discourse community' comprises many discourse communities. Depending on how the information is expressed, communication is categorized into verbal and written communication. In that light, a significant part of maritime communication goes to verbal VHF communication connecting many members of a maritime discourse community (VTS communication, ship-to-ship VHF communications) [4]. All these types of communicative activities utilize patterns of communication characteristic of a distinctive genre (such as the use of the nautical alphabet in VHF communication). In addition, communication about the berth includes many participants sharing their knowledge about the mooring ropes, activities and shore communication carried out during ship arrival or departure. Therefore, it can be said that verbal communication is somewhat more flexible and informal to a certain extent. Still, it does not relieve the participants from the responsibility for what they said and how they interpreted verbal statements (especially considering standardized communication and the normative languages such as the Standard Marine Communication Phrases). Email communication has replaced many written genres in shipping (conventional letter, telex) and has become a common means of written correspondence. It presents a reliable, fast and economical way to

communicate the message and can be used in private and official communications [4]. Different genres such as shipping contracts, Bill of Lading, Charter Party, check lists, company guidelines, forms, reports, crew contracts, warnings to shipping, and circular safety messages have long ago become digital genres and obtained the prefix e– (electronic).

3. Method and Corpus

As said, the corpus of our paper consists of 100 pages of text obtained by the ship's masters sailing on foreign shipping companies. The material is divided into inward and outward communication: emails received and emails sent. We observed that ship's masters documented this communication in their computers, separated into different files, marked as 'ingoing' and 'outgoing' correspondence.

After reading the texts, we found that the most significant part of the commercial correspondence is carried out by email. The topics and participants in the emails vary from informal to formal. Everyday correspondence refers to greetings and personal letters. In contrast, the formal correspondence includes notifications on the ships' arrivals/departure, embarkation or disembarkation of the crew, claims, masters reports (damage to ship, activities on ship).

We shall present some typical structural features of email communication on board ships using the above-mentioned *move* and *step* model. To analyse the language material, we used the *WordSmith Tools 5.0* [5]. In addition to analysing syntactic, morphological and lexical features, we shall provide a qualitative analysis, i.e., an interpretation of participants' use of the linguistic means. For example, Figure 1 shows different participants involved in shipping business communication connected by email as a genre.

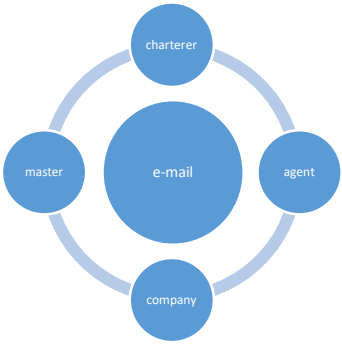

Fig.1 – *Some participants in ship's business using email*

4. Method and Corpus

In this part of the paper, we shall first present the email structure and then analyze each identified move.

A. The structure of emails in the shipping correspondence

The corpus analysis revealed that the structure of emails in shipping communications, to a great extent, follows the pattern of a business email. For example, the average length of emails is three to ten lines. The four identified moves are given in Table 1:

Table 1 – *The structure of emails in the shipping correspondence*

Move 1	Salutation
Move 2	Introductory phrases
Move 3	The body of the email
Move 4	The complimentary close

*Move 1***–** *Salutation*

The analysis revealed that out of 413 incoming emails, the salutation starts with *'Dear Captain'*. In addition, it was found that formal addressing (by surname) was found in 102 examples '*Dear Mr Smith'* whereas the introduction e.g. *"Dear Mr Smith"* was found in 54 instances.

In the outgoing correspondence in which the captain addresses the agent, charterer, port or consular authorities, the most common way of starting an email is with an informal *'Good day',* as presented in Table 2.

Table 2 – *The phrase 'Good day' in maritime correspondence* [4]

15	Dear Mr. K. **Good day. This is to confirm**
16	report attached. With many thanks. **Good day, Please be informed**
17	Radczyc on 04th of December. **Good day Please confirm that**
18	Shipping - TM, PM Dear Sirs **Good day You are kindly informed**
19	**Good day This is to confirm that..**
20	04-June-2012.With many thanks. **Good day, Your message well noted**
21	With many thanks Regards **Good day, Please be advised**
22	ailed report. With many thanks **Good Day, We have completed**
23	e belonged to me. Best regards **Good day, Please be informed**
24	Requisitions. With many thanks. **Good day, I am sorry**. I had
25	nd attached. With many thanks. **Good Day**, **Please be informed**
26	for us. Dear Captain P. **Good day. This is to confirm**

Move 2– Introductory phrases

Regarding the introductory phrases characteristic of the correspondence analyzed in our paper, we find that the authors of emails do not, to a large extent, utilize conventional phrases characteristic of the shipping business. Instead, they immediately move on to the core of the problem. Thus, the most elicited examples ensuing the informal salutation *'Good day'* are: *'Please be informed that...', 'Please be advised that...'*, '*You are kindly informed that...', 'This is to confirm that...', 'Your message well noted'.* Concerning the incoming emails in which the captain is asked or notified about something, out of 130 analysed introductions, 68 examples contain: '*You are kindly requested'*. The polite introduction *'Please ...' is found in 38 instances and 'Thank you'* in 24:

(1) ***You are kindly requested*** *to hand over to Mr Carlston.*
(2*)* ***You are kindly requested*** *to resend as extract from ship accounting programme as excel sheet.*
(3) ***Please find*** *attached bank letter for 2/O Car as requested.*
(4) ***FYI pls find*** *my mail to Mr. Firth below.*
(5) ***Please kindly be noted*** *that the quarantine officer will be on board upon yr good vessel for inspection.*
(6)***Thank you*** *for your 2 messages dated 28/10, explanation much appreciated.*

Move 3 – The body of the email

The main communicative aim of the correspondence in maritime shipping is the precision of information. Excluding abbreviations, collocations and maritime register terms, the analysis has revealed that the texts are organized, and that tone and style are adapted to a discourse of commercial correspondence. However, in order to correctly interpret emails, it is necessary to have knowledge of the world or an understanding of the context [6].

It would be impossible to classify emails according to their content as navigation and discourse types change. In this light, companies' rules concerning the possibility of sending emails change and affect the shaping of texts in terms of language. This can be explained by the fact that some ships impose restrictions on the number of allowed emails per day, as they can impede the performance of other automated information and communication networks on ships. In addition, we must bear in mind digitalization and the tendency to facilitate ship-to-shore communication [7].

B. The content of an email

The content of emails in maritime correspondence is becoming more and more diverse. The fact is that e-correspondence enables an instantaneous flow of information and effective communications between ships and their parent company. By email, ships can send new notifications and circular letters usually sent by company management containing information on novelties in the company's administration or any other valuable notices. In addition, the so-called circular letters (fleet letters) sent to fleets regarding the topics such as safe routes and safety of navigation are regularly sent in electronic form. We shall illustrate an example of the email in which a company notifies the ship of the new measures aimed at protecting fleets from pirate attacks in the bay of Aden and the master's answer accordingly:

(7) *Captain,*
Further to 26/08/08 decision, the coalition force (USA, France, UK, Canada) has settled a maritime secured corridor in the Golf of Aden in order to assist as much as possible in case of piracy act. When navigating in the Golf of Aden please use this corridor.
Best regards,
Capt. A. P.

What follows is the captain's answer. The answer is brief and contains the already noted elements of standard email communication (Good day, This is to…).

(8) *Dear Captain Pazdzioch,*
Good day,
This is to confirm the safe receipt of your message and attachment Maritime Security Advisory - 02/2007 "Significant Threats to Golf of Aden Navigation: 2008". Many thanks.
We should follow strictly these instructions and will instruct the crew accordingly.
Captain

A crucial aspect of ships' communication, as already said, deals with operational messages [4]. Operational correspondence encompasses different correspondents, such as ship masters, shippers, port authorities, carriers, agents, and refers to 'operational' procedures such as ship's arrival/departure, transition through a channel, berthing, anchoring, and cargo stowage. We evidenced about 145 'operative' emails in our corpus. They are short and look like service emails, and emails aiming to speed up service procedures

(order confirmation, postponement, scheduling, feedback, and email receipt). From a syntactic angle, these emails are short and employ abbreviations, such as in the following examples:

(9) *Good day,*

Yr message well noted. Please be informed:
ETA Yantian is 1930 LT 03/08 Pilot Station.
ETB Yantian is 20:30 LT 03/08.
ETD Yantian 07:30 LT04/08.
If there are no changes whilst port stay in Yantian our best ETB for Hong Kong is around 13:00 LT 04/08. I will receive the schedule for Hong Kong after berthing in Yantian and you will be informed immediately.
Regards,
Master of HS Bizet

Some examples of communication in our corpus refer to crew members signing on or signing off the vessel. Therefore, we also focused on analysing the syntactic and lexical features of this part.

Communication about signing on/off crew members

About fifty emails from our corpus refer to the embarkation and disembarkation of crew members. This requires much paperwork and email correspondence from arranging the embarkation port, flight tickets, payments, health certificates to visa admissions.

(10) *Dear Captain,*

You are kindly requested to send the necessary invitation letter for arranging Chinese entry visa for ***joiner*** *as the on-signer is of Serbian & Montenegrin nationality.*

(11) *Good day,*

Onsigners *joined in Panama and* ***offsigners*** *left. Could you please advise Christmas bonus for* ***onsigners****?*
There is an evident tendency to convert the existing lexical units (conversion refers to making a new word class using an existing word), as shown in Table 3.

Table 3 – *Examples of conversion*

Verb	**Noun**
to sign on	On-signer
to relieve	Reliever
to sign off	Off-signer
to join	Joiner
to hand over	Handover (time)
Verb	**Adjective**
to join	Joining (officer)
to embark	Embarking (chief)
to disembark	Disembarking (mate)
to leave	Leaving (cadet)
to depart	Departing (crew member)

As shown in the table above, there are many conversion examples in the terminology about the crew change. The terms from general language are used to get a specific meaning. As we can see, the suffixation, such as the prefix – 'on' in *on-signer*, is prevalent in forming new, abbreviated forms. In this way, *on-signer, off-signer* and *joiner* denote crew members signing on/signing off/joining the vessel. The suffix –*er* is also used to indicate a person doing some activity as *in-joiner, reliever*, and *on-signer and off-signer* (double affixation). Some instances of abbreviations used to refer to crew members rankings are C/E (Chief Engineer), 2nd Eng. (Second Engineer), C/O (Chief Officer), and double forms such as E/E and El/E (Electrical Engineer), 3/Off and 3/O (Third Officer). Therefore, to understand the meaning of abbreviations in a specific setting, the employees in the shipping industry have to grasp and learn the related abbreviations pertaining to their professional background [8]. Other instances of abbreviations are those already established in business correspondence such as *pls (please), tks/tnks (thanks), yr (your), asap* (*as soon as possible*), *abv (above)*, *rcvd (received)*, *LT (local time)*, *asf (as follows)*, and those belonging to maritime and/or aviation register such as *(ETA- estimated time of arrival)*, *(ETB - estimated time of berth)*, *(ETD - estimated time of departure)*. Abbreviations in a technical and specialized language develop quickly and it is hard to evidence them. In that sense, there is a thin line between standard and non-standard forms of abbreviation and acronyms. Also, what seems to be a standard acronym in one register may be a non-standard in the other [4].

Table 4 – *Examples of abbreviations in emails*

Abbreviation	Full form (Standardized-S, Non standardized - NS)
OS	Ordinary seaman (S)
AB	Able-bodied seaman (S)
Recvd, rcvd	Received (NS)
arrvl	Arrival (NS)
Av	Average (S)
asf	As follows (NS)
e'ward	Eastward (S)
LT	Local time (S)

Move 4 – The complimentary close

This specific maritime correspondence segment is present in most of the analysed emails. The examples of a standard ending that we detected in the above text are: *'Thank you', 'Thanks for your kind assistance', 'With many thanks', 'Thank you for your cooperation'*. However, it is noticeable that some standard endings prevalent in standard business emails such as '*Yours sincerely', 'Yours faithfully'* are found only in a few instances. Instead, ship masters prefer using '*Best regards',* more precisely, its abbreviated form '*Brgds'*. We assume that this ending is taken from telex.

5. Conclusion

A genre analysis approach enables us to reveal specific characteristics of a genre embedded in a particular setting. For example, email as a genre in the maritime discourse community has taken over the conventional structural form of the traditional email. However, these changes have to be considered within a larger context and changes in global shipping. Namely, the globalization of discourse and the tendency to achieve efficient communication affected the choice of genre. In addition, modern information technologies enable ships to connect with shore-based computers and instantly send a large quantity of data. Thus, operational and service emails, manuals, fleet and circular letters are sent via email.

However, the language features of an email, most noticeable on a semantic level, differ from other commercial emails. In order to interpret a message correctly, the participants have to be familiar with 'the rules' of that particular genre. Regarding the changes in maritime business and the tendency to achieve the economy of discourse, we may expect that the email in shipping may be expected to take a more shortened format in the future. In that sense,

a genre analysis approach in exploring maritime written genres requires continuous research of the changes in maritime professional setting and co-operation with subject experts from the maritime field, which can be further applied in teaching specific maritime genres [9]. We believe that the genre analysis approach applied in this paper will inspire other scholars to discover recurrent features of different written or verbal maritime genres.

References

[1] V. K. Bhatia, Analysing Genre*:* Language Use in Professional Settings*.* London: Longman, 1993.

[2] J. Swales. Genre Analysis: English in Academic and Research Settings. Cambridge: Cambridge University Press, 1990.

[3] I. Lakić, "Genre Analysis of Article Introductions in Economics." Asp: la revue de GERAS 15–18 (1997): pp. 409–426. Accessed March 15, 2015.

[4] M. Dževerdanović-Pejović, "Types of discourses and genre features in the maritime communication". Doctoral dissertation [Tipovi diskursa i žanrovska obilježja u pomorskoj komunikaciji]. Belgrade, Faculty of Philology, 2012.

[5] M. Scott, WordSmith Tools, Oxford: Oxford University Press, 1996.

[6] M. A. AlAfnan, "Critical Perspective to Genre Analysis: Intertextuality and Interdiscursivity in Electronic Mail Communication", Advances in Journalism and Communication, vol. 5, no. 1, pp. 23-49, 2017.

[7] Convention on Facilitation of International Maritime Traffic, 1965, as Amended: Including the Explanatory Manual to the Convention. London: International Maritime Organization, 2011.

[8] Z. Yang "Abbreviations in Maritime English", English Language Teaching, vol. 4, no. 1, 2011.

[9] M. Dževerdanović-Pejović "Learning technical genres – a blended learning approach". Scientific Journal of Maritime Research vol. 34, pp. 212–222, 2020.

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Hybrid Twinning on Marine Engine Simulators*

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Abstract: The notion of twinning can refer to a number of things. Here, however, we refer to the specific recommendation by the IMO Model Course 3.17 – Maritime English, as also discussed by a number of recognized Maritime English instructors, anticipating the teaming of English teachers with teachers of technical subjects held on marine simulators. This recommendation coincides with contemporary trends in teaching English for Specific Purposes, such as Content-Based Instruction, Content and Language Integrated Learning and/or English as a Medium of Instruction. In particular, we provide specific examples of hybrid twinning classes conducted on marine engine simulators at the Faculty of Maritime Studies Kotor, University of Montenegro. Additional possibilities and pedagogical implications of the presented and related activities are also offered. We hope they can be of assistance and inspiration to other teachers involved in maritime education for upgrading their teaching methodologies as it has been the case with the authors.

Keywords: Twinning, Maritime English, Engine room simulator, Online/hybrid teaching.

1. Introduction

The ever-demanding position and role of teachers are at special test today. In addition to constant professional training, they need to keep up with modern teaching methodologies and technical opportunities and requirements. On top of those, we have had a new hybrid teaching environment where blended formats has become a necessity.

When it comes to the teachers of English for Special Purposes (ESP), the main guiding line should be the professional needs and requirements for their language learners [1][2][3]. These would be the main specifics of ESP instruction compared to that of General English (GE), often requiring the application of combined (advanced) teaching methodologies. Even within Maritime English, a distinction is made between General Maritime English and Specialized Maritime English [4], i.e. English for Deck Officers, Engineering

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Officers, and Electrotechnical Officers. Moreover, Maritime English has a variety of language branches comprising distinctive genres and registers to cover various maritime professional and communicative purposes, such as maritime law, shipbuilding, vessel traffic services and many more [5].

Having in mind numerous multicultural complements onboard world fleets and the importance of proper communicative performance among the members of this specific professional discourse community, maritime language skills have been in special focus of both the maritime community and maritime English teachers. This paper aims to present a practical way of incorporating the aforementioned aspects through a contemporary recommendation for the Maritime English (ME) teaching called twinning.

2. Modern Trends in ESP teaching

The specific features of ESP teaching are also reflected in the interaction between teacher and student, i.e. instructor and language learner. This type of language classes should always be closely related to the professional discipline and discourse community it is meant for. Not rarely, the language teacher can take the role of merely a "language consultant" [6]. Considering the specifics of Maritime English, there have even been suggestions for the standardization of certain professional competencies, the process known as "marination", according to which the ME teachers would spend a certain period onboard, even obtain some basic Certificates of Competences. This would provide them with a better insight into the profession, as well as better authority in the maritime community and among the language learners [7].

3. Twinning

The notion of twinning can refer to various types of joint and coordinated activities, such as, for example, of peer institutions for a mutual purpose and benefit in terms of expertise, performance or funding. Another aspect anticipates two teachers or instructors, with various perceptions on the possible team members [8][9]. One of the possibilities is to have two language teachers working together, which is generally considered more appropriate for primary and secondary school students [10] [11] [12] [13].

In this paper, we refer to combined classes taught by the team of a language teacher and professional instructor, as suggested for modern ESP instruction [14][15][9][16]. In particular, we refer to twinning as a contemporary ESP trend in ME anticipating the team teaching or co-teaching of language and simulator classes. As it is generally the case with education for seafarers, some guidelines and requirements are provided by the Interna-

tional Maritime Organization and its international convention on the Standards of Training, Certification and Watchkeeping for Seafarers (STCW), with more detail and recommendation given by the Model Course 3.17 – Maritime English [4]. Following those, some of the leading researchers in Maritime English instruction have also been pointing to the importance of teaming up teacher(s) of English for Maritime Purposes (EMP) with teacher(s) of technical subjects on marine engineering simulators [17]. In this paper, we are providing practical examples, implications and possibilities of its application which would also fulfil some of the most contemporary ESP trends such as Content-Based Instruction (CBI), English-medium Instruction (EMI) and Content and Language Integrated Learning (CLIL)(Fig.1).

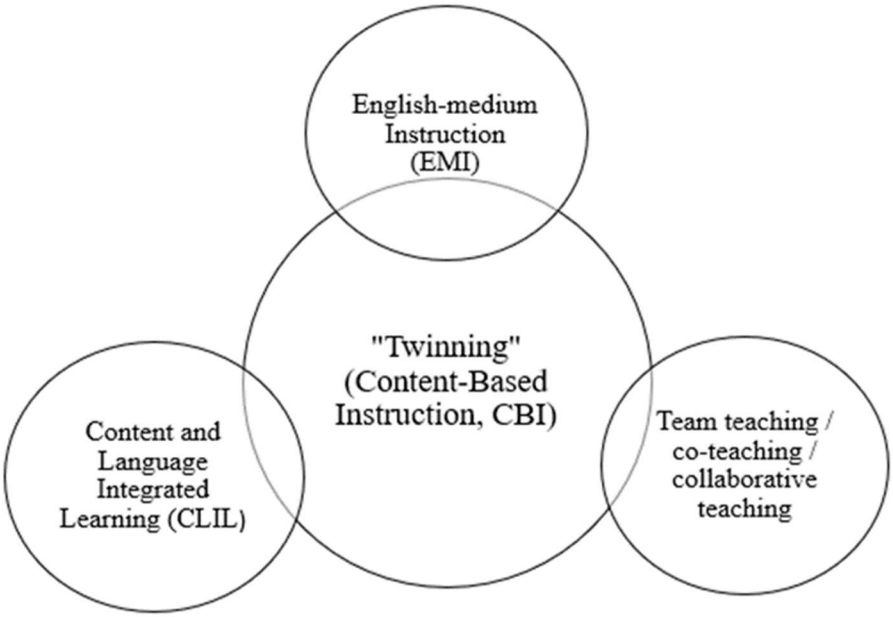

Fig. 1 – *Modern approach to ESP and ME teaching [18]*

4. Twinning on Marine Engine Simulators

The twinning activities have been conducted with second-year students of Marine Engineering and Marine Electrical Engineering study programmes at the Wärtsilä Engine Room Simulator compliant with international standards and regulations such as STCW 2010 Convention and Code, ISM Code, relevant IMO Model Courses and Conventions. Due to the pandemic restrictions in the past two years, this interactive activity was designed to be held in the online format through the Zoom application, which provides it with another important implication in terms of the imposed hybrid teaching environment and all its challenges. During these classes, the technical teacher in charge of simulator classes operates the simulator, whereas the

students give instructions and explanations as coordinated by both the English and technical teacher. In this way, in addition to acquiring and applying knowledge and skills through a technical subject, the students acquire and practice their language skills as tools that help them expand their professional views and perspectives and exchange professional activities and concepts [19].

Moreover, the teachers themselves greatly benefit from the preparation and conducting of twinning classes. Language instructors get more and better familiarized with the profession, while the teachers of technical subjects have the opportunity to improve their own English skills and possibly correct some of the "broken" English they have been using or could have incorrectly acquired during their onboard service or otherwise.

The twinning classes conducted at the Faculty of Maritime Studies in Kotor so far have been primarily review and experimental classes. Their purpose was to review the gained knowledge from both subjects and practice productive language skills. For example, texts on marine boiler design and operation are a part of the language syllabus, but are also an important area of technical subjects, even a subject per se. One of the twinning classes was therefore dedicated to boiler monitoring and control system (Fig. 2). Another example would be starting the generators and electrical systems, monitoring and responding to possible errors and faults (Fig. 3). Similar classes are organized in relation to other marine systems and possible onboard situations and activities, such as, for example, fire-fighting. The special advantage of these classes is that they comprise, test and broaden the acquired technical and language knowledge from a series of units previously taught. For example, when operating the fuel system, it is interconnected with the main engine, diesel generators, boilers, comprising pumping and separation systems, valves, alarms, monitoring systems and similar. Also, a lot of the teaching materials overlap between the two study programmes mentioned, thus both classes can attend online at the same time and can interact and simulate the cooperation and interdependence during onboard activities and situations. Considering that in regular circumstances different classes are not usually put together, and the number of students to attend the simulator stations is limited, this would be an advantage of online teaching formats.

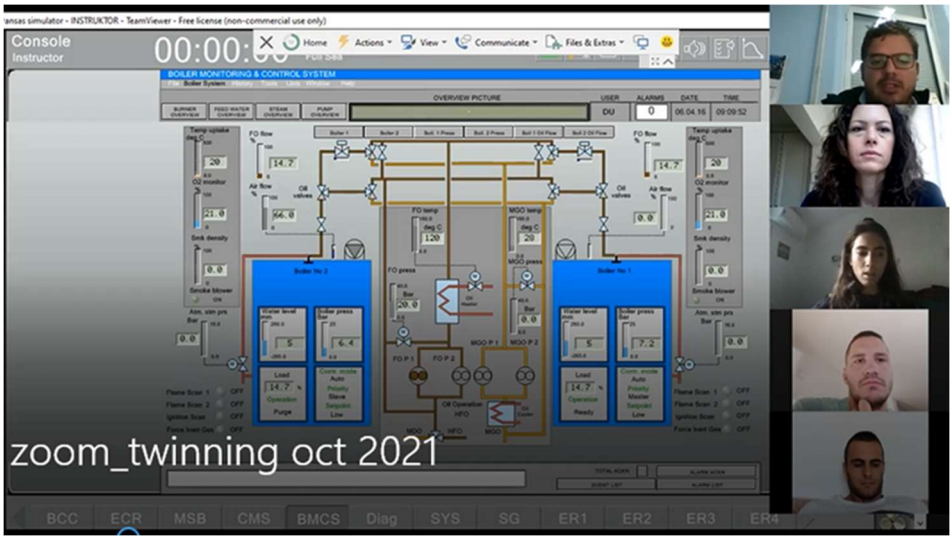

Fig. 2 – *Online twinning class – Boiler Monitoring and Control System*

Bearing in mind that the classes presented have been designed and conducted during the pandemic period, the format presented would generally be a great asset for preparatory classes, i.e. before the students start working in groups on simulator stations, or as follow-up activities and review classes in any circumstances. Also, as already proved, it is an excellent opportunity to have combined classes of different study programmes, as, in our case, Marine Engineering and Marine Electrical Engineering, this way being able to exchange their experiences and learn from each other to upgrade their knowledge on certain systems.

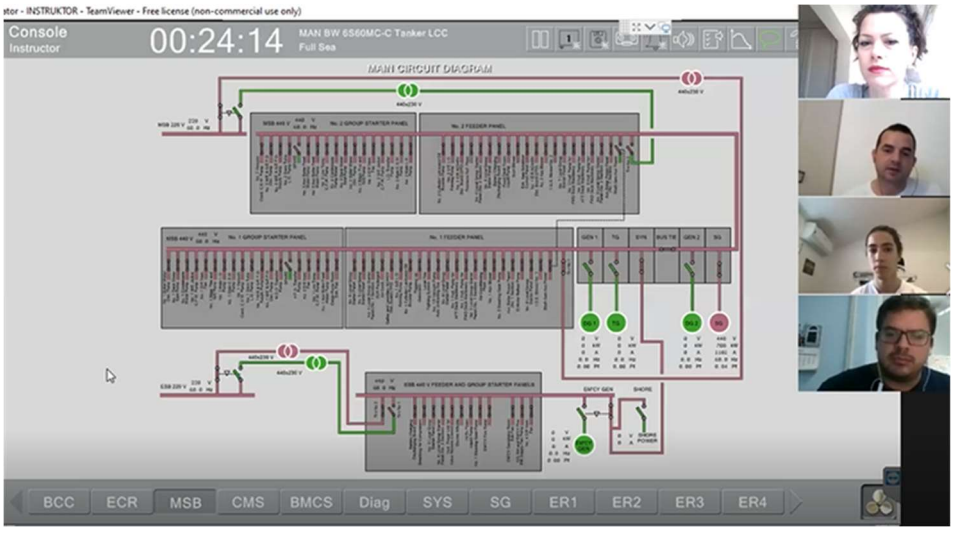

Fig. 3 – *Online twinning class – power system operation*

4.1. Challenges and pedagogical implications

In addition to meeting the official requirements and recommendations for the twinning activities, as mentioned, a series of challenges need to be addressed here. As more and more classes migrate to the online environment, teachers are called upon to pay special attention to interactivity and motivation issues. A research survey conducted in the USA shows that, although the majority of teachers rated the student learning outcomes in online education as equal or even superior to face-to-face instruction, they all share certain common concerns. For example, about 70% of academic staff believe that "students need more discipline to succeed in an online course than the one conducted face-to-face [20].

The phenomenon of emerging digital generations here makes the process much easier for the students, although teachers are now more than ever forced to overcome the gap and use additional web-based tools and applications to maintain the focus and engagement of the online attendees. Online simulations here particularly come in handy. In addition, the twinning activity on a marine engine simulator is meant to be interactive in multiple ways. First of all, it anticipates close interaction and collaboration between the teachers, then between the teacher(s) and the student(s), and finally, it is interactive and collaborative among the students. That way, it encourages students' collaborative learning, gaining certain experience and collective meaning-making [21]. They are generally more consumed by the process presented and going on on the screen. They assist their colleague in explaining the process, continue the explanation or clarification of the procedure, add comments or correct him/her.

This is a very important aspect for engine room personnel. The exercises conducted have actually been a great introduction to Engine Room Resource Management (ERM), which is even designed as a separate course. ERM is a system of achieving safe engineering operations by proactively managing personnel, equipment, and information. Generally, it anticipates monitoring an individual performance while working within the engineering team in various situations. The ERM exercises are generally designed to be done in teams, e.g. two students per simulator station, so that they can discuss the situation and help each other, which is a common situation and a necessity in engine room daily operation, especially in case of a failure, error, breakdown or similar problem to be promptly and efficiently resolved.

The other issue in hybrid or online format of classes, but also those held on-site, is that they lack the experiential component. Since twinning is the simulation of real-life onboard situations, we can say that this aspect is also partially fulfilled. Also, in addition to reviewing the previously gained knowledge, these activities also review previously gained practical knowledge of the teacher(s) and some of the students who have already had

some onboard experience. The shared "hands-on" experiences is generally recommended for helping learners enjoy learning, learn more and remain committed and engaged [20].

Twining classes provide another great advantage to the students. In addition to the multiple benefits mentioned, they are also a great preparation for their future jobs interview, both in terms of (Maritime) English proficiency and especially in answering technical questions frequently asked in relation to ship systems and their operation.

4.2. Related Activities

In terms of language, specifically, some immediate class activities following the twinning class could be done through the Moodle platform commonly used as a distance learning platform at the Faculty of Maritime Studies, such as short quizzes, (technical) vocabulary exercise(s) and/or translation exercise(s). The teacher can also subsequently go through the recording, detect possible incorrectly used vocabulary and expressions, grammar or pronunciation mistakes and prepare additional exercises for the next class. Naturally, a similar can be done for the paired or "twinned" technical subject, as well.

In addition, the simulator offers the possibility of creating tests related to simulator exercises (Fig. 4). Those are in English, thus providing and requiring proper reading comprehension, especially in terms of technical English. The assessment can again include both technical and language components, in variable ratio, and the overall performance can be tracked through the Trainee Performance Monitor. Having in mind that these online tests generated on the simulator are generally a multiple-choice concept anticipating primarily receptive language skills, they would be a good combination with twinning classes which would again be crucial for the enhancement and testing of generative language skills and productive use of technical vocabulary.

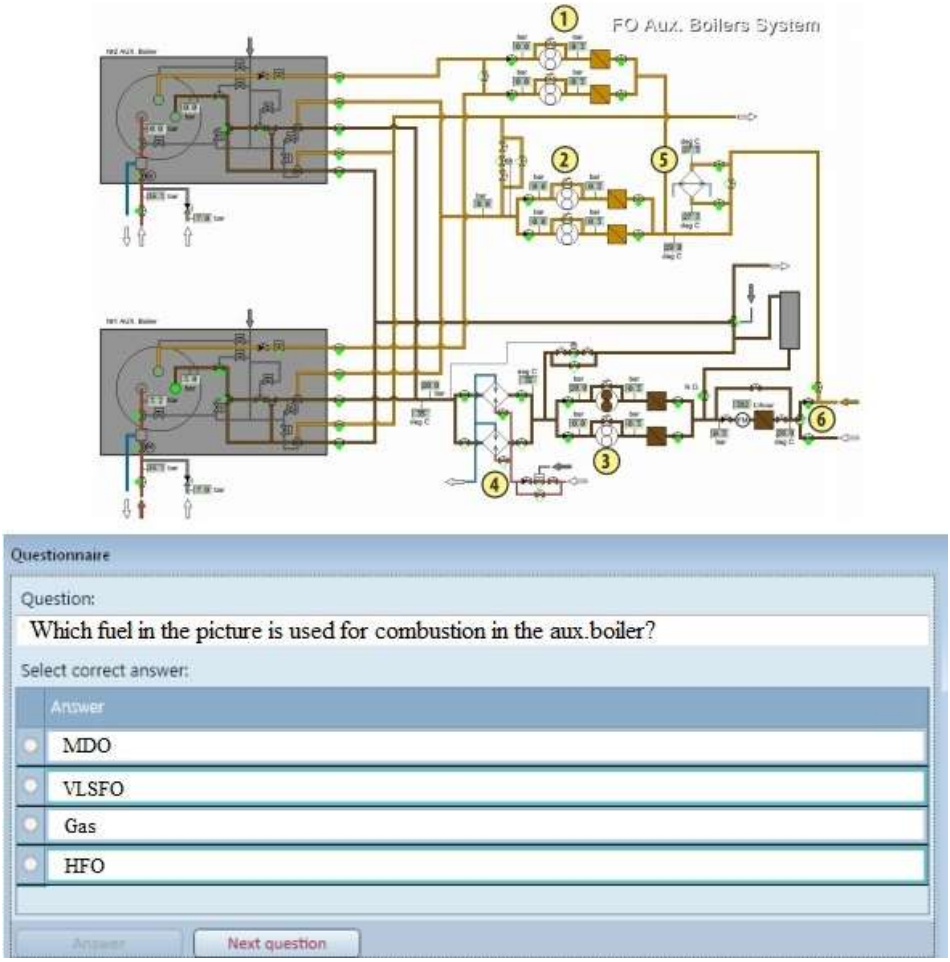

Fig. 4 – *An example of a simulator test question*

The technical subject taught on the simulator is a distinct example of English Medium Instruction, including assessment and testing. What we tend to do with the twinning refers more to CLIL or Content-Based Instruction of language. The portion of the learning outcomes of the two subjects would be challenging to define and conduct, but the intertwining and necessity of cooperation are more than evident.

4.3. Other twinning possibilities

The activities referred to above have been conducted in the most practical way in terms of the limitations imposed by the pandemic. Another possibility would be to have a group of students at the simulator stations where they do the practical operation as assigned by the teacher(s). At the same time, the rest can follow online, answer questions and give instructions or

help their colleagues complete the assignments and provide adequate responses to the situations, give comments, and similar.

Naturally, in the regular teaching environment on the site, the simulator classes are done in groups where the English teacher can also join and have a more or less active role, depending on the class design. For example, it can be done similarly to the online format where the students need to explain their actions regarding the operation of a particular part of the ship's system or reaction to a situation.

Similar twinning classes could also be designed on nautical simulators, for Vessel Traffic Service stations. To the best of our knowledge, there are no official twinning courses or subjects formally designed and taught through twinning activities. The twinning classes presented in this paper have been conducted not as regular classes but as additional, review, and experimental classes. The students' responses and feedback, however, have been very positive. Thus we believe it would be more than helpful to have similar activities as integral parts of the subjects' syllabi or a separately accredited twinning subject.

5. Conclusion

The idea behind this paper was to present some practical solutions and experiences in terms of contemporary recommendations for teaching methodologies and class designs, particularly in terms of English for Marine (Electrical) Engineering purposes. The examples of twinning exercises are given aiming to meet both the practical needs of our language learners, but also to meet some general requirements and recommendations in terms of the Maritime English instruction. Having some practical experience with this kind of classes, the authors also provided further pedagogical implications and possibilities of the method, anticipating both hybrid and regular teaching environment. The next big step in that direction would be the possibility of including the classes as regular tutorials or as an accredited twinning subject of the official study programmes. Having in mind the afore considered, it is a method that should be more widely explored and tested, and eventually integrated into regular ME courses. The authors are in favour of further research and will hopefully be able to exchange relevant experiences, findings and recommendations with other colleagues.

References

[1] V. K. Bhatia, Analysing Genre, Language Use in Professional Settings. London: Longman, 1993.

[2] Z. Đurović, Using corpus linguistics methods for the purpose of enhancing the teaching and learning of Marine Engineering English vocabulary (Upotreba metoda korpusne lingvistike u svrhu unapređenja nastave i učenja leksike engleskog jezika brodomašinske struke), doctoral dissertation. Nikšić: University of Montenegro, Faculty of Philology, 2021.
[3] S. Gollin–Keis, D. R. Hall, and S. H. Moore, Language for Secific Purposes, Hampshire: Palgrave Macmillan, 2015.
[4] IMO Model Course 3.17, Maritime English, 2015 edition. London: International Maritime Organization, 2015.
[5] M. Dževerdanović Pejović, Types of discourse and genre features in maritime communication, doctoral dissertation (Tipovi diskursa i žanrovska obilježja u pomorskoj komunikaciji). Belgrade: Faculty of Philology, 2012.
[6] T. Dudley–Evans, and M. J. St. John, Developments in English for Specific Purposes. Cambridge: Cambridge University Press, 1998.
[7] C. W. Cole, B. Pritchard, and P. Trenkner, "Maritime English instruction – Ensuring instructors' competence", Iberica, vol. 14, (2007): 123-148.
[8] J. R. Davies, Interdisciplinary Courses and Team Teaching, New Arrangements for Learning. Phoenix: ACE/Oryx, 1995.
[9] R. Soltani, and S. N. Shafaei, "Implementation of Team Teaching in an ESP Program and the Investigation of its Effectiveness on Students of Computer science ESP Vocabulary Achievement", Language in India, 13 (8), 2013, pp. 513–523.
[10] R. S. Anderson and B. W. Speck, "Oh what a difference a team makes, Why team teaching makes a difference", Teaching and Teacher Education, 14(7), 1998, pp. 671–686.
[11] T. Dudley–Evans and M. J. St. John, Developments in English for Specific Purposes. Cambridge: Cambridge University Press, 1998.
[12] M. Friend and L. Cook, Interactions, collaboration skills for school professionals (6th ed.). Columbus, OH, Merrill, 2010.
[13] M. Welch, "Collaboration, staying on the bandwagon", Journal of Teacher Education, 49(1), 1998, pp. 26–37.
[14] L. Maletina, Y. Karmanova and V. Kashpur, "Implication of interdisciplinary team teaching of an ESP Course", Mediterranean Journal of Social Sciences, 6, 2015. DOI:10.5901/mjss.2015.v6n5p556
[15] Mohammed, O. K., "ESP Teaching, Reversal of Roles between ELT Teachers and Subject Specialists", International Journal of Social Science and Humanity, 2 (6), 2012. Retrieved September 2020 from the World Wide Web http://www.ijssh.org/papers/157-A10022.pdf
[16] Team teaching in ESP, English Teaching Information Centre. London: The British Council, Printing and Publishing Department, 1980.

[17] J. G. Davy and C. K. Noh, "A basic study on Maritime English education and the need for raising the instructor profile", Journal of Navigation and Port Research International Edition, 34(7), 2010 pp. 533-538.
[18] Z. Đurović, and M. Dževerdanović, "Blended approach to teaching Maritime English", Nauka, nastava, učenje u izmenjenom društvenom kontekstu, Snežana Marinković, Ed. Užice: Faculty of Pedagogy, 2001, pp. 385-400.
[19] Y. Kirkgöz and K. Dikilitaş, "Recent developments in ESP/EAP/EMI Context, in Y. Kirkgöz and K. Dikilitaş
[20] Babson Survey Research Group, Grade Change: Tracking Online Education in the United States, 2013. Retrieved from http://sloanconsortium.org/ publications/survey/grade-change-2013
[21] J. Morellion, "Increasing interactivity in the online learning environment: Using digital tools to support students in socially constructed meaning-making", TechTrands, 2015, 59(3), pp. 41-47.

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Development of Small Container Ports: Case Study – Port of Bar*

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Abstract: Container ports are just one point on the international transport chain. Therefore, their development is determined by the cooperation of all participants in the transport chain that connects users of transport services with the ports, both economic entities and administration. This paper presents the basic preconditions for development of small container ports and the challenges they face. The Port of Bar was used to study the case. The main goal of this paper is to determine the development steps or phases that small container ports should implement in order to better position themselves on the regional market, i.e. to meet the requirements set by shipping companies. The paper analyzes different types of transport connections with the hinterland as well as a state of port infrastructure and superstructure in relation to ports in the region. The research hypothesis says that the correct sequence of different development steps directly affects the development of small container ports. The methods which will be used in the paper are analysis, synthesis, induction, deduction, generalization and concretization, as well as the method of comparison. The results of the research will provide a new understanding of the issue of development policies of small container ports in relation to available capacities and transport connections. The results can be used by the management structures of small container ports, but also in the work of national bodies in the field of maritime and transport. The research is based on the example of the Port of Bar as well as the ports in the region of Balkans until it doesn't take into consideration other small container ports from around the world. Therefore, the obtained results of the research could not be completely generalized. Thus is, this issue requires further research that would consider its various aspects.

Keywords: Small container ports, Port of Bar, infrastructure, shipping companies.

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1. Introduction and background

This paper aims to review the experience of advanced container ports and logistics routes in the region of Balkans, cargo availability and comparative advantages of the Port of Bar in order to improvement intermodal transport on the logistics route passing through Montenegro and the Port of Bar. Maritime transport experienced a revolution in the mid-1960s with the invention of the container unit for the transport of goods. Since then, intermodal transport of all types of cargo has been continuously growing [5]. The situation is similar in the region of the Western Balkans, which is the hinterland of the Port of Bar. More and more goods are being transported in containers. Due to the merging of shipping companies into large alliances, ports are facing challenges. There are special challenges for small ports where this phenomenon calls into question their survival [8]. In the Balkans region, at present, there is far greater benefit than the constraints that economies of scale entail, so small container ports must have to respond to that fact. The answer lies in the far greater use of rail transport than has been the case so far. This is especially true for the Port of Bar. The involvement of the state is necessary because the port is only one important point on the transport chain and its development depends on the connection with the hinterland. All participants from Montenegro must be involved in this process and give their contribution which will result in higher container transhipment in the Port of Bar.

2. Literature review

International maritime trade using container transport has been grown far more than past three decades than other types of maritime transport. In 2019, global containerized trade expanded at a slower rate of 1.1%, down from 3.8% in 2018 bringing the total to 152 million TEUs. In 2019, nearly 65% of global port-container cargo handling was concentrated in Asia – the share of China alone exceeded 50%. Europe ranked second in terms of container port-handling volumes, behind Asia, whose share was more than four times greater. Other regions in descending order are North America (7.7%), Latin America and the Caribbean (6.5%), Africa (4%) and Oceania (1.6%) [23]. In Table 1 we can notice that the route Europe - Asia along the Transpacific route is the most important in the world. Most of Western European ports are used as a link between the European continent and Asia, which may be changed in the coming years keeping in mind proximity of Mediterranean and Adriatic ports in the terms of less transit time by 7-10 days compared to Western European ports. The main obstacle is infrastructure connection from these ports compared to the infrastructure connections of

Western European ports with the central of Europe. Today, ports are showing more interest in strengthening connections with the hinterland to get closer to the shippers and tap the cargo volumes that could be committed.

Table 1 - *Containerized trade on major East-West trade routes 2017-2020 in percentage*

	Trans-Pacific			**Asia-Europe**			**Transatlantic**		
year	***East-bound***	***West-bound***	***To-tal***	***East-bound***	***West-bound***	***To-tal***	***East-bound***	***West-bound***	***To tal***
2017	19,2	7,3	26,7	7,1	16,4	23,4	3,0	4,6	7,5
2018	20,8	7,4	28,2	7,0	17,3	24,3	3,1	4,9	8,0
2019	20,0	6,8	26,8	7,2	17,5	24,7	2,9	4,9	7,9
2020	18,1	7,0	25,1	6,9	16,1	23,0	2,8	4,7	7,4

Source: [23]

In the second quarter of 2020, there were 939 seaports that were connected to the global liner shipping network through regular container shipping services. If all ports had direct connections with each other, there would be 440,391 port-to-port liner shipping services. In reality, only 12,748 port pairs had such direct services, that is to say, 2.9 per cent of the theoretical total. For trade between 97.1 per cent of port pairs, containers need to be trans-shipped in one or more other ports. The necessary number of trans-shipments is one or two for most port pairs. The least connected port pairs require up to six trans-shipments [8]. The goal is for the port to be connected to other ports with as few transhipment ports as possible. In order for that to happen, that is, for shipping companies to be justified in maintaining weekly services on longer routes, it is necessary to have enough cargo. In addition to the economic development of the hinterland in which a port is located, good infrastructural connection is one of the most important preconditions. One of chances for small container ports that are not well connected with its hinterland is to be transhipment ports. This may be considered to be applied on the case of Montenegro and the Port of Bar. Ports must be prepared for the future. This means improving local connections to the wider road, rail and inland waterways networks; fully optimising services to make the best use of ports as they are now; and creating a business climate to attract the investments that are so badly needed if capacity is to expand, as it must do. The proposal to review EU ports policy focuses on the ports of the trans-European Transport Network, which accounts for 96% of goods and 95% of passengers transiting through the EU ports system. Lastly, as in many other economic sectors, staffing needs in ports are changing rapidly and there is a growing need to attract port workers. Without a properly

trained workforce and skilled people, ports cannot function [22]. Port selection/choice is a complex process, which has been studied from various perspectives. Most studies dealing with the choice behaviour of shippers and third-party logistics service providers focus on modal choice and carrier selection, instead of port selection. The main selection criteria of logistics companies and shippers can be identified as a competitive price of port services, reliable services, low time costs for goods, cargo security and damage prevention, facilitation through the use of information platforms and good intermodal connectivity to the hinterland [14].

3. The research problem

The research regarding the Development of Logistics Routes of Intermodal Transport in the Eastern Adriatic [17] had for aim to show how certain significant economic and logistical factors (marked as independent variables) affect the stated dependent variable. The initial research model connects three independent variables with one dependent variable. The paper investigated the impact assessment of three independent variables: a) seaport connectivity measured by the LSCI (Liner Shipping Connectivity Index), b) seaport development and c) seaport connectivity with dry ports (intermodal terminals, i.e. economic centres) in the hinterland on the dependent variable. The container throughput as the dependent variable is given in Figure 1.

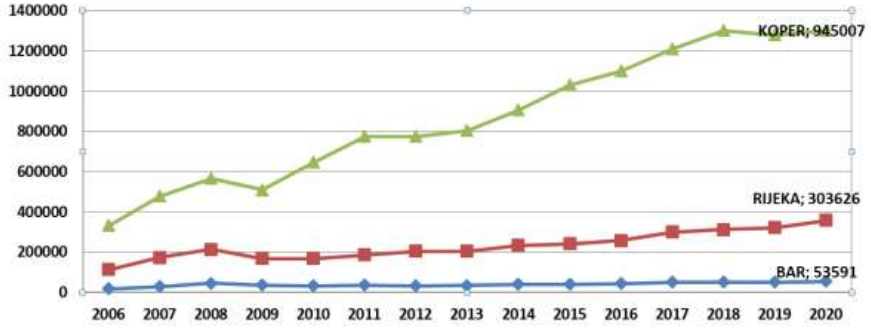

Fig. 1 - *Container throughput 2006-2020/TEU*
Source: [17]

The first independent variable in the research was Liner Shipping Connectivity Index depicted in Table 2.

Table 2 - *Liner Shipping Connectivity Index 2006-2020*

LSCI	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
BAR	1,51	1,51	2,51	3,82	3,50	3,37	4,40	3,65	3,88	3,65	4,55	3,92	3,11	4,27	5,25
RI-JEKA	10,36	11,43	13,80	10,82	16,89	17,35	17,87	18,72	19,97	23,17	26,99	29,80	29,32	32,34	33,35
KO-PER	13,23	13,85	16,67	17,83	19,28	19,91	20,12	21,05	22,61	26,78	29,96	32,44	31,37	34,26	35,32

Source: [17]

In this paper, the economic modelling was applied to the three selected the Eastern Adriatic seaports (Koper, Rijeka and Bar), in which was conducted a field survey (the samples of 60 respondents in each of these seaports). The aim of the survey was to obtain valid responses, based on the perception of 180 respondents about the level of development of logistical routes of intermodal transport in the three mentioned seaports, as well as about the possible positive impacts of the selected factors. In this sense, the responses had been obtained to the following research questions: – What is the level of development of logistical routes of intermodal transport in the three mentioned seaports? (the dependent variable in the model); – What is the positive impact of LSCI on the development of logistical routes of intermodal transport in the three mentioned seaports? (the first independent variable in the model); – What is the positive impact of the development of the seaport on the development of logistical routes of intermodal transport in the three mentioned seaport? (the second independent variable in the model), and – What is the positive impact of connection of the seaport with the network of intermodal terminals in the hinterland (the third independent variable in the model). In addition to theoretical considerations, and in order to verify the initial and auxiliary hypotheses, the numerical tables have been used with graphical and statistical analysis and regression multiple linear analyses applied to the data obtained in the course of surveying 180 respondents. For the realization of multiple linear regression analysis, it was used Modules Solver and SPSS [17]. The constructs used in the study were measured on a Likert scale from 1 to 5, where 1 means the least impact and 5 the greatest impact. Multiple regression analysis was applied to the results of the respondents & # 39; perceptions obtained through the survey, for cases of specified ports. The research showed that the seaport of Bar is noticeably behind the seaports of Rijeka and Koper. The reasons are numerous, and they are dominated by the low level of infrastructural, superstructural and logistical development of the Port of Bar, high costs of its port and logistics services, deteriorating political relations between Montenegro and Serbia, the poor infrastructural transport connections of the Port of Bar with

Serbia, development investment deficit, orientation of Serbia to other seaports, a percentage of idling of engaged containers in the return direction, etc [17]. The main competition today for the Port of Bar is Rijeka port while their main overlapping market is Serbian market that is the most important market for the region of Western Balkans. The Port of Piraeus becomes another strong competition to the Port of Bar for Serbian market keeping in mind COSCO's regular container train connecting Piraeus and Belgrade established in 2017. The new threat for development of intermodal transport via Bar port is MBOX intermodal terminal in Niš that will be connected with Thessaloniki port by regular container train. The service is expected to start by the end of 2021 attacking the last main market in South-eastern Serbia that used to go via the Port of Bar. The quality hinterland connection of the Port of Bar is currently far behind the other main ports in southeast Europe, resulting in all other ports expanding their capacity, while the Port of Bar cannot utilize 30% of the capacity installed in the last century. In the hinterland of the Port of Bar, only 4% of cargo is on the territory of Montenegro, 8% on the territory of Kosovo, 17% from Bosnia and Herzegovina and 71% of cargo on the interior of Serbia. Well-built infrastructure from the northern Adriatic ports to Serbia have enabled 70% of Serbian goods to go to those ports. Poor condition and when we look at the liner shipping connectivity index where the Port of Bar in 10 years (2009-2019) fell by about 150 places while the Port of Rijeka advanced by 214 places on the same scale [4].

3.1. Intermodal transport in Croatia

The Port of Rijeka port is the main Croatian port while AGCT (Adriatic Gate Container Terminal) is container terminal operator. AGCT is connected to 5 services within the Mediterranean and 2 services from the Far East, which makes it extremely well connected for regional conditions and attractive for users of intermodal transport. Official statistics for 2020 says that 10 world shipping companies are present in AGCT, the terminal handled 303,500 TEU in 2020, that is 11% more than in 2019. One of the main reasons for the success of the Port of Rijeka in intermodal transport is the good connection by container trains with its hinterland, of which the connection with Serbia and Hungary stands out. 40% of transhipped containers in the Port of Rijeka are transported by Rail [1]. In addition to AGCT as a container operator in Croatia, there are also the ports of Split and Ploče, which deal with container transhipment and together make up about 13% of the total transhipment of Croatian ports [6], which is a confirmation of the importance of Rijeka and AGCT for Croatia and the region. The main market for the Port of Rijeka is the Serbian market with 38%, followed by Croatia 32%, Hungary, the Bosnian market and, to a lesser extent, Austria, the Czech Republic and Slovakia [2]. Over 60% of containers were transported to and

from Serbia by rail in 2019, according to the interviews with the main Serbian freight forwarders. All cargo and vessels processing is done through Terminal Operating System (TOS) NAVIS. It also includes internal processes as well as interaction processes with 3rd parties needed in order to provide smooth and clear container flow through AGCT [3]. A total of around EUR 935 million was invested in the reconstruction of railways, plants, stations, stops and other infrastructure facilities from 2010 to the end of 2019, in accordance with the realization of investments under the programs, while the plan for the period from 2020 by 2024 amounts to 1.8 billion euros, of which almost 78.7% refers to projects co-financed by the European Structural and Investment Funds (ESI) and the Connecting Europe Facility - CEF). The estimated value of the planned projects co-financed by European funds is more than 2.7 billion euros by 2030. As the most significant, both in terms of coverage and financially, these are projects co-financed from European funds on the RH1 corridor from the state border with Slovenia to the state border with Serbia and on the RH2 corridor from the state border with Hungary to Rijeka. On the RH1 corridor, the length of two-track lines will increase by 82 km (section Dugo Selo - Novska) and after the implementation of this project, the entire corridor from the state border with Slovenia to the state border with Serbia will be two-track. On RH2 corridor, the length of two-track lines will increase by at least 190 km. So it is planned to both corridors be with two-truck lines by 2030 [10]. The Community for combined transport was established on 22 March 1995. At its 22nd session, held on 6 July 2015, the Management Board of the Croatian Chamber of Commerce passed a decision amending the name of to the Community for Intermodal Transport and Logistics. Objectives are integration and effective cooperation between the academic sector and economy, networking of economic sector, identification of changes in the intermodal transport and logistics market, proposal for the development of intermodal transport and logistics, scientific and professional research for the purpose and application of the economic sector of the Republic of Croatia. The mission is to promote the use of intermodal transport and logistics services in the Republic of Croatia, application of the highest European and world standards in Croatia with special emphasis on sustainable development, satisfaction of all users of intermodal transport and logistics service. Vision is that all those involved in business and work in intermodal transport and logistics be informed about world trends and that they achieve their maximum in raising the quality of service and the application of technological developments [9].

3.2. Intermodal transport in Greece

The Port of Piraeus is located at the crossroads of Europe, Asia and Africa. It specializes in container handling. The main characteristics of the port are the following: the natural port for Athens and the main Greek port, the

main European port after the Suez Canal with a branched feeder connections to the Black Sea, the Mediterranean and the Adriatic, land connection (road and rail) to the Balkans and Central Europe. The largest container terminal in the Mediterranean, the fourth largest terminal in Europe and 26 in the world [21]. Significance of the entry of COSCO in 2009 in the Port of Piraeus speaks the fact that in 2007 Piraeus was not even among the 15 first ports in Europe. The acquisition enabled a much shorter transit time from the Far East to the central economic centres in Central Europe compared to Western European ports, with the activation of PEARL [18]. For example, the Czech market received a 9-day shorter travel time via Piraeus than via the ports of Rotterdam and Antwerp. With its investments, COSCO plans to enable the Port of Piraeus to tranship over 10,000,000 TEU per year. How significant was the takeover of the Port of Piraeus by COSCO is shown by the fact that the transhipped cargo increased by 5.5 times from 2009 to 2018, while the amount of transhipped TEU units increased by over 1100%. Of the total transhipment in Greek ports, as much as 86% of containers are transhipped in the Port of Piraeus [19]. PEARL is a railway operator that received a permit from the Greek authorities on May of 2016 to operate. It is estimated that in 2019 there were over 1000 container trains that transported over 80,000 TEU freight [18]. The current line map is given in Figure 2. Greece has more than 25 commercial ports, of which the ports of Piraeus and Thessaloniki are the most important. Thessaloniki is the second largest container port in Greece, but the largest port for bulk and general cargo, which is part of the trans-European transport network TEN—T. Its position is such that the market of northern Greece is its main user as well as the Balkan countries. Unlike the Port of Piraeus, which specializes in container transhipment, the Port of Thessaloniki strives to attract as many containers and bulk goods as possible to its piers [21].

Fig. 2 - *Rail intermodal connection of Piraeus port with its hinterland*
Source: [18]

Container transhipment is ca 500,000 TEU in Thessaloniki port, while the planned investments will increase the capacity to 1,300,000 TEU. During the launch of the first container train on the route Thessaloniki – Sofia, CEO of the Port of Thessaloniki Franco Nicola Cupolo stated that the Port of Thessaloniki is committed on the strategic development of intermodal railway transport to the Balkans, starting from November 27, 2020. With a direct train connection to the dry Port of Sofia owned by the Port of Thessaloniki [21].

3.3. Intermodal transport in Montenegro

Intermodal activities in the Port of Bar are being performed through the company Port of Adria AD with an annually transshipment capacity of TEU 50,000. Four shipping lines operates in Bar [20] with no direct service from Far East. There was only 0.9% of transported containers by rail out of the total amount of 50,444 TEU (twenty-foot equivalent unit) [16]. According to the interviews with the local representatives of shipping lines and freight forwarding companies, there are 70% of cargo that is being stripped in the port while it is 82% of transit cargo that don't leave the port but being stripped on the port territory. It doesn't help boosting of intermodal activities since the significant amount of containers are being loaded onto vessel

empties what causes costs for shipping lines which doesn't exist at this scope at other regional port. According to the official statistics of Port of Adria, there is 38.5% of empty containers that is being loaded empty in Bar while in Rijeka and Thessaloniki, according to their statistics, it is cca. 16-17%. Another problem is the max allowed gross capacity of rail of 1060t. Although it is built in 1976, there was not significantly investments till 2009, since that it was reconstructed 26% of the railway from Bar to Vrbnica (the cross border with Serbia). It is a reason for lower bandwidth compared to competing routes [24]. Comparing to competitive routes from Croatia and Greek that are connected with Belgrade with full profile of high-way there is still no high-way in use in Montenegro. The main problems are the political relation between Montenegro and Serbia which does not allow increasing activities which would lead to better infrastructural connectivity and investment accordingly. While Croatia has the community for intermodal transport and logistics since 1995, there is no body in Montenegro although the coordination committee for transit traffic was established in 2021 [19].

4. Conclusion

It is argued at the beginning of this paper the importance of intermodal transportation that is still growing unstoppably and more and more goods are being transported in this way, both in the world and in the Western Balkans. By uniting shipping companies in alliances, the position of small container ports becomes even more marginalized and for some the survival on the map of feeder services of global shipping companies will be questioned. The two main container routes today are Transpacific and Far East - Europe. The most frequently used European ports are those on the Western European continent due to the poor infrastructure network from the Mediterranean and Adriatic ports to Central Europe. In the coming years, it is to be expected that part of the goods from Western European ports will be transferred to Mediterranean and Adriatic ports. The Port of Bar must be ready for it. The research raises an important question about the manner in which the cargo flow through the Port of Bar may be increased. Using the methods of comparison, analysis, synthesis, induction, deduction, generalization and concretization, the level of development of intermodal transportation in Montenegro is compared to the level of development of intermodal transportation in Croatia and Greece. The research hypothesis confirmed that the correct sequence of different development steps directly affects the improvement of cargo flow through the small container ports. The absolute priority of Montenegro is to include the country in the map of pan-European corridors, i.e. the TEN-T network. The same will enable easier access to EU funds related to the financing of capital infrastructure projects, primarily the completion of the Bar-Belgrade highway and the reconstruction of the Bar-

Belgrade railway, which passes through Montenegro. In order to make sense of investing in the highway and railway, it is necessary that Serbia, for its part, plans to build infrastructure to Montenegro. In that sense, the relations between Serbia and Montenegro are important. Infrastructural connection with Serbia is important because through Serbia, the Port of Bar comes to Hungary and Romania, where the logistics route through the Port of Bar may have comparative advantages. Montenegro must also get an Intermodal Transport Strategy, which will have its own action plan. The above is primarily the responsibility of the state administration, which with the help of the economy in the field of logistics should create the preconditions for the development of intermodal transport. After investing in capital infrastructure facilities, connecting with dry ports in the region should be one of the priorities of the Port of Bar and the logistics route through Montenegro. One of these possibilities is illustrated in Figure 3 as countries that can use the logistical route through Montenegro. The above aims to make the logistics route through the Port of Bar far more interesting to regional users than is the case today, which will result in greater interest of shipping companies for the Port of Bar. Greater competition and the introduction of direct lines from the Far East will contribute to a lower price of sea freights, which will further strengthen the position of the Port of Bar. In parallel with the above activities, it is necessary to work on the modernisation of infrastructural equipment of the port itself in terms of adapting the port infrastructure and superstructure to the requirements that include operations for vessels over 15,000 TEU. It is necessary to work in parallel on attracting cargo as well as planning investments in port infrastructure. It is important for the partner to be found a renowned world company in the field of logistics, preferably one of the world's largest shipping companies that would made the Port of Bar as its gateway port for this part of Balkans.

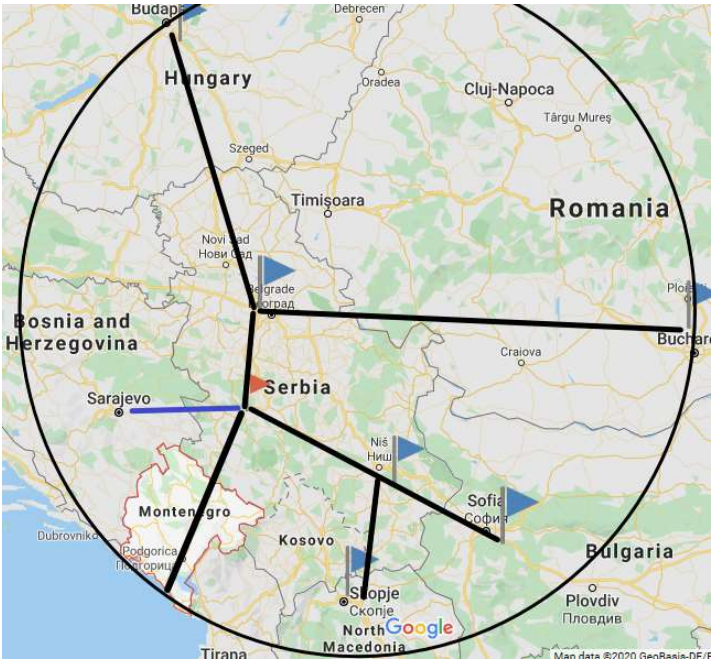

Fig. 3 - *Example of Potential Connection of the Port of Bar with Dry Ports of Long and Medium Range in the Region*

Source: [16]

References

[1] AGCT, The most cost effective Adriatic GATEWAY. Official Presentation, AGCT Rijeka, 2019, Croatia. 18p.
[2] AGCT, Annual statistics, AGCT Rijeka, 2019, Croatia.
[3] AGCT, Official web site, 2021, available at https://www.ictsi.hr
[4] Beologistika, , Logistika & Transport, 2021, Novi Sad.
[5] De Langen,P., Sharypova,K. ,"Intermodal connectivity as a port performance indicator", Research in Transportation Business and Management, Vol. 8, 2013, pp. 97-102.
[6] Državni zavod za statistiku – Republika Hrvatska, Official web site, 2021, available at https://www.dzs.hr
[7] Economic Commission for Latin America and the Caribbean, Facilitation of transport and trade in Latin America and the Caribbean, 2020, United Nation.
[8] EU horizon research, Capacity with a positive environmental and societal footprint: ports in the future era, 2018, Brussels

[9] Hrvatska gospodarska komora-Zajednica za intermodalni transport , Official web site, 2021, https://www.hgk.hr/odjel-promet/vazni-dokumenti-z-intermodalni-logistiku
[10] HŽ Infrastruktura, Ministarsto mora, prometa i infrastrukture Republike Hrvatske, EU, Željeznica za budućnost, 2020, Zagreb.
[11] ICTSI, Official web site, 2021, available at https://www.ictsi.com/what-we-do/our-terminals/adriatic-gate-container-terminal
[12] McKinesy&Comany,, Container shipping: The next 50 years,2017, Travel, Transport & Logistics October 2017
[13] MKI , Official web site, 2021, available at https://www.gov.me/clanak/odrzana-konstitutivna-sjednica-koordinacionog-odbora-za-tranzitni-saobracaj
[14] Notteboom T.E., Parola, F., Satta, G. and Pallis A.A., The relationship between port choice and terminal involvement of alliance members in container shipping. Journal of Transport Geography, 64, 2017, pp. 158-173.
[15] Parola, F.,Notteboom, T., Satta, G.,Rodrigue, J.P., Analysis of factors underlying foreign entry strategies of terminal operators in container ports, Journal of Transport Geography 33:72–84. 2013, DOI: 10.1016/j.jtrangeo.2013.09.010
[16] Pelevic, D., "Possibilities of Connecting a Sea Port with Dry Ports in the Hinterland in Order to Attract Regional Cargo: Case Study - Port of Bar", International Journal for Traffic and Transport Engineering, Vol. 11, 2021, Issue 3.
[17] Pelevic, D., "Development of Logistics Routes of Intermodal Transport in the Eastern Adriatic", Montenegrin Journal of Economics, Vol. 17, No. 4, 2021, pp. 193-202.
[18] Piraeus Europe Asia Rail Logistics , Official web site, 2021, available at https://pearl-rail.com/category/news/
[19] Piraeus port authority, Official web site, 2021, available at https://www.olp.gr/en/
[20] Port of Adria, Official web site, 2021, available at https://www.portofadria.me
[21] Port of Thessaloniki, Official web site, 2021, available at https://www.thpa.gr/index.php/en/
[22] Preparing our ports for the future: making the most of a vital resource, Article by Sim Kallas, 2013, available at https://timesofmalta.com/articles/view/Preparing-our-ports-for-the-future-making-the-most-of-a-vital-resource.470936
[23] UNTCAD, Review for maritime transport, 2020, United Nation

[24] ŽICG, Projekat rekonstrukcije pruge Bar – Vrbnica, 2021, available at https://zicg.me/AdminCMS/public/pdf/projekti/1%20Pruga%20Vrbnica-Bar.pdf

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Review paper

GHG Abatement Potential Due to the Implementation of Slow Steaming*

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Abstract: All branches of industry as well as the maritime transport industry are encountering the challenge of reducing greenhouse gas (GHG) emissions to prevent hazardous climate change. The ratification of the Paris agreement has set a restrain for global average temperature significantly lower than 2 °C and preferably restrains the growth to 1.5 °C compared to preindustrial levels. Therefore, International Maritime Organization (IMO) has imposed an aim to decrease carbon dioxide (CO_2) emissions per transport work by a minimum of 40 % by 2030 and to 70 % by 2050 compared to 2008. IMO has proposed various short-term, mid-term, and long-term measures for accomplishing this aim. Speed reduction i.e., slow steaming is a crucial short-term measure, that can be effortlessly implemented, and does not depend upon any supplementary infrastructure. Even a slight speed reduction will lead to substantial fuel reduction and therefore substantial CO_2 abatement considering the hypothesis that ship speed and fuel oil consumption are related with the cubic function. The implementation of slow steaming leads to a larger voyage time and consequently to a larger number of ships to attain yearly transport work constant. Therefore, it is essential to analyse the increase in fuel oil consumption and CO_2 emissions due to the larger number of ships engaged in maritime transport. This paper provides an extensive review of slow steaming and GHG abatement potential and points out the disadvantages of its application.

Keywords: ship energy efficiency, GHG emissions, fuel oil consumption, slow steaming, maritime transport industry.

1. Introduction

Climate change represents one of the most important issues in the 21st century and it consists of global warming caused by humans as well as the large-scale impact of global warming on weather patterns. The main cause of climate change is the emissions of greenhouse gas (GHG), mostly carbon dioxide (CO_2) and methane (CH_4), and among other things, one can monitor

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climate change through the increase in the global average temperature. The increase in the global temperatures increases the rate of evaporation, which then leads to more severe storms as well as weather extremes [1]. Furthermore, changes in climate impact ecosystems through the relocation or biological annihilation of species due to changes of the environment, and it endangers humans with food and water scarcities, floods, infectious diseases, high temperatures, financial loss, as well as the forced movement of people. These influences on people have forced the World Health Organization to declare climate change an utmost danger to worldwide health in the 21st century [2]. The increase in the global average temperature can be noticed in Figure 1, where a simulated and observed change in annual average global surface temperature is shown [1]. Currently, the increase in the global average temperature is about 1.2 °C in comparison to pre-industrial levels.

The need for climate action is increasingly emphasized and urgent. One of the most important documents related to climate action is the Paris Agreement adopted in 2015. At the United Nations (UN) Conference on Climate Change held in Paris in 2015, 196 members participated in the negotiations on the Paris Agreement. The ratification of the Paris Agreement started on 22nd April 2016, and it became obligatory on 4th November 2016. Since October 2021, 192 members of the UN Framework Convention on Climate Change are included in the agreement. It should be noted that the United States retracted from the Agreement in 2020 but re-joined in 2021. The ratification of the Paris agreement has set a restrain for global average temperature significantly lower than 2 °C and preferably restrains the growth to 1.5 °C compared to preindustrial levels [3], which would substantially decrease the effects of climate change. To achieve these aims, GHG emissions should be reduced immediately and attain net-zero by 2050.

In 2016, 73.2 % of global GHG emissions are caused by the energy sector, 18.4 % from agriculture, forestry, and land use, 5.2 % from direct industrial processes, and 3.2 % from waste. The energy sector is the leading GHG emitter, and these emissions can be classified into several categories. Thus, 24.2 % of global GHG emissions are caused by energy use in industry, 16.2 % from the transport sector, 17.5 % from energy use in buildings, 7.8 % from unlocated fuel combustion, 5.8 % from fugitive emissions from energy production, and 1.7 % from energy use in agriculture and fishing [4].

GHG emissions from the transport sector are very important and their reduction is necessary. Maritime transport is the most important part of globalized trade considering that more than 80 % of world trade is conducted at sea by 98140 ships of 100 gross tons (GT) and above, having more than 2 billion dead-weight tonnage (DWT) and sailing under flags of 150 countries [5]. The majority of the world's fleet uses carbon-based fuels causing GHG emissions. The fourth International Maritime Organization (IMO)

GHG study stated that the portion of emissions caused by ships in global anthropogenic emissions has raised from 2.76 % in 2012 to 2.89 % in 2018 [6]. What is more, it is predicted that emissions will increase from approximately 90 % of 2008 emissions in 2018 to 90-130 % of 2008 emissions by 2050 for various possible long-term economic and energy scenarios. The reduction of emissions growth can be accomplished with further steps regarding the ship energy efficiency and its emissions [6]. Thus, IMO has proposed an aim to decrease carbon dioxide (CO_2) emissions per transport work by a minimum of 40 % by 2030 and to 70 % by 2050 compared to 2008 [7]. In addition to GHG emissions, the maritime transport industry significantly contributes to the non-GHG emissions i.e., sulfur dioxides and nitrogen oxides, which are detrimental to the environment [8].

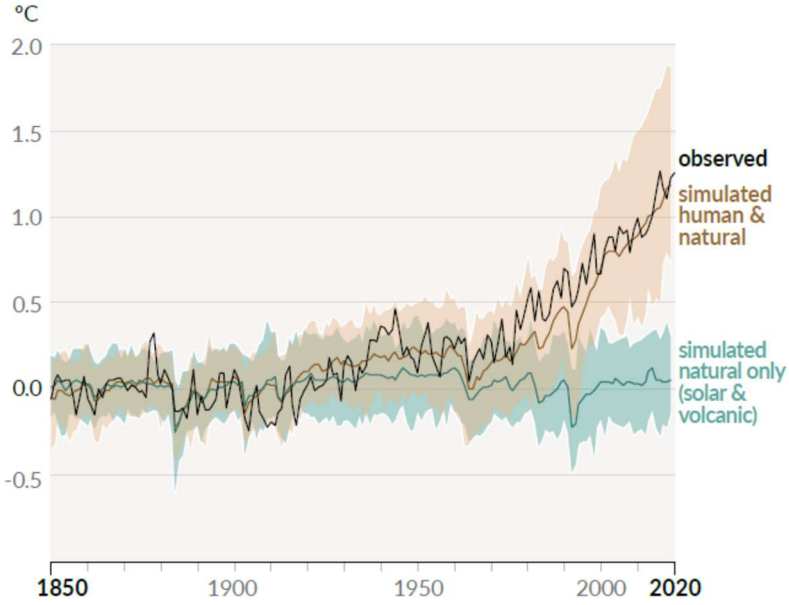

Fig. 1 – *Change in annual average global surface temperature [1].*

2. Measures for reducing GHG emissions in the maritime transport industry

Various measures have been suggested by IMO from 2011 onward to curb CO_2 emissions from the maritime transport industry. Thus, the Energy Efficiency Design Index (EEDI) is introduced for new ships and keeping the Ship Energy Efficiency Management Plan (SEEMP) onboard is obligatory for both new and existing ships. Also, data regarding the fuel oil consumption (FOC), and the other significant data must be collected for ships having 5000 GT and above. Furthermore, it was suggested that the operational perfor-

mance of ships, which can be examined with the Energy Efficiency Operational Indicator (EEOI) or some additional indicators, should be monitored [9].

To achieve a reduction in GHG emissions several possible short-term, mid-term, and long-term measures were proposed. Thus, candidate measures listed in Initial IMO Strategy [7] should be within the following timelines: short-term measures should be completed and agreed by the Committee between 2018 and 2023, mid-term measures between 2023 and 2030, and long-term measures beyond 2030. Possible candidates for short-term measures are:

- additional development of EEDI and SEEMP,
- advancement of technical and operational measures for energy efficiency of both new and existing ships,
- introduction of an Existing Fleet Improvement Programme,
- speed optimization/speed reduction,
- addressing CH_4 emissions as well as emissions of Volatile Organic Compounds,
- advancement of policies and strategies to address GHG emissions from international maritime transport,
- continuing and enhancing technical cooperation and capacity-building activities,
- considering and analysing measures to stimulate port developments and activities globally to facilitate the decrease in GHG emissions from maritime transport,
- R&D activities regarding marine propulsion, alternative low-carbon, and zero-carbon fuels, as well as innovative technologies for enhancing ship energy efficiency,
- motivations for first movers to develop and embrace new technologies,
- development of robust lifecycle GHG/carbon intensity guidelines for all types of fuels,
- actively promoting the work of the Organization to the international community, undertaking additional GHG emissions studies, and considering other studies to inform policy decisions.

Possible candidates for mid-term measures are:

- a program for the efficient implementation of low-carbon and carbon-free alternative fuels,
- operational energy efficiency measures for both new and existing ships,

- new mechanism for emissions reduction possibly including Market-based Measures,
- additional continuation and enhancement of technical cooperation and capacity-building activities,
- development of a feedback mechanism to enable lessons learned on the implementation of measures to be collated and shared through possible information exchange on best practices.

Finally, the potential candidates for long-term measures are pursuing the development and supply of carbon-free or fossil-free fuels and stimulation and facilitation of the general adoption of other possible new/innovative emissions reduction mechanisms [7].

Usually, the measures for GHG abatement are classified into technological and operational measures [9]. Additionally, alternative fuels and energy sources represent a third category of mitigation measures, which can be considered the independent one [10]. However, mitigation measures can be classified differently. Bouman et al. [11] presented a classification of mitigation measures in five categories including hull design, power & propulsion system, alternative fuels, alternative energy sources, and operation. The authors also presented the CO_2 reduction potential of each measure from a certain category, based on the detailed literature review. Eide et al. [12] concluded that speed reduction, the utilization of natural gas as a marine fuel, waste heat recovery, and contra-rotating propellers are measures with the highest CO_2 reduction potential, among 25 analysed measures. The classification of mitigation measures is shown in Figure 2.

As explained within [13], technological or technical measures achieve CO_2 reduction through the utilization of enhanced hardware, while operational measures achieve this aim through operational effort. Environmentally friendly fuels and alternative power sources can be considered technological measures since they include modified hardware and new designs. However, commercial and legal frameworks are also very valuable courses for the encouragement of the implementation of mitigation measures. They do not reduce ship's emissions directly; however, they encourage ship owners or ship operators to implement mitigation measures to fulfill these regulations.

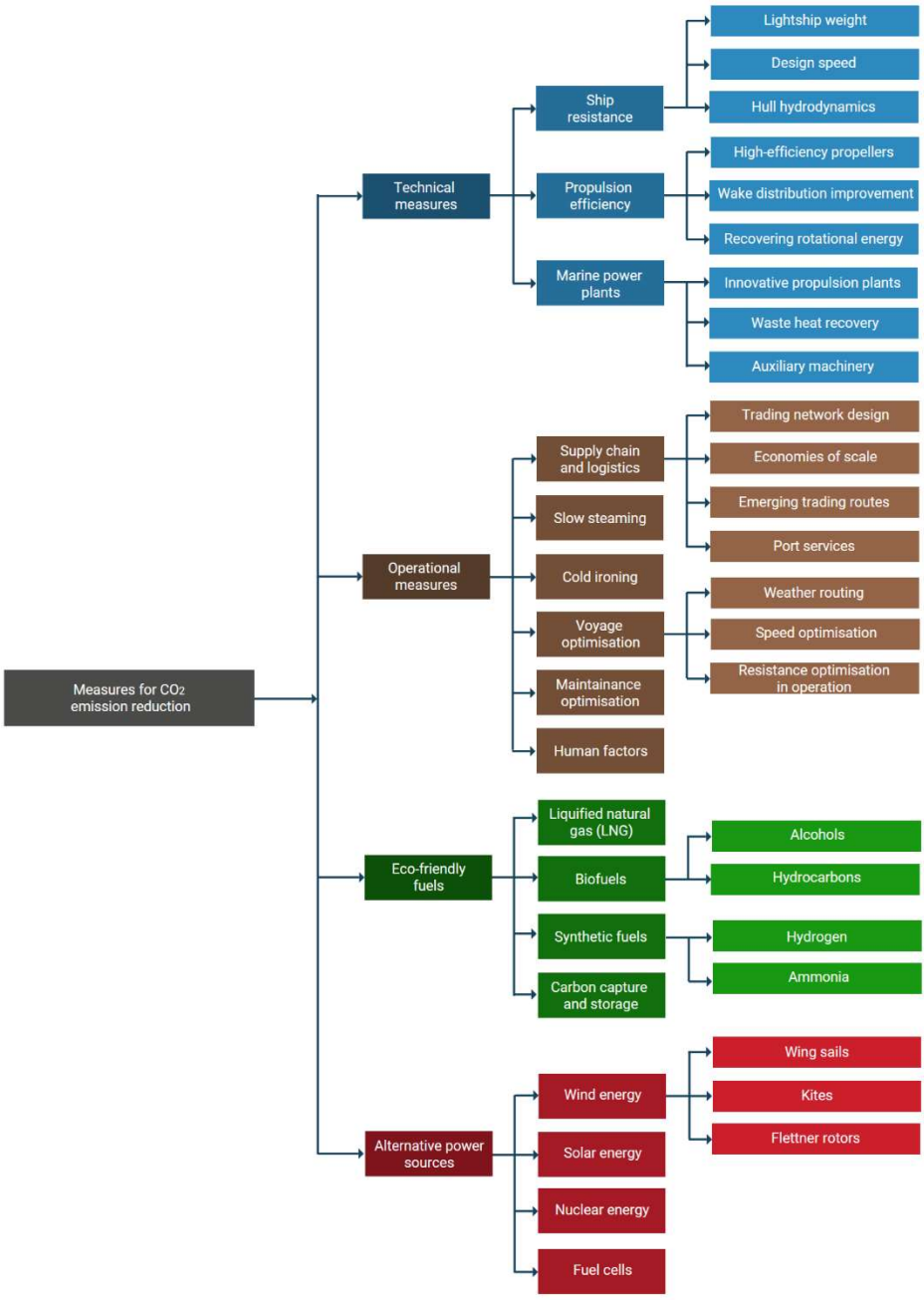

Fig. 2 – *Mitigation measures within the maritime transport industry [13].*

Even though there are a lot of possible mitigation measures, questions are being raised about which pathway could assist the maritime transport industry to accomplish goals defined within the Initial IMO Strategy [7]. Namely, to adopt a particular measure of energy savings, shipping companies consider the return on the investment [14]. Consequently, only a several of the listed measures are practically applied, and the most implemented ones are bulbous bow, energy-saving devices, tuning, derating, and waste heat recovery of ship engines [15]. A comprehensive review of mitigation measures for CO_2 emissions in the maritime transport industry is presented in [13], where the authors reviewed 268 studies. The authors demonstrated that the economic and legal frameworks are so far major challenges for the implementation of mitigation measures. Therefore, the CO_2 emissions reduction potential of certain mitigation measure must be observed from an economic perspective as well. There are also additional parameters that should be taken into account before applying certain mitigation measure. For example, the application of slow steaming has already started, which can be noticed from the obtained containership operating profiles [16]. However, it is crucial to point out that due to the application of slow steaming, ships are operating in conditions significantly different from those for which they were designed and optimized [17]. Therefore, additional investigations related to ship hydrodynamic performance for slow steaming conditions, as well as to the engine operation in such conditions would be beneficial.

3. Slow steaming as a mitigation measure for GHG abatement

To preserve and encourage the development of the maritime transport industry, which was significantly affected in 2008 because of the worldwide economic recession as well as reduced demands for maritime transport, several measures were adopted by ship owners/ship operators. One of the possible measures is slow steaming i.e., sailing at a lower speed than the design speed [18]. The adoption of slow steaming is directly related to saving fuel costs and is introduced by almost all worldwide shipping companies if the shipping market is slugged. The reduction of fuel costs arises from the fact that required power and consequently fuel consumption is nearly related to ship speed with a cubic function.

The reductions in fuel consumption as well as CO_2 emissions range from 20 % to 40 %, or even above 60 %, depending on the percentage of speed reduction [10, 19]. Slow steaming has other benefits which are related to the adaptability to increase the speed to prevent the detrimental effects of the randomness of port times, which then improves the service quality [20]. The selection of the optimal speed represents a dynamic process that includes balancing advantages and disadvantages. Thus, the benefits of speed reduction largely depend on charter rates and fuel prices, and the highest savings

are achieved if the fuel price is high, and charter rates are low [21]. Tillig et al. [22] analysed the impact of speed reduction on a decrease in fuel consumption and on the environment. The study is carried out for a containership sailing on a Pacific Ocean trade route. The authors demonstrated that an increase in fuel price will cause significant economic motivation for speed reduction in liner traffic. Degiuli et al. [23] presented the benefits of slow steaming for a containership on a sailing route through the Mediterranean Sea. The authors estimated the decrease in fuel consumption and CO_2 emissions both in calm water and in waves due to the application of this short-term measure. Shipowners or ship operators will utilize speed reduction, only if the saved fuel cost is higher than the incurred capital and operating costs [24]. Therefore, it is worthwhile to analyse the critical fuel prices at various speeds to determine the optimal speed.

Adland et al. [25] developed an adaptable framework for the assessment of the relationship between fuel consumption and speed. The authors have demonstrated that the cubic relationship between fuel consumption is accurate only around the design speed. Furthermore, the speed exponent can be significantly lower at the speeds which were noticed in noon reports. Berthelsen and Nielsen [26] analysed the relation between speed and required power using a coupled econometric and naval architecture data-driven model based on the operational data from noon reports. The authors showed that the speed power exponent is substantially lower than three at lower ship speeds. This is important for the discussions regarding the advantages of slow steaming since the introduction of slow steaming may not be beneficial as commonly stated. Taskar and Andersen [27] investigated fuel savings related to speed reduction using detailed modelling of ship performance. The authors concluded that the classical cubic law can be a source of a substantial error in the determination of fuel consumption. Furthermore, the authors demonstrated that savings in fuel consumption due to the application of slow steaming depend on weather conditions. Medina et al. [28] estimated the total resistance and the fuel consumption for containerships at full load, taking into account the impact of wind and waves according to the Beaufort scale. Since added resistance in waves has a substantial effect on fuel consumption, the authors presented the wind and wave hindcast climate information as well as the increases in added resistance for these conditions to allow a more accurate ''a priori'' assessment of fuel consumption.

A very important review regarding the ship voyage optimization based on the control of emissions is presented within [29]. In [29] a careful review of the recent articles regarding the voyage optimization driven by emissions is presented and the investigation of the state-of-art and additional identification of possible future work are presented. Lashgari et al. [30] proposed a

scenario-based stochastic linear integer programming model which considers routing, sailing speed, and bunkering policy under the uncertainty of fuel price together. They demonstrated that the proposed model could achieve a reduction in total costs and provide acceptable decisions regarding speed and route optimizations. Ng [31] analysed the relationship between the sailing speed and the number of ships required to attain yearly transport work constant. The author demonstrated that there is only a limited choice regarding the number of ships to deploy.

Even though there are lots of benefits related to the introduction of slow steaming, there are many concerns related to a mandatory slow steaming policy. The most important concern is related to the fact that slow steaming will result in an increased voyage time, weakened just-in-time delivery service, and reduced yearly ship's number of voyages, which could result in the risk of distorting the market. The increase in voyage time is of particular importance for cold chain logistics, such as fresh fruit, vegetables, and meats since increased voyage time could lead to degradation of product quality and higher energy consumption for refrigeration [32]. Furthermore, slow steaming could alter transport because of increased voyage time, and traders could choose air or road transport as an alternative, which is inopportune from an environmental point of view [13]. Also, the world fleet could expand, and capital investments could increase due to the mandatory slow steaming since a higher number of ships would be necessary to attain the yearly transport work constant [13]. Even though increased voyage time associated with lower speeds means more ships or load is required to attain yearly transport work constant, a 10 % reduction in speed may result in a total average emissions reduction of 19 % [33, 34]. Finally, ships would operate in conditions that are significantly different from those for which they were designed and optimized [17]. This is of particular importance for engine operation since the application of slow steaming causes the engine to operate at lower loads. Guan et al. [35] demonstrated the significance of blower activation at lower loads, and the fact that without it, a significant increase in exhaust gas temperature and thermal loading would occur. Besides the operation of the main engine, which needs to be carefully investigated under the lower loads, there is the requirement for optimization of auxiliary systems to improve the energy efficiency [36].

Consequently, several technical, market, and economic factors including voyage number, chartering time, customer demand, and additional operational costs will impact the slow steaming. Mandatory slow steaming would result in reduced CO_2 emissions from the maritime transport industry. However, the imposition of mandatory application of slow steaming would significantly impair the sustainable growth of the maritime transport industry in the longer term since the application of slow steaming does not encourage

innovative novel technologies for emission mitigation [13]. On the other hand, policies regarding speed reduction could be introduced within the regulatory framework based on fair markets and voluntary actions, without the necessity of becoming a mandatory regulation [37]. To familiarize the application of slow steaming, several future studies should be carried out. These studies should be related to the investigations of off-design conditions, firstly from a hydrodynamic point of view, but from an engine and structural point of view as well.

4. Conclusion

One of the most important issues in the 21st century is climate change, which is caused by the emissions of greenhouse gas and as a result has the rise in the global average temperature. To preclude detrimental climate change all branches of industry including maritime transport are dealing with the challenge of reducing emissions. The important step regarding the climate action is surely the ratification of the Paris agreement, which has set a restrain for global average temperature significantly lower than 2 °C and preferably restrains the growth to 1.5 °C compared to preindustrial levels. Since the maritime transport industry produces 2.89 % of global anthropogenic emissions, it is very important that certain steps towards curbing shipping emissions are made. Therefore, International Maritime Organization (IMO) has imposed an aim to decrease carbon dioxide (CO_2) emissions per transport work by a minimum of 40 % by 2030 and to 70 % by 2050 compared to 2008. Furthermore, several mitigation measures are proposed, which can be classified into short-term, mid-term, and long-term measures. It should be noted that only a few of them are applied in practice since shipping companies consider the return on the investment before adopting a particular measure of energy savings. What is more, many mitigation measures are in the early stage of development, and the maritime transport industry accepts their application very gradually. Speed reduction i.e., slow steaming is a crucial short-term measure, that can be effortlessly implemented, and does not depend upon any supplementary infrastructure. This paper provides an extensive review of slow steaming and GHG abatement potential and points out the disadvantages of its application. Also, it includes the discussion of whether the mandatory slow steaming policy should be introduced. Finally, some proposals for further considerations of the slow steaming policy are provided.

5. Acknowledgments

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References

[1] Intergovernmental Panel on Climate Change, Climate Change 2021. The Physical Science Basis. Working Group I contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, 2021.

[2] World Health Organisation, WHO calls for urgent action to protect health from climate change – Sign the call, https://www.who.int/news/item/06-10-2015-who-calls-for-urgent-action-to-protect-health-from-climate-change-sign-the-call , accessed 26th October 2021.

[3] United Nations, The Paris Agreement, https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement , accessed 26th October 2021.

[4] Our World in Data, Emissions by sector, https://our-worldindata.org/emissions-by-sector , accessed 26th October 2021.

[5] United Nations Conference on Trade and Development, 2019. Review of Maritime Transport. Geneva: United Nations.

[6] International Maritime Organisation, 2014. Third IMO Greenhouse Gas Study 2014. IMO, London.

[7] Marine Environment Protection Committee, 2018. 72/71/Add.1. Initial IMO Strategy on Reduction of GHG Emissions from Ships. IMO, London.

[8] Farkas, N. Degiuli, I. Martić, and M. Vujanović, "Greenhouse gas emissions reduction potential by using antifouling coatings in a maritime transport industry," J Clean Prod, Vol. 295, 2021, 126428.

[9] S. Zhang, Y. Li, H. Yuan, and D. Sun, "An alternative benchmarking tool for operational energy efficiency of ships and its policy implications," J Clean Prod, Vol. 240, 2019, 118223.

[10] V. N. Armstrong, "Vessel optimisation for low carbon shipping," Ocean Eng, Vol. 73, 2013, pp. 195-207.

[11] R. A. Halim, L. Kirstein, O. Merk, L. M. Martinez, "Decarbonization Pathways for International Maritime Transport: A Model-Based Policy Impact Assessment," Sustainability, Vol. 10, No. 7, 2018, 2243.

[12] E. A. Bouman, E. Lindstad, A. I. Rialland, and A. H. Strømman, "State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping–A review," Transport Res D-Tr E, Vol. 52, 2017, pp. 408-421.

[13] M. S. Eide, C. Chryssakis, and Ø. S Endresen, "CO2 abatement potential towards 2050 for shipping, including alternative fuels," Carbon Manag, Vol. 4, No. 3, 2013, pp. 275-289.

[14] H. Xing, S. Spence, and H. Chen, "A comprehensive review on countermeasures for CO2 emissions from ships," Renew Sust Energ Rev, Vol. 134, 2020, 110222.
[15] A. Farkas, N. Degiuli, and I. Martić, "Impact of biofilm on the resistance characteristics and nominal wake," P I Mech Eng M-J Eng, Vol. 234, No. 1, 2020, pp 59-75.
[16] N. Rehmatulla and T. Smith, "Barriers to energy efficient and low carbon shipping," Ocean Eng, Vol. 110, 2015, pp. 102-112.
[17] C. Banks, O. Turan, A. Incecik, G. Theotokatos, S. Izkan, C. Shewell, and X. Tian, "Understanding ship operating profiles with an aim to improve energy efficient ship operations," In Proceedings of the low carbon shipping conference, London (Vol. 9), September 2013.
[18] T. Tezdogan, Y. K. Demirel, P. Kellett, M. Khorasanchi, A. Incecik, and O. Turan, "Full-scale unsteady RANS CFD simulations of ship behaviour and performance in head seas due to slow steaming," Ocean Eng, Vol. 97, 2015, pp. 186-206.
[19] H. Lindstad and G. S. Eskeland, "Low carbon maritime transport: how speed, size and slenderness amounts to substantial capital energy substitution," Transport Res D-Tr E, Vol. 41, 2015, pp.244–256.
[20] IMO. Introduction to IMO. http://www.imo.org/en/About/Pages/Default.aspx, accessed 26 October 2021.
[21] C. Y. Lee, H. L. Lee, and J. Zhang, "The impact of slow ocean steaming on delivery reliability and fuel consumption," Transport Res E-Log, Vol. 76, 2015, pp. 176-190.
[22] C. C. Chang and C. M. Wang, "Evaluating the effects of speed reduce for shipping costs and CO2 emission," Transport Res D-Tr E, Vol. 31, 2014, pp.110–115.
[23] F. Tillig, J. W. Ringsberg, H. N. Psaraftis and T. Zis, "Reduced environmental impact of marine transport through speed reduction and wind assisted propulsion," Transport Res D-Tr E, Vol. 83, 2020, 102380.
[24] N. Degiuli, I. Martić, A. Farkas and I. Gospić, "The impact of slow steaming on reducing CO2 emissions in the Mediterranean Sea," Energy Reports, Vo. 7, 2021, pp. 8131-8141.
[25] W. M. Wu, "The optimal speed in container shipping: Theory and empirical evidence," Transport Res D-Tr E, Vol. 136, 2020, 101903.
[26] R. Adland, P. Carriou, and F. C. Wolff, "Optimal ship speed and the cubic law revisited: Empirical evidence from an oil tanker fleet," Transport Res D-Tr E, Vol. 140, 2020, 101972.
[27] F. H. Berthelsen and U. D. Nielsen, "Prediction of ships' speed-power relationship at speed intervals below the design speed," Transport Res D-Tr E, Vol. 99, 2021, 102996.

[28] B. Taskar and P. Andersen, "Benefit of speed reduction for ships in different weather conditions," Transport Res D-Tr E, Vol. 85, 2020, 102337.
[29] J. R. Medina, J. Molines, J. A. González-Escrivá and J. Aguilar, "Bunker consumption of containerships considering sailing speed and wind conditions," Transport Res D-Tr E, Vol. 87, 2020, 102494.
[30] H. Yu, Z. Fang, X. Fu, J. Liu and J. Chen, "Literature review on emission control-based ship voyage optimization," Transport Res D-Tr E, Vol. 93, 2021, 102768.
[31] M. Lashgari, A. A. Akbari, and S. Nasersarraf, "A new model for simultaneously optimizing ship route, sailing speed, and fuel consumption in a shipping problem under different price scenarios," Appl Ocean Res, Vol. 113, 2021, 102725.
[32] M. Ng, "Vessel speed optimisation in container shipping: A new look," J Oper Res Soc, Vol. 70, No. 4, 2019, pp. 541-547.
[33] P. Balcombe, J. Brierley, C. Lewis, L. Skatvedt, J. Speirs, A. Hawkes, and I. Staffell, "How to decarbonise international shipping: Options for fuels, technologies and policies," Energy Convers Manag, Vol. 182, 2019, pp. 72-88.
[34] J. Faber, H. Wang, D. Nelissen, B. Russell, and D.S. Amand, "Reduction of GHG emissions from ships: marginal abatement costs and cost effectiveness of energy-efficiency measures," London, UK: International Maritime Organization (IMO), 2011.
[35] C. Guan, G. Theotokatos, P. Zhou, and H. Chen, "Computational investigation of a large containership propulsion engine operation at slow steaming conditions," Appl Energ, Vol. 130, 2014, pp. 370-383.
[36] C. Dere, and C. Deniz, "Load optimization of central cooling system pumps of a container ship for the slow steaming conditions to enhance the energy efficiency," J Clean Prod, Vol. 222, 2019, pp. 206-217.
[37] H. N. Psaraftis, "Speed Optimization vs Speed Reduction: the Choice between Speed Limits and a Bunker Levy," Sustainability, Vol. 11, No. 8, 2019, 2249.

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Review paper

An Analysis of Qualifications and Personal Characteristics of Successful Marina Manager*

Senka Šekularac Ivošević, Dragana Milošević

Abstract: As a modern industry based on meeting the high-demanding customers who prefer vacation and recreation at sea, nautical tourism requires professional staff with renowned qualifications and personalities developed. Marina managers especially should reach this imperative of industry mentioned. The methodology in this paper is inherent in the methodology of social sciences. The primary research includes surveys and in-depth interviews examining the attitudes of marina managers in Montenegro about professional requirements and personal attributes that describe successful careers. The research results confirm previous findings in the literature and shape the position of marina managers based on the necessary education, experience, technical and leadership skills, and personalities. Implications of this paper refer to improving study plans and programs in maritime education, which is the first step in developing high-quality management staff in the marina business.

Keywords: Marina, Management, Professional requirements, Personality development.

1. Introduction

Tourism is an activity that achieves continuous expansion on a global level, excluding the period of the pandemic crisis when there was a significant decline in activity, primarily in air and maritime, road, and rail transport. Before the pandemic, all projections indicated that the tourism sector was expected to grow by 3 to 4% in 2020. As one of the most visited destinations in the world, the Mediterranean region recorded an increase in the share of tourism in the GDP of 75% from 1995 to 2020 [1; 2]. Nautical tourism is rated as the most promising selective type of tourism globally and in Montenegro. It records annual growth of approximately 2-3% [3; 4; 5; 6]. Projections before the COVID 19 pandemic indicated that the global size of the marina market would reach $ 51.37 billion by 2025, with an average growth rate of 4.3% over the period 2019-2025 year [7].

*An earlier version of this paper was presented at the 1st Kotor International Maritime Conference – KIMC 2021, Kotor, Montenegro.

According to Montenegrin official statistical reports there was a permanent increase in the turnover of nautical vessels and passengers from 2007 to 2019, as illustrated in Fig. 1. In 2020 the traffic of nautical vessels decreased by 61.1%, and the passenger traffic by 73.9%, compared to 2019. Preliminary data from 2021 indicate the revitalization of nautical tourism with an increase in vessel traffic by 124.76% and passenger traffic by 236.86 %, compared to 2020 [6].

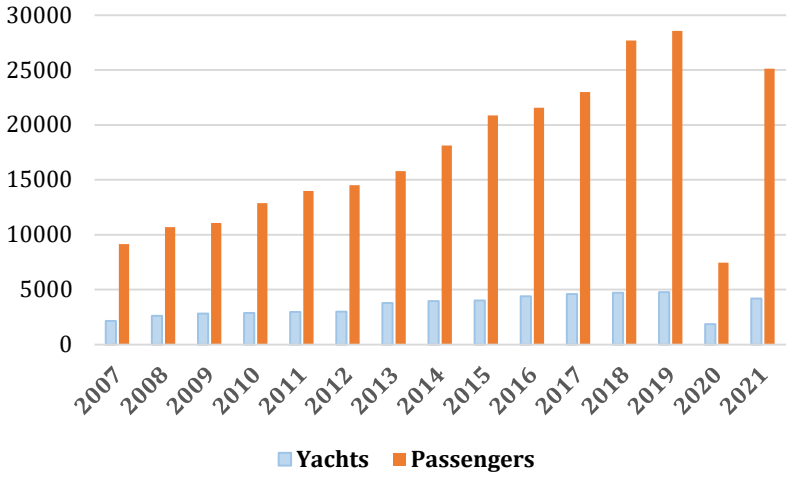

Fig. 1 - *The traffic of nautical vessels and passengers 2007-2021 [6]*

Along the 294 km of the Montenegrin coast there are 11 marinas with about 4,000 berths. Significant foreign investments have contributed to the development of marine infrastructure on the Montenegrin coast, which has created the need for managerial staff in modern marinas.

Many studies implemented the concept of a systematic review approach to explore the literature that has been conducted in human resources in the maritime industry, especially in shipping, where it has been proven that human error was the cause of 80% of accidents [8]. Some of these errors are crew management errors, as preoccupation with minor technical problems, failure to delegate tasks and responsibilities, failure to set priorities, inadequate monitoring, failure to utilize available data, inability to communicate intent and plans, etc [9].

In particular, leadership, teamwork, communication, situation awareness, decision making, ethics, and environmental awareness are explored as essential elements of maritime management onboard. Generally, in the maritime industry, a lot of research is dealing with the question: *Who are the maritime managers of the future* [10; 11; 12]? In this paper, the aim is to answer this question with application in the marina business.

It is a great responsibility to run the activities of marina managers. In the long run, the management staff in marinas is responsible for the market position and represents one of the foundations of marina success [12]. The success of a marina manager is measured by how well he/she can ensure the efficiency and profitability of the marina's operations and manage the entire marina's assets. Marina manager working through personal example and collaborating with subordinate supervisors aims to maximize the development of all facility's potential. The leading task of marina managers is to manage the marina to implement and maintain systems and processes that effectively provide all marina customers, tenants, and contractors with the highest level of professionalism and customer service. This leading task can be divided into several ones as management of technical processes in the marina, marina business management and activities, financial and strategic planning of the marina, communication and coordination with external (partners, guests) and internal (employees) stakeholders, protection of the sea and environment, improving the knowledge in maritime law and other relevant regulations [13]. Previous research shows that the goal of marina managers is to achieve the best possible differentiation of marine services and provide marketing positioning based on the high quality and unique service offers using modern technology [14].

Searching numerous web platforms that could help marina managers get jobs (Indeed Job Search, Glassdoor Jobs, LinkedIn, Google for Jobs), the authors of this paper systematized that fundamental duties and responsibilities of the candidates are in the domain of:

- Management of marina facilities in a way that ensures all property and assets are maintained, monitored, and presented in a manner that is in keeping with the marina standards,
- Business Planning & Finance,
- Sales & Marketing,
- Marina Operations,
- Law & Legislations,
- Standards & Regulations,
- Customer care, and
- Management of all employees effectively and following all HR policies established.

Previous research has shown that marina managers are not prone to decentralization. Middle and senior managers are responsible for operational and repetitive activities but less for strategic and tactical ones while avoiding

business risks. The main factors that influence the decision-making of marina managers are professionalism in the preparation of decisions and availability of accurate information [11].

In addition to essential duties and responsibilities, it is imperative to explore the qualifications of the candidates for the position of marina manager: education, experience, language skills, computer skills, physical demands.

This paper aims to propose qualifications and personal characteristics needed for the position of marina manager. Furthermore, the paper seeks to encourage maritime education and training institutions to improve subjects such as Maritime Management, Maritime Marketing, Finance and Human Resources Management in Maritime Affairs to meet the demand of the growing marina labor market in Montenegro.

2. Methodology

In this paper, the authors used a qualitative method to examine employees' attitudes on managerial positions in Montenegrin marinas. The survey method is suitable for collecting primary data, including facts, opinions, attitudes, intentions, and motives of respondents.

For the first part of the research related to the business qualifications of marina managers, a survey questionnaire was created in Google Drive form. The questionnaire was forwarded to the target respondents via email addresses available on the official websites of the marinas. Online data collection through online surveys in academic research has numerous advantages over traditional ones, in terms of wide geographical dispersion, time and cost efficiency, functionality, flexibility, and the aesthetic moment [15; 16]. The structure of the online questionnaire consists of topics related to gender and age structure, functional position of marina manager, level and field of education qualifications, and previous work experience in the marina business.

For the second part of the research related to the personality of marina managers, an in-depth interview as a popular questioning technique was used. The two questions were:

1. What are the moral character, integrity, and sincerity of a person's commitment to marina management as a profession? and
2. Describe an ability of a person to become a marina manager.

The questions are formulated based on a prestigious reference for the position of marina manager issued by Global Marina Institute, i.e., CMM certificate - Certified Marina Manager.

The sample consists of sixteen (16) managers in Montenegrin marinas: Marina Bar, Marina Kotor, Luštica Bay, Porto Montenegro, D-Marin Portonovi, and Lazure Marina. The sample size is considered respectable given the smaller population of marinas in Montenegro.

3. Results

The results obtained based on questionnaires (qualifications of managers) and in-depth interviews (personal characteristics of managers) are presented in the following sections.

3.1. Analysis of Qualifications of Marina Managers

For equations Analysis of the answers obtained through the online questionnaire shows that the sample of 16 managers employed in Montenegrin marinas is characterized by gender equality. When it comes to the functional position of manager in the marina, most responses were received by the operations managers (44%), followed by marketing and communications managers (19%), CEOs (18%), and others (19%).

According to age, the participation of respondents in the sample is on average the highest between 21-30 years (7 managers - 44%) and 31-40 years (5-31%), followed by 41-50 (2 managers, 12,5%) and 51-60 years (2 managers, 12, 5%). The survey did not detect marina managers over 60 years old (see Fig. 2).

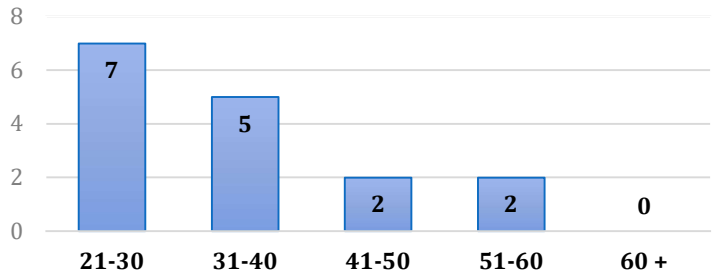

Fig. 2 - *The age structure of marina managers in Montenegro [Authors]*

According to the age structure, it can be noticed that there is a difference between the managerial staff in Montenegrin marinas compared to neighboring Croatia, for example. Namely, in 2004, the dominant age structure of Croatian marina managers was between 41 and 50, and 51 to 60 in 2014 [11;12;17].

According to the level of educational qualifications, on average more than half of managers (57%) have a Bachelor's degree, and 31% have a Master's degree (see Fig. 3). Two respondents pointed out that they completed a CMM - Certified Marina Manager course in addition to formal education.

These results align with previous research that confirms that marina managers' dominant level of education is higher [11;12].

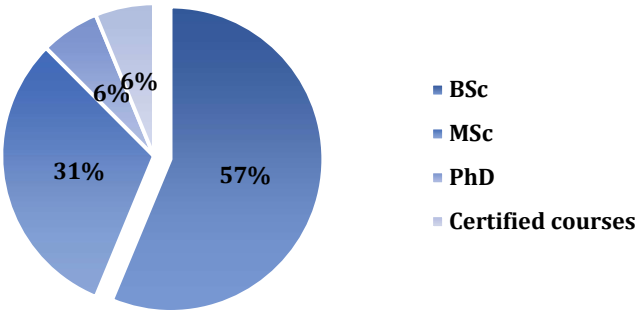

Fig. 3 - *Level of educational qualifications that managers hold in Montenegrin marinas [Authors]*

It is complex to define the best educational background for marina managers. However, it is considered that maritime and economic educational experience has an advantage, given the group of jobs in marinas that most correspond to these areas [18].

The field of education of managers employed in Montenegrin marinas mainly corresponds to maritime affairs, management, and economics (see Fig. 4).

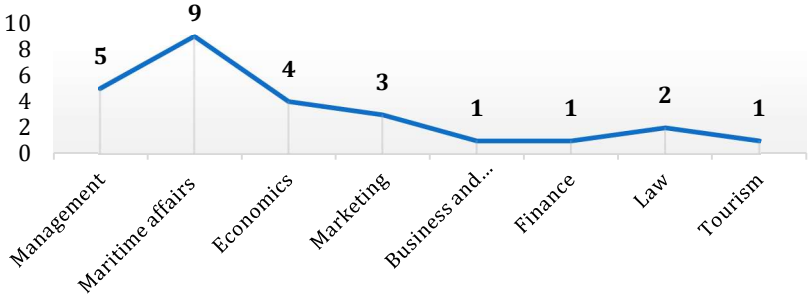

Fig. 4 - *Field of education of marina managers in Montenegro [Authors]*

According to Fig. 5, respondents, on average, have up to 5 years of work experience in the role of marina managers (8 managers, i.e., 50%). They are followed by managers with 10-20 years of work experience (4 managers, i.e., 25%). Finally, three marina managers (19%) have 5-10 years of work experience.

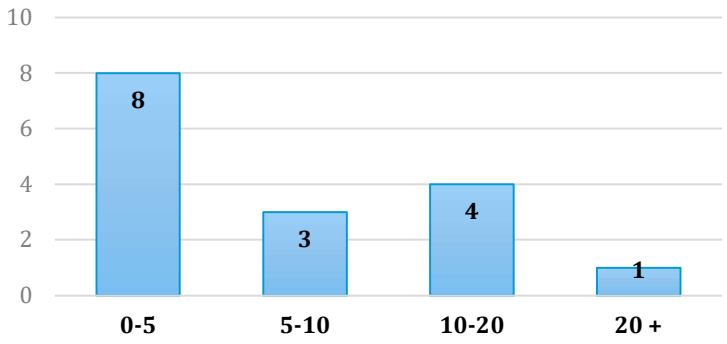

Fig. 5 - *Work experience of managers in Montenegrin marinas [Authors]*

The majority of managers gained work experience in a particular marina, which is in line with the respondents' age structure and work experience. Senior managers state that they have worked in two to four marinas so far.

3.2. Analysis of Personal Characteristics of Marina Managers

The results of an in-depth interview realized to discover the personal characteristics of the respondents led to the findings explained in the continuation of the paper. After survey realization, firstly, the authors detected moral character, integrity, and sincerity of commitment of the person for being marina manager. Secondly, the ability of a person to become a marina manager is defined.

Firstly, marina managers in Montenegro emphasized the crucial attributes of the manager's personality. Awareness that staff is the essential resource a marina has is the basis for good HR management practice. A professional manager shows good qualities to direct people, avoiding favoring employees. It is crucial to have personal integrity built on honesty to represent a model of good behavior for other employees in marinas. When it comes to management styles, the autocratic style where the manager has a dominant attitude of a “closed mind” is avoided by marina managers in Montenegro. The respondents believe that they will not retain high-quality staff in this way for a long time. They think that managers should use different leadership styles according to the situation and work ethic.

Secondly, one of the most critical qualifications for a marina manager is knowledge of the industry, which was confirmed by the respondents interviewed in this paper. Namely, they emphasized the importance of good business results that managers previously achieved by operating in the marinas and other companies during their careers. In other words, the reputation that managers enjoy in the professional and social community is a highly ranked ability (e.g., how socially responsible the manager is).

Top managers show an active commitment to duties and tasks, constantly developing knowledge and skills and following the market and yachting industry trends. Managers emphasized the importance of communication skills, especially in delegating tasks to employees with different intellectual abilities. In that sense, managers must communicate effectively with employees, customers, and other partners. In addition, active listening is crucial in daily communication with employees and assessing the work done, as well as patience and mentoring skills to use the strengths and reduce the weaknesses of the marina team members.

Furthermore, the managers highly ranked good decision-making and problem-solving skills. For the marina manager, process management, i.e., control and monitoring of financial operations, is a challenging task given the large number of companies involved in the marina business. To manage the current situation, marina managers must control the profit centers independently and individually and identify checkpoints [19;20]. Additionally, marina managers pointed out that they developed the ability to face challenges of this type by obtaining certified courses.

A wide range of courses covering various subjects is highly recommended for future marina managers. Some of them are financial management, sales and marketing management, regulatory obligations of the marina business, successful bottom line management principles, fundamentals of high character and ethics standards, supervision and managing people [21].

4. Conclusion

This research is motivated by the fact that marina management is a complex activity. Among other elements, the complexity in running a marina business is reflected in the provision of luxury services, the satisfaction of exquisite customer taste, high safety, and environmental standards. Starting from the above mentioned, the authors investigated the qualifications and personal characteristics of marina managers in Montenegro. Modest sources dealing with the profile of managers in the marina business have been found in the scientific literature.

The findings show that the managers surveyed have the necessary work experience and higher education qualifications in maritime affairs, management, and economics. In addition, the educational qualifications are upgraded with certified courses relevant for the position of marina manager.

Regarding personal characteristics, morality and ethics in relations with staff and clients, orientation towards socially responsible behavior, leadership and communication skills, decision-making and problem-solving skills, and the financial skills of marina managers are highly emphasized.

It was concluded that many maritime faculties offer courses in management, marketing, human resource management, and finance in maritime affairs. However, there is a need to connect experts from practice with academic staff to innovate the curricula according to the modern requirements of the marina market. This kind of cooperation would provide a solid foundation for creating better human potentials for managerial positions in marinas.

References

[1] Eco-union. The future of Mediterranean tourism in a (post) covid world back to mass tourism or leapfrog towards sustainability. 2021, available at: https://www.ecounion.eu/wp- content/uploads/2021/04/Nota_Thefuture_mediterranean_tourism_03.pdf [accessed: 10/10/2021].

[2] Statista Research Department. International tourist arrival growth in European countries 2020. 2021, available at: https://www.statista.com/statistics/543713/european-countries-international-tourist-growth/[accessed: 12/10/2021].

[3] European Commission. Study on specific challenges for a sustainable development of coastal and maritime tourism in Europe – Final report. 2016, available at: http://publications.europa.eu/resource/cellar/ab0bfa73-9ad1-11e6-868c 01aa75ed71a1.0001.01/DOC_1, [accessed 12/10/2021].

[4] The Superyacht Annual Report. Marinas & migration. 2017, available at: https://shop.thesuperyachtgroup.com, [available at: 04/10/2021].

[5] Risposte Turismo. Adriatic sea tourism report 2019 edition – execute summary. 2019, available at: http://www.adriaticseaforum.com [accessed: 14/10/2021].

[6] MONSTAT. Nautical tourism – releases. 2021, available at: https://www.monstat.org/eng/page.php?id=499&pageid=43 [accessed: 14/10/2021].

[7] Atehnologymarket. Marinas market by new market opportunities production cost analysis market development and market dynamics forces 2019-2025. 2019, available at: https://atechnology-market.com/marinas-market-by-new-market-opportunities-production-cost- analysis-market-development-and-market-dynamics-forces-2019-2025/ [accessed: 15/10/2021].

[8] J. Sánchez-Beaskoetxea, I. Basterretxea-Iribar, I. Sotés and M. de las Mercedes Maruri Machado, "Human error in marine accidents: Is the crew normally to blame?," Maritime Transport Research, 2, pp. 1-16, February 2021.

[9] S. Šekularac-Ivošević. "Seaferers' education and training in the context of improvement leadership and managerial knowledge and skills," In Proceedings TIO 2016, 6th International conference Technics and Informatics in Education - TIO 2016, I. Milićević, Ed. Čačak, Serbia, 28-29th 2016, pp. 361-366.

[10] B. A. B. Fjærli, K. I. Øvergård and T. V. Westerberg. "Maritime managers of the future – What do they think is good leadership?," TransNav - the International Journal on Marine Navigation and Safety of Sea Transportation, Vol. 9, No. 1, pp. 107-111, March 2015.

[11] A. Jugović. "Functioning of the management in ports of nautical tourism of the Republic of Croatia," Scientific Journal of Maritime Research, Vol. 30, No. 1, pp. 51-57, June 2016.

[12] A. Jugović, S. Gorana and S. Donald. "General competence analysis of management in nautical tourism ports in the republic of Croatia," Interdisciplinary Management Research XIII, pp. 287-296, 2017.

[13] M. Slišković, H. Ukić and E. Marušić. "Labor market need analysis as basis for the foundedness of occupational standards in the field of maritime management," Transactions on Maritime Science. Vol. 05, No. 01, pp. 29-39, 2016.

[14] D. Milošević, I. Milić-Beran, and S. Šekularac-Ivošević. "Montenegrin marinas before and during the Covid-19 pandemic: Cost Leadership Strategic Perspective," Proceedings of the 2nd International Conference of Maritime Science & Technology "Naše More", Maritime Department University of Dubrovnik, Dubrovnik, Croatia, pp. 242-254, 17 – 18 September 2021.

[15] S. Lefever, M. Dal, and Á. Matthíasdóttir. "Online data collection in academic research: advantages and limitations," British Journal of Educational Technology, 38(4), pp. 574–582, 2007.

[16] J. Lumsden, Online-questionnaire design guidelines. In Handbook of research on electronic surveys and measurements, R.A. Reynolds, R. Woods, and J.D. Baker, Eds. Hershey, PA: Idea Group, pp. 44-64, 2007.

[17] P. Sikavica, F. Bahtijarević-Šiber. Menadžment, Teorija menadžmenta i veliko empirijsko istraživanje u Hrvatskoj (Management, theory of management and great empirical research in Croatia; processing data from the questionnaire), Masmedia, Zagreb, 2004.

[18] T. Luković. "Nautički turizam – definicije i dileme," Naše more, Vol. 54, No. 1/2, pp. 22-31, 2007.

[19] D. Kissman, Basic marina management: Simply complex. 2003, available at: https://marinamanagt.squarespace.com/blog/category/Software, [accessed 25/10/2021].

[20] Signal Connected, 8 Traits for marina management. 2018, available at: https://www.signalconnect.com/blog/8-traits-for-marina-management/, [accessed 25/10/2021].
[21] Association of Marina Industries, CMM certification, available at: https://marinaassociation.org/trainingcmmcertification, [accessed 28/10/2021].

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Review paper

Review of Cargo Operations on Crude Oil Tankers and Methods/Models Used for Optimisation and Improvement of Safety*

Mislav Maljković, Srđan Vukša, Pero Vidan, Ivica Pavić

Abstract: Very Large Crude Carriers (VLCCs) are special ships because of their length, breadth, draft, stability stresses and manoeuvrability. Cargo handling is one of the most sensitive operations in terms of safety and oil pollution, as oil is a dangerous cargo to transport. Of particular concern is the potential marine pollution from accidental oil spills. Operational oil spills on crude oil tankers are caused by operations such as loading and unloading, tank cleaning, crude oil washing, ballasting and discharge of oily water overboard. Over the years, advanced equipment, numerous procedures and checklists have made cargo operations safer, but unfortunately have also made ship crews and officers less attentive. Strict control must be maintained throughout the loading, unloading and all other cargo related operations. The main objective of this article is to review the methods and models used to improve the safety of cargo handling operations.

Keywords: Tanker, Cargo operations, Safety, Oil spill, Cargo pumps, Cargo planning.

1. Introduction

Cargo handling operation on Crude oil tankers is a very sensitive operation in terms of safety and oil pollution and must be carried out with great care. Tanker operations such as loading, unloading, crude oil washing (COW), inerting, purging, tank cleaning, and degassing (gas free) pose a great risk to marine pollution and to the ship itself, as there is a risk of fire and explosion. An operations plan must be prepared for each operation, including permits and checklists, accompanied by a risk assessment. The plan must be strictly followed when carrying out each operation. Any deviation from the plan must be discussed with all persons involved and the risk assessment reviewed. A safety meeting must be held with all persons involved before

*An earlier version of this paper was presented at the 1st Kotor International Maritime Conference – KIMC 2021, Kotor, Montenegro.

work commences and all crew must be aware of their duties and responsibilities. Oil spill equipment must be in place in accordance with the plan to prevent possible pollution from cargo and to prevent oil spill overboard. All natural vents must be closed and the air conditioning system set to recirculation mode in the event that hazardous gases are spread.

Loading and discharging operations on very large crude carriers are very demanding and require full commitment in cargo planning. Particular care must be taken in stability calculations, especially when more than one parcel of crude oil is loaded. When more than one parcel of crude oil is loaded, the stability calculation must take into account that any loaded parcel of crude oil may be discharged first. Therefore, proper distribution of cargo is very important. Oil tankers are designed to withstand the loads (stresses) on the ship's structure, but cargo plan must be prepared in order to minimise the loads. The bending moment of the ship (BM) and the shear factor (SF) must always be within their safety limits. During the discharge process on crude oil tankers, a crude oil wash (COW) is carried out. During the crude oil wash, the cargo tanks are washed with the existing cargo to remove the remaining sediments of crude oil in the cargo tanks. If tank cleaning is required after COW, the removal of the remaining residues in the cargo tanks will be significantly reduced. To control oil residues, at least 25 percent of cargo tanks must be washed with crude oil before each ballast voyage and each cargo tank must be washed with crude oil at least every fourth time crude oil is discharged from the cargo tank.

On crude oil tankers, inerting cargo tanks is a procedure that is carried out by an experienced crew due to the high risk of fire and explosion. The procedure is carried out before loading to prevent an unsafe (explosive) atmosphere in the cargo tanks. At this time, the lower explosive limit (LFL) in the cargo tanks can be lowered by inerting the cargo tanks. Therefore, the gas mixtures in the cargo tanks are not in the flammable zone because the oxygen concentration is below 8% or less. Although this process is critical to the safe operation of tankers, harmful consequences of particular operation could represent potential harm to human life (oxygen deficiency), the environment (hazardous gas emissions) and the cargo on board (explosion). Therefore, it is of utmost importance for ship operators and marine engineers to assess the risk of human error during the inerting process to avoid unexpected consequences [1].

Degassing (gas free) operation is described as one of the most dangerous operations on crude oil tankers. The aim of degassing process is to remove explosive or toxic gases from cargo tanks and to increase oxygen content to atmospheric conditions. The atmosphere in the cargo tank must contain sufficient oxygen to be entered. The procedure is performed after tank cleaning to prepare the tank atmosphere for entry so that it is available for

inspection and maintenance. A typical degassing (gas free) operation begins by inerting the cargo tanks to reduce the oxygen content to 8% or less. Then tank cleaning operation is done in order to remove sediments of previous cargo. This increases the volatile organic compound content (VOC). Then the cargo tanks are purged before gas free operation. There are two methods of degassing widely used on tankers: Degassing by displacement and degassing by dilution. Degassing (gas free) operation starts with fixed or portable fans through an open manhole. In this way, toxic and flammable gases (inert gas and residues from VOC) are removed from the cargo tanks and fresh air is introduced into the cargo tanks. The cargo tanks are ″gas-free″ when the oxygen concentration is 20.9% and no traces of toxic gases are present. As the process is harmful to the crew and the maritime environment due to the toxic gases release during ventilation, all personnel are required to wear personal gas detectors and respirators as required [2].

2. Crude oil carriers

The size of tanker depends on the amount of cargo to be carried, the size and limits of the port, and draft restrictions. Ultra Large Crude Carriers (ULCC) with a capacity of 300-500,000 dwt are the largest crude oil tankers. Due to their size, most ports and terminals cannot accommodate these huge tankers, so they have to transfer their cargo to smaller tankers which then proceed to the terminals. Such "smaller" tankers are called Aframax tankers with a capacity of 79,999 dwt.

Very Large Crude Carriers (VLCC) have a very large cargo capacity of 160-300,000 dwt and can call at many ports, giving them an advantage in the amount of crude oil they can transport. They can carry several types of crude oil (usually four) and have a simple loading system. Larger ships, lower transportation costs and the ability to call at numerous ports around the world make VLCC's unique vessels in the tanker business.

Product tankers range in size from 26-40,000 dwt and are used to transport clean and dirty products as well as crude oil.

Handy- sized tankers (coasters) have a carrying capacity of 16-25,000 dwt and are used to transport clean and dirty products and crude oil along the coast, usually between the same locations [3].

3. Important parameters of crude oil for cargo operations

Crude oil is a liquid that comes directly from deposits beneath the earth's surface. It is called crude oil because this liquid must be processed (refined) into usable products such as gasoline. There are different types of crude oil around the world. Important characteristics (properties) of crude oil related to cargo operations are density (API), vapour pressure, flash

point, pour point, wax content, cloud point, viscosity, sediment and water, sulphur content, benzene content. Density is the ratio of mass to volume. API (American Petroleum Institute) gravity is an inverse measure of the density of an oil liquid relative to the density of water. Vapour pressure indicates the tendency of a liquid to change into a gaseous or vapour state. Flash point is the lowest temperature at which a liquid gives off enough gas to form a flammable gas mixture near the surface of the liquid. Pour point is the lowest temperature at which a liquid remains in the liquid state. Crude oils with a high pour point must be heated to reduce viscosity so they can be discharged by cargo pumps. Only crude oil tankers with a heating system for cargo can carry such crude oil. Wax content is the percentage of paraffinic wax by volume. Cloud point is the temperature at which a liquid hydrocarbon begins to solidify and take on a cloudy appearance. Viscosity is the ability of a liquid to resist flow. Crude oil with high viscosity is unsuitable for crude oil washing (COW). Basic sediment and water (BS &W) are a percentage of free water, sediment and emulsion. This value is added to the total amount of crude oil volume loaded. Sulphur content is the amount of hydrogen sulphide (H2S) present in the crude oil. This is a dangerous gas that smells like rotten eggs and can cause instant death in large quantities. When transporting crude oil with high H2S content, warnings must be posted and special precautions taken during transportation and loading.

Benzene is found in aromatic hydrocarbons and is carcinogenic. Physical contact, ingestion or inhalation must be avoided.

Because of these properties, there are different procedures for transport, loading, unloading, COW (crude oil washing), purging, tank cleaning and degassing [4], [5].

4. Cargo equipment

Fig. 1 shows the most common cargo pumps on crude oil tankers are centrifugal pumps located in the pump room. There are three centrifugal pumps in the pump room, each connected to a separate cargo line that can be connected by crossover valve when the same crude oil is being loaded. They are used for bulk transfer of crude oil. There are also two centrifugal ballast pumps in the pump room for ballast transfer. Centrifugal pumps consist of two main components: the impeller and shaft as rotating elements and the casing, mechanical seals and bearings as stationary elements. Before starting the pump, liquid must enter the pump (priming) and pressure must be released from the pump (purging). The pump must never be started without liquid, as this may cause severe damage to the cargo pump. During discharge, when the cargo tanks are full, the pumps operate at high capacity and are called bulk discharge. When the liquid in the cargo tanks drops to the

stripping level, the capacity of the cargo pumps drops to low suction and the discharge must be completed with the stripping system.

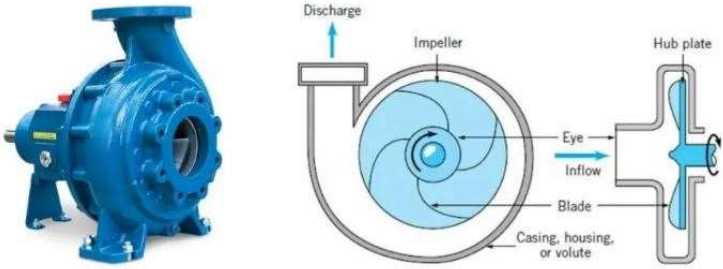

Fig. 1 – *Centrifugal pump [4].*

Fig. 2 shows fluid driven educator which are used for the final stripping of the cargo tanks. The eductor requires a constant and adequate flow rate to create suction, which must remove the remaining cargo from the cargo tanks.

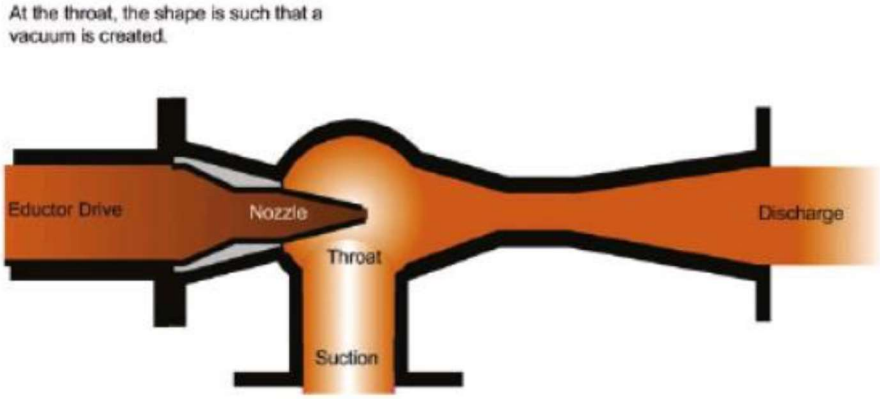

Fig. 2 – *Eductor [4].*

Fig.3 shows a stripping pump which is used to complete the discharge and final stripping of the cargo lines and tanks. Stripping pumps shall be steam driven duplex piston pumps.

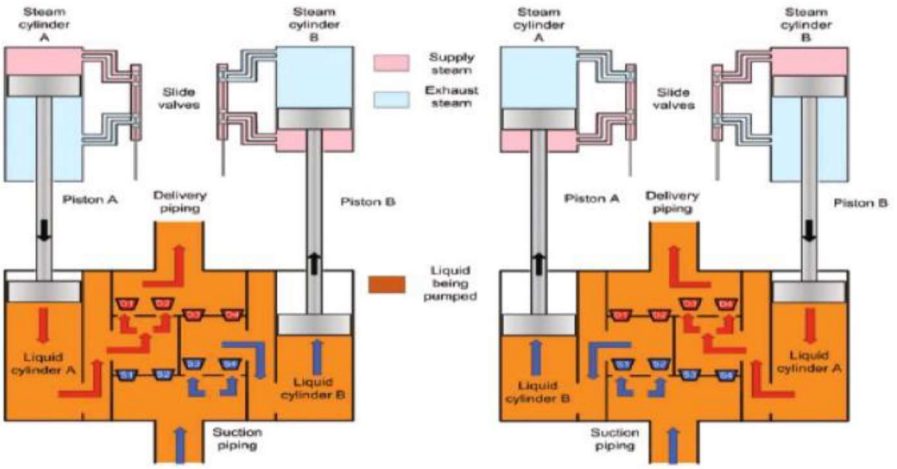

Fig. 3 – Stripping pump *[4].*

The operation of cargo pumps must only be carried out by an authorized person such as the Chief Officer or a Deck Officer under the supervision of the Chief Officer. A sudden change in flow velocity when the line valve on the discharge side is closed rapidly or partially may cause water hammer. This may cause structural damage, pollution, or injury. Water hammer must be avoided by opening and closing valves slowly or gradually. When handling with cargo pumps rapid change in flow rate must be avoided by increasing and decreasing cargo pumps revolutions gradually [3], [4], [6]. The amendments to SOLAS regulations II-2/4.5.5 and II 2/16.3.3 require an inert gas system to be fitted on all new oil and chemical tankers of 8,000 dwt and above, (when transporting low-flash point cargoes of < 60°C). Oil tankers above 20,000 dwt were already required to install such systems. For tankers fitted with exhaust gas inerting systems, the application of inert gas must be carried out during loading, on passage, unloading, tank cleaning and purging prior to gas freeing. The oxygen limit (all tankers) for inert gas supplied to cargo tanks has also been lowered from 8% to 5% for new systems [7]. The importance of inert gas system on tankers is that the atmosphere in cargo tanks is always kept below 5% of oxygen and decreases risk of fire and explosion to minimum. Crude oil washing was made mandatory for new tankers by the 1978 Protocol to the MARPOL Convention. Regulation 33 of MARPOL Annex I requires every new crude oil tanker of 20,000 tons deadweight and above to be fitted with a cargo tank cleaning system using crude oil washing [8]. Crude oil washing was introduced to reduce cargo residues (sludge) to minimum after discharge operation. The outcome is less oil aboard after discharging operation and substantial reduction in air pollution.

5. Cargo planning

Cargo planning can begin as soon as the ship receives the complete voyage order. The voyage order must include the amount of cargo to be loaded, the API value or density, and the temperature of the crude oil for cargo calculation. The name of the port of loading must also be included. The first step is to create a loading plan using the information contained in the voyage order as shown on Fig. 4.

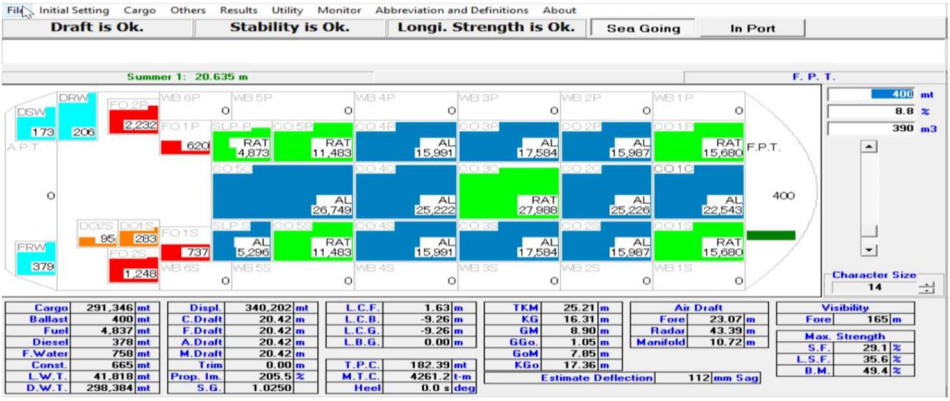

Fig. 4 –*Cargo plan VLCC MT "Pacific Voyager" [4].*

If the vessel is to load more than one grade of crude oil (usually up to four grades for VLCC), the loading plan should be prepared so that each grade loaded can be discharged first at the discharge port. Normally, the vessel does not know which grade will be discharged first until it reaches the discharge port. This loading plan is not easy and sometimes impossible to achieve due to the large load (stresses) of VLCC tankers. The plan must include the details of how cargo handling and ballasting will be carried out. A good cargo plan must include procedures for the safe operation of cargo equipment, standing instructions detailing the stages of cargo operation, and emergency procedures in the event of a fire, explosion or oil spill. Information about the cargo should be clearly stated in the plan, as should the arrangements for pipelines, pumps and the venting arrangements for each type of crude oil. Segregation arrangements must be indicated for each grade and the valves that must not be opened. Cargo plan must be clearly understood by all parties, contain sufficient detail and be easy to understand. The cargo plan must include qualified personnel capable of performing the task, personnel performing critical operations, and rest periods for all personnel involved in the cargo operation. The terminal at berth must provide a Material Safety Data Sheet (MSDS) for all cargo to be loaded, which should be included in the cargo plan [5].

6. Methods/models for optimisation and improvement to safety

Over the years, computerised (automated) systems have been introduced on tankers to improve safety and make it easier for officers. An automated system detects anomalies much faster than the officers on watch and alerts them, giving the officers enough time to correct the anomalies in a timely manner. The officers on watch must be familiar with computerised or automated systems to recognise certain alarms and respond accordingly. The emergency shutdown system (ESD) on tankers in the event of an oil spill can be remotely controlled from the ship as well as from shore. Automated systems can interrupt certain operations on tankers, for example, the cargo pump automatically shuts down if it overheats, preventing damage to the pumps. Over the years, computerised and automated systems, checklists, routines and procedures have minimised human error. Computer programmes and automated systems cannot replace the officer on watch, but they can make the job easier and assist to complete cargo operation in a much safer way for the ship and the environment. Automated systems and computer programs are welcome on tankers but must be under the strict control of trained personnel. Therefore, seafarers are required to be familiar with automated systems on board and to continuously educate throughout their sailing life. Every new automated system introduce on board must be accompanied by a trained crew who will have to take the appropriate course for a particular automatic system installed on board. Automated systems are good as long as there is good supervision over them by trained personnel [9].

Human factor is one of the major causes of accidents and breakdown in the shipping sector. A cognitive reliability and error analysis method has been developed (CREAM) to provide estimates of human error probability (HEP) in tanker operational safety [10].

Over the last decade, the regulatory framework in the shipping industry has put enormous pressure on ship designers, owners and operators to improve on-board safety and drastically reduce the environmental footprint of shipping. Holistic methodology was developed for the systematic variation and optimization of new tanker designs based on the principles of simulation-based driven design in the Friendship Framework [11].

Collision and grounding data registered in GISIS (Global Integrated Shipping Information System) were studied for oil tankers. Risk assessments were carried out using the Fault Tree Analysis (FTA) programme for incidents resulting in collisions and groundings for oil tankers [12].

Advanced computer methods were used to model and simulate gas freeing processes to determine the progress of gas freeing in terms of studying

the concentration and distribution of vapours in the cargo tank during the gas freeing process. The simulation also includes the study of the decrease in vapour concentration in terms of forming a quality model to predict the time required for degassing, given the initial conditions [13].

In order to improve the safety and operational reliability in the maritime industry for the tank cleaning process on board chemical tankers, ship methodology is extended by integrating the Analytic Hierarchy Process (AHP) technique into the approach HEART. It is a methodological development in the field of decision making and human factors to weight the share of impact in the calculation of error-causing conditions by operations [14].

7. Conclusions

Although safety on tankers has improved considerably in recent years, accidents still occur, a high percentage of which are attributable to the human factor. Modern tankers have integrated systems and are equipped with all the alarms foreseen for each operation. Ship safety is closely related to ship procedures and depends on the ability of the crew to follow the required procedures. With the advent of technology on ships, shipping companies have attempted to solve the problem of managing automated systems with a series of checklists and work permits. In recent years, there has been a significant increase in administration on ships and a decrease in the number of crew members on board, which has affected the work of the crew. Due to the overload of paperwork, officers no longer read permits and checklists thoroughly, which poses a danger to the ship and the environment. Permits and checklists have contributed to safety on board, but their number should be limited or we will have the opposite effect. Reducing the number of crew on board leads to an increase in the volume of work and therefore fatigue. This significantly increases the risk of human error.

Tankers will be even more modern in the near future in terms of safety for the crew and the environment, but the crew must be trained to operate such vessels and monitor new systems for cargo operations. To maintain safety on board, shipping companies must find a way to keep a certain number of crew members on board who are able to thoroughly monitor automated systems without compromising the safety of the ship. The crew must also be constantly trained (educated) in various courses for certain new automated systems on board.

Cargo handling on super tankers is complicated and challenging due to a variety of factors that affect the process. Contributing to this are the different types of crude oil that are transported to the port of discharge. Each type of crude oil needs to be unloaded separately, so a good handling plan is very important.

Due to the large volume and different types of cargo (grades), it is important to have a quality cargo plan in place to reduce stress on the ship's structure and avoid damage to the handling equipment. A quality cargo handling plan increases safety in general and reduces the possibility of pollution of the marine environment.

References

[1] E. Akyuz, "Quantification of human error probability towards the gas inerting process on-board crude oil tankers," Saf. Sci., vol. 80, pp. 77–86, 2015, doi: 10.1016/j.ssci.2015.07.018.

[2] E. Akyuz and E. Celik, "A fuzzy DEMATEL method to evaluate critical operational hazards during gas freeing process in crude oil tankers," J. Loss Prev. Process Ind., vol. 38, pp. 243–253, 2015, doi: 10.1016/j.jlp.2015.10.006.

[3] "VIDEOTEL STCW Training Module, Oil Tanker Operations".

[4] C. P. Armitage, Crude oil tanker basics. Edinburgh, Scotland; UK: Witherby Seamanship International Ltd, 2009.

[5] "SEAGULL MARITIME, Oil Tanker Operations, Advanced Oil tanker Course".

[6] Anon, International Safety Guide for Oil Tankers and Terminals. 6th ed., no. 171. International Chamber of Shipping, 2020.

[7] SOLAS, Safety of Life at Sea (SOLAS). International Maritime Organization (IMO), 2020.

[8] MARPOL, International Convention for the Prevention of Pollution from Ships (MARPOL). International Maritime Organization (IMO), 2017.

[9] S. O. Fagerland, "A computerized system for loading and discharging oil tankers," Auckland University of Technology, 2013.

[10] Q. Zhou, Y. D. Wong, H. Xu, V. Van Thai, H. S. Loh, and K. F. Yuen, "An enhanced CREAM with stakeholder-graded protocols for tanker shipping safety application," Saf. Sci., vol. 95, pp. 140–147, 2017, doi: 10.1016/j.ssci.2017.02.014.

[11] L. G. Nikolopoulos, "A holistic methodology for the optimization of tanker design and operation and its applications," National Technical University of Athens, School of Naval Architecture and Marine Engineering, 2012.

[12] Ö. Uğurlu, E. Köse, U. Yıldırım, and E. Yüksekyıldız, "Marine accident analysis for collision and grounding in oil tanker using FTA method," Marit. Policy Manag., vol. 42, no. 2, pp. 163–185, 2015, doi: 10.1080/03088839.2013.856524.

[13] K. Chow, "Gas-freeing of crude oil tanks - Analysis using numerical simulation," Proc. Inst. Mar. Eng. Sci. Technol. Part A J. Mar. Eng. Technol., no. 17, pp. 3–11, 2010.
[14] E. Akyuz and M. Celik, "A methodological extension to human reliability analysis for cargo tank cleaning operation on board chemical tanker ships," Saf. Sci., vol. 75, pp. 146–155, 2015, doi: 10.1016/j.ssci.2015.02.008.

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Review paper

Temperature Measurement and Applications on Board Ships with Example from Marine Engineers Education*

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Abstract: There are various methods and sensors for measuring temperature, which are common on board ships. Hence, it is very important to choose the right sensor for a particular purpose. In this paper, two sensors and their working are described. The paper presents experimental work in measurement with these sensors. The samples measured and their parameters are also described. Additional value of this paper is connection of this paper diploma thesis. The experiments are executed under the same environmental conditions. Also, it is discussed what the best purpose is for each of the two sensors.

Keywords: Thermal imaging camera, Pt-100, Marine engineering, Education.

1. Introduction

Temperature sensors play an important role on board ships in control systems [1 - 4]. Therefore, it is important to include them in the education of marine engineers. The Faculty of Maritime Studies in Split has received a new automation laboratory. Hence, it was expected to use such equipment for educational and/or scientific purposes.

Importance of temperature measurement in marine engineering is well known. The temperature can be used for fault diagnosis and preventive maintenance [5 - 7]. Such methods are widely used, as the following examples show: thermography diagnosis of electronic elements [8], condition diagnosis of HV cable accessories [9], fault diagnosis of reciprocating compressors [10], fatigue life evaluation of filled rubber [11], detection and identification of defects in 3D printed dielectric structures [12], determination of the operating condition of a conveyor belt drive system [13], detection of trucks in rest areas under winter conditions [14], tracking of people [15], evaluation of warm roofs in cold regions [16], detection of oil spills [17], use of thermography in the diagnosis of ship piston internal combustion engines

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[18], use of fiber bragg grating temperature measurement for long-period monitoring for LNG marine auxiliary [19], etc.

In this paper, we describe the comparison of temperature measurement using PT sensor and a thermal imaging camera. Thermal imaging cameras are usually used for periodic inspection and prevention on board ships. The experimental work was carried out by a student, which is a start for incorporating new devices into education. A similar interesting research was done in [20] where the measurement of strain was studied.

The paper is divided into 4 sections. The second section describes material and equipment. The third section presents the results. Finally, conclusions are drawn.

2. Materials and Methods

Types of temperature sensors used on board ships are thermistors, resistance temperature detectors (RTD), thermocouple, and periodically thermal imaging camera, which was brought aboard with a maintenance team. Here is only the basic of this two sensing devices.

The commonly used component as resistance wire (sensing element) of the RTD are Platinum (Pt), Nickel (Ni), and Copper (Cu). Popularly used Platinum RTD are Pt-100, Pt-1000. The name Pt-100 is because at 0°C resistance is 100 Ω. Measurement of this sensor is based on one of the basic electric laws – thermal dependency of the electrical resistance:

$$R = R_0\left(1 + \alpha\Delta\vartheta\right) \tag{1}$$

where R is the electrical resistance at desired temperature, R_0 the resistance at the referent temperature, α thermal coefficient and $\Delta\vartheta$ the temperature difference between the desired temperature and the referent temperature.

Thermal imaging camera, on the other hand, grasps the radiation reflected or emitted from the measured object (body). The real emission of thermal radiation from any object can be computed by multiplying the blackbody radiation and the emissivity, ε. The emissivity of an object is the ratio of the amount of radiation actually emitted from the surface to that emitted by a blackbody at the same temperature. Emissivity of the body can be derived from Kirchoff's law, which states that the amount of radiation absorbed is equal to amount of radiation that is emitted by this object, which is expressed by $\varepsilon = \alpha$, where ε and the so-called absorptivity α denote the fraction of radiation that is either emitted or absorbed. Considering the fraction of the incident radiation this law can be written as:

$$1 = R + T + \alpha \tag{2}$$

where R and T denote the fraction of radiation that is either reflected or transmitted. Hence, thermal imaging camera can detect only surface temperature or something/some process that changes the temperature of the surface.

2.1. Test material

Antifreeze is used to lower the freezing point of refrigerant for equipment operating at relatively low temperatures. The antifreeze is placed in a stainless steel (also called Inox) container with a volume of 0.001 m^3. The antifreeze used is INA ANTIFRIZ SUPER (trade mark). The basic properties of the sample are:

– The density at 20 °C is equal to 1.114 g/cm^3.

– The flow rate is -36 °C and the boiling point is 164 °C.

2.2. Experimental equipment

The thermal imaging camera used, Testo 885, can be used in a wide temperature range from -15 to +50 °C. Humidity can range from 20% to 80%, and vibrations can be up to 2 G.

Electrical temperature sensors are implemented in the experimental unit WL 202, which covers many temperature measurement methods. A digital multimer with high-precision resistors was used for calibration.

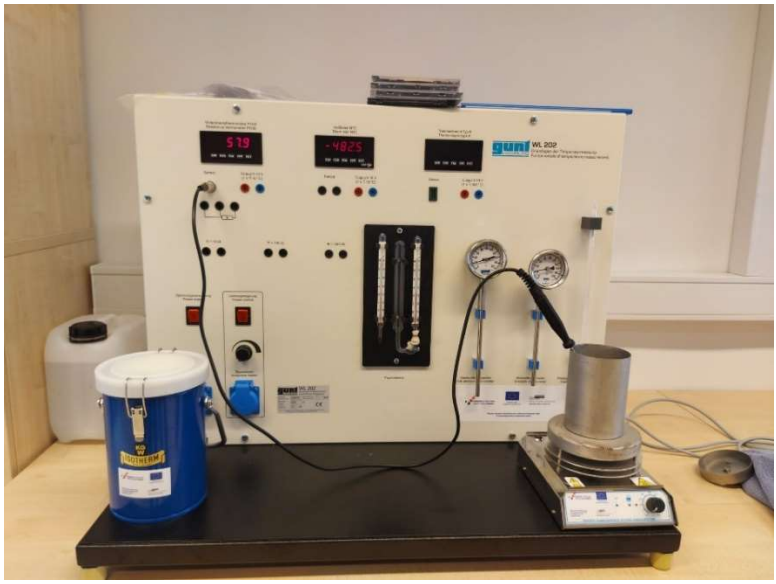

Fig. 1 – *Experimental device WL 202.*

The antifreeze was heated in a stainless steel container with a volume of one liter. The laboratory heating is set to 50 °C. The measurement started after 20 minutes of heating. The average ambient temperature was 25.4 °C.

The measurement temperatures were: 50°C, 60°C, 70°C, 80°C, 90°C, 100°C, 110°C. The emission factor of the device was ε_d = 0.95 m and the emission factor of the antifreeze was ε_a = 0.98.

3. Results

In this section, we present the experimental results. Table 1 shows the measurement results for the two sensors used: Pt-100 and thermal imaging camera. The first obstacle in the comparison lies in the nature of the devices. The thermal imager displays the spatial distribution of the temperature. Therefore, it is possible that there are points with the same temperature detected by the Pt -100 sensor. However, we need to determine the measurement point visually.

Table 1 – *Measured temperatures with sensor and thermal imaging camera.*

	Measured temperature (°C)		
	Thermal imaging camera		Pt-100 sensor
Measured set point (°C)	Measurement point (M_I)	Average temperature (AV_I)	Measurement temperature
50	49.9	51.1	50
60	57.8	57.3	60
70	73.2	73.3	70
80	80.6	80.5	80
90	91.6	90.6	90
100	99.6	98.4	100
110	112	112.9	110

Figure 2 shows comparison of measured results. It can be seen that thermal imaging cannot grasp the exact temperature due to various external factors, such se refraction, abortion from the air, etc. Consequently, the Pt-100 sensor is better when exact measurement is necessary. However, in cases when Pt sensor cannot be applied, there is a use of thermal imaging cameras, such is in detection of cracks and stress.

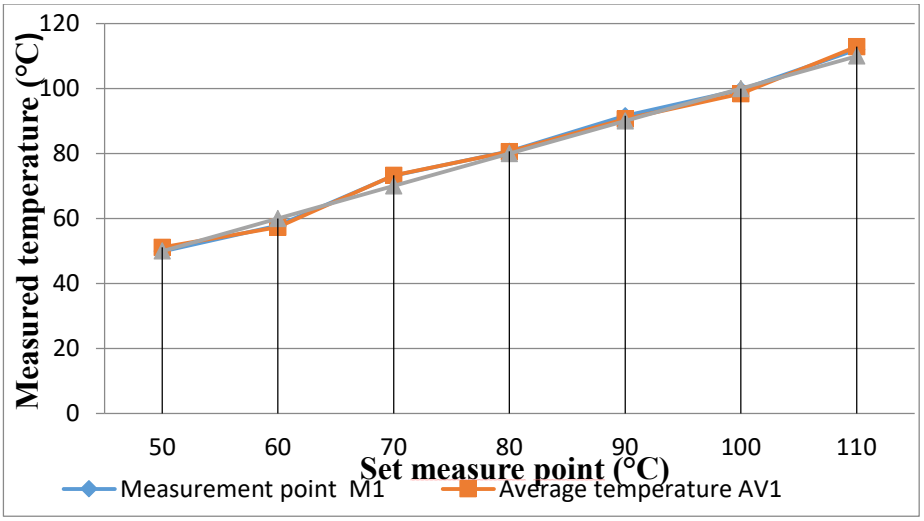

Fig. 2 – *Comparison of measured temperatures for Pt-100 and camera's average temperature.*

Figures 3 and 4 shows examples of measurement by thermal imaging camera. The images and tables are taken exactly from the camera app.

It can be seen that the thermal imaging camera provides more data, but it is difficult to know which temperature is the correct one for a possible control system.

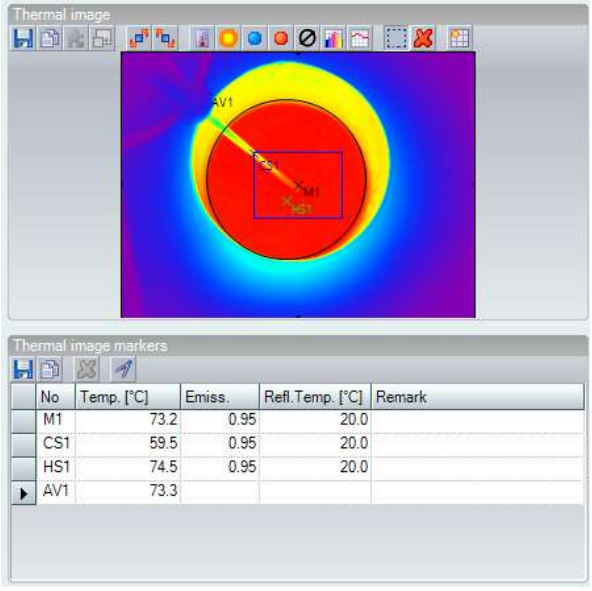

Fig. 3 – *Example of measurement obtained by thermal imaging camera: the set temperature is 70 °C.*

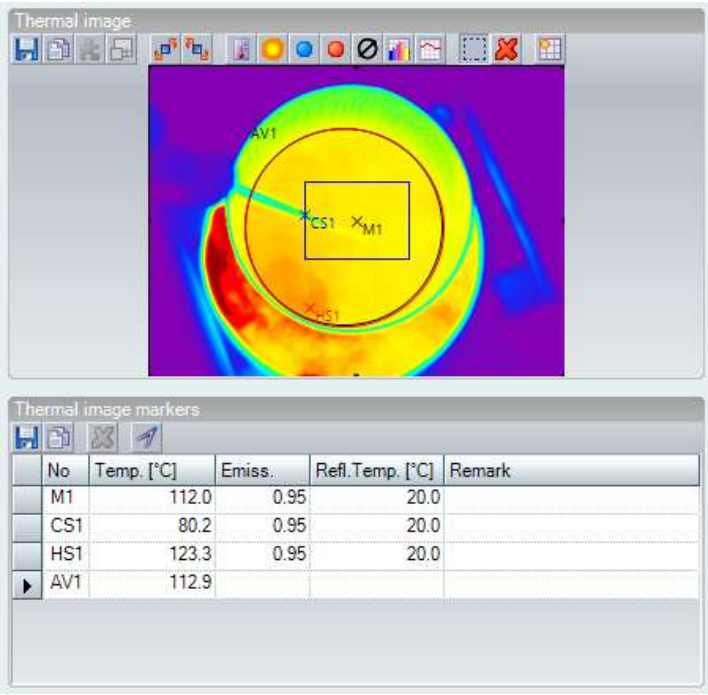

Fig. 4 – *Example of measurement obtained by thermal imaging camera: the set temperature is 110 °C.*

4. Conclusion

Students could make conclusion that PT -100 sensors measure temperature more accurately even though the camera is more expensive and a more sophisticated device. There is also confusion about what temperature should be used for the control system in the case of the camera. On the other hand, PT -100 gives a temperature that is not confusing. Students should be taught that both sensors have their range of application. In such an application, the respective sensor has an advantage.

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References

[1] H. Laurila, “Pt100 temperature sensor – useful things to know,” available at: https://blog.beamex.com/pt100-temperature-sensor, (accessed 20.09.2021.)
[2] “MI RTD Sensor failure,” available at: https://www.sterlingsensors.co.uk/pt100-rtd_case-study, (accessed 20.09.2021.)
[3] “Marine Industry Sensors,” available at: https://www.senmatic.com/sensors/business-areas/marine-industry, (accessed 20.09.2021.)
[4] “Types of Temperature Sensor Used on Board Ship – METO,” available at: http://www.marineeto.we.bs/2020/07/06/temperature-sensor-types-used-on-board-ship/, (accessed 20.09.2021.)
[5] P. Goswami, “Thermal Imaging and its Applications,” available at: https://www.slideshare.net/priyanka1194/thermal-imaging-and-its-applications, (accessed 20.09.2021.)
[6] “Industries applications,” available at: https://www.infratec.eu/thermography/industries-applications/building-thermography/, (accessed 20.09.2021.)
[7] B. Dudojc, and J. Mindykowski, “New Approach to Analysis of Selected Measurement and Monitoring Systems Solutions in Ship Technology,” Sensors, 2019, 19, 1775; doi:10.3390/s19081775
[8] K. Dziarski, A. Hulewicz, G. Dombek, R. Frackowiak, and G. Wiczynski, "Unsharpness of Thermograms in Thermography Diagnostics of Electronic Elements,“ Electronics, 2020, 9, 897; doi:10.3390/electronics9060897
[9] L. Mu, X. Xu, Z. Xia, B. Yang, H. Guo, W. Zhou, and C. Zhou, "Autonomous Analysis of Infrared Images for Condition Diagnosis of HV Cable Accessories,“ Energies, 2021, 14, 4316. https://doi.org/10.3390/en14144316
[10] R. Deng, Y. Lin, W. Tang, F. Gu. and A. Ball, "Object-Based Thermal Image Segmentation for Fault Diagnosis of Reciprocating Compressors,“ Sensors, 2020, 20, 3436; doi:10.3390/s20123436
[11] W. Luo, Y. Huang, B. Yin, X. Jiang, and X. Hu, "Fatigue Life Assessment of Filled Rubber by Hysteresis Induced Self-Heating Temperature,“ Polymers, 2020, 12, 846; doi:10.3390/polym12040846
[12] B. Szymanik, G. Psuj, M. Hashemi, and P. Lopato, "Detection and Identification of Defects in 3D-Printed Dielectric Structures via Thermographic Inspection and Deep Neural Networks,” Materials, 2021, 14, 4168. https://doi.org/10.3390/ma14154168
[13] D. Szurgacz, S. Zhironkin, S. Vöth, Jiří Pokorný, A.J.S. Spearing, M. Cehlár, M. Stempniak, and L. Sobik, "Thermal Imaging Study to Determine

the Operational Condition of a Conveyor Belt Drive System Structure," Energies, 2021, 14, 3258. https://doi.org/10.3390/en14113258

[14] M. Kasper-Eulaers, N. Hahn, S. Berger, T. Sebulonsen, Ø. Myrland, and P. E. Kummervold, "Short Communication: Detecting Heavy Goods Vehicles in Rest Areas in Winter Conditions Using YOLOv5," Algorithms, 2021, 14, 114. https://doi.org/10.3390/a14040114

[15] S. Yeom, "Moving People Tracking and False Track Removing with Infrared Thermal Imaging by a Multirotor," Drones, 2021, 5, 65. https://doi.org/10.3390/drones5030065

[16] K. Lee, J. Park, S. Jung, and W. Lee, "Roof Color-Based Warm Roof Evaluation in Cold Regions Using a UAV Mounted Thermal Infrared Imaging Camera," Energies, 2021, 14, 6488. https://doi.org/10.3390/en14206488

[17] T. De Kerf, J. Gladines, S. Sels, and S. Vanlanduit, „Oil Spill Detection Using Machine Learning and Infrared Images," Remote Sens., 2020, 12, 4090; doi:10.3390/rs12244090

[18] J. Monieta, "The use of thermography in the diagnosis of ship piston internal combustion engines," 17th Int. Conf. Diagnostics of Machines and Vehicles, MATEC Web of Conferences, 2018, 182, 01027, doi: 10.1051/matecconf/201818201027

[19] Fenghui Han 1,2 , Zhe Wang 1,2,* , Hefu Zhang 1, Dongxing Wang 1, Wenhua Li 1,2 and Wenjian Cai, "Experimental Study of Large-Temperature-Range and Long-Period Monitoring for LNG Marine Auxiliary Based on Fiber Bragg Grating Temperature Measurement," J. Mar. Sci. Eng., 2021, 9, 917. https://doi.org/10.3390/jmse9090917

[20] X. Yue, H. Chen, H. Qu, R. Min, G. Woyessa, O. Bang, and X. Hu, "Polycarbonate mPOF-Based Mach–Zehnder Interferometer for Temperature and Strain Measurement," Sensors 2020, 20, 6643; doi:10.3390/s20226643

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Review paper

Analysis of Technical Properties of Small Passenger Ships in the Mediterranean Sea with Overview of Future Market Needs – Environmental and Comfort Issues*

Nikola Vladimir, Andro Bakica, Maja Perčić, Ivana Jovanović

Abstract: Coastal shipping is nowadays a very important research topic, where the emphasis is mainly on the improvement of ship energy efficiency (reduction of fuel consumption) and its environmental performance. In line with this, the ship design procedure is being more complicated aiming to offer competitive products with high level of comfort for both crew and passengers, low operative costs and minimum environmental footprint. This paper reviews the technical properties of existing small passenger vessels in countries in the Mediterranean and future market needs for these vessels considering more stringent habitability criteria and future emission reduction targets. It represents an important step of a novel design procedure for small passenger vessels for Mediterranean, based on the modular principle. Analysis of technical properties of existing small passenger vessels has been made from data available in the IHS Fairplay database. Beside overview of design requirements related to ship environmental friendliness and comfort, available countermeasures are reviewed.

Keywords: passenger vessel, Mediterranean Sea, market analysis, regulatory framework, technical measures

1. Introduction

Ship design process is determined by technical complexity, long exploitation life of the final product, high unit cost and production in small series. Designing of a ship in a way that it performs its missions effectively for a lifetime of 25 years or longer is quite demanding. Small passenger vessels for short-sea shipping, mostly build in small shipyards, are often based on previous concepts with low-cost design and low energy efficiency, but relatively high lifetime costs and harmful environmental impact [1]. Decisions made during the early design stage have a large impact on the direction of

*An earlier version of this paper was presented at the 1st Kotor International Maritime Conference – KIMC 2021, Kotor, Montenegro.

the design process and the product performance, since the freedom to make changes will rapidly decreases [2]. Nowadays, ship design is strongly influenced by regulations on emissions [3], owners of all kinds of ships are seeking higher standards of comfort for both crew and passengers, while economic criteria are continuously important. On the other hand, due to market uncertainty, it is difficult for ship designers to design a vessel that has the right size and capabilities for use over multiple decades [4]. Vladimir et al. [5] illustrated the design procedure for small passenger vessel in the Mediterranean using modular approach, where the ship is virtually assembled from three predefined modules. In that paper the lifecycle CO_2-eq emissions and costs of small passenger vessel with capacity of 250 passengers for diesel, electricity, methanol, liquefied natural gas, hydrogen, ammonia, and biodiesel power system configuration are investigated, and it is found that electrification is the most environmentally friendly and most cost-effective powering options among those considered. This paper sheds light on some aspects of the overall procedure given in [5], that are not explained very detailed. Therefore, in the next section IHS Fairplay database is outlined, while third section deals with the analysis of technical properties of the selected ships. Future design requirements and available solutions are dealt with in fourth section, while concluding remarks are drawn in the fifth section.

2. IHS Fairplay database

The first step in the analysis of technical properties of existing vessels is to limit the range of vessels according to some criteria. Passenger ships - usually defined as ships carrying more than 12 passengers - on international voyages must comply with all relevant IMO (International Maritime Organization) regulations, including those in the SOLAS (International Convention for the Safety of Life at Sea) and Load Lines Conventions [6]. There are different criteria according to which the ship can be designated, such as the length, capacity, gross tonnage, etc. The source of the data used in this paper is IHS Fairplay database, [7], which is the largest maritime database in the world, evolved from the Lloyd's Register of Ships, covering ship characteristics, movements, ports, casualties, and research (Fig.1).

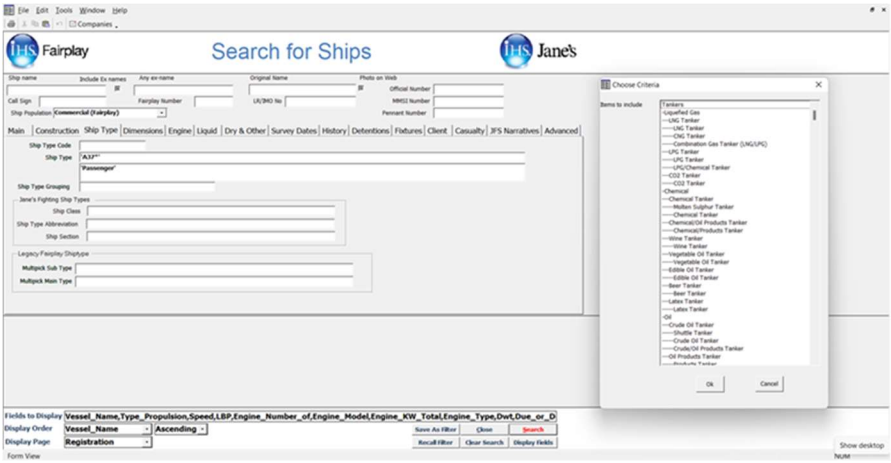

Fig. 1 – *World register of ships, IHS Fairplay database.*

In this investigation, the length is selected as the relevant quantity and technical properties of all passenger ships registered in the Mediterranean countries, Fig. 2, with a length below 100 m are extracted from the IHS Fairplay database. The rules that are relevant to small vessels take the upper length boundary very differently. In this sense, according to the International Association of Classification Societies (IACS) small ships are those below 24 m, while depending on the context they can be up to 65 m in length (Bureau Veritas) or even up to 100 m (Det Norske Veritas), [8].

Fig. 2 – *Mediterranean countries [9].*

3. Technical properties of small passenger vessels in the Mediterranean

The ship characteristics are obtained for 692 small passenger vessels sailing under the flag of one of Mediterranean country (Albania, Croatia, Cyprus, Egypt, France, Greece, Italy, Malta, Montenegro, Morocco, Spain, Tunisia, Turkey), build between 1999 and 2015. While obtaining data, the maximum length overall (LoA) of 100 m is set as a limit. Using obtained data relationship is derived between ship characteristics and illustrated on Fig. 3. With respect to the power system, it is found that diesel engine serve as prime movers in about 97 % cases. Most of the vessels is equipped with fixed pitch propellers, Fig. 3 d).

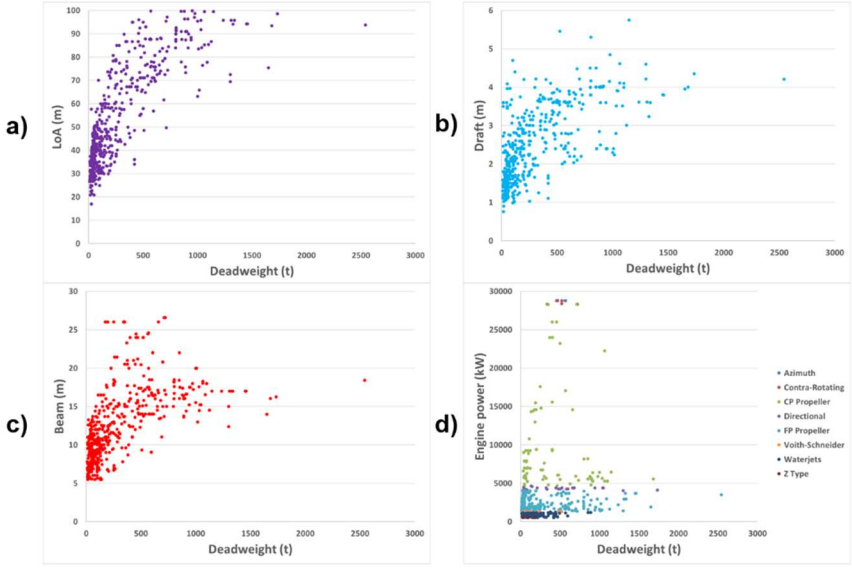

Fig. 3 – *(a) Deadweight vs Length overall, (b) Deadweight vs Draft, (c) Deadweight vs Beam, (d) Deadweight vs Power with Type of Propulsion.*

Taking into consideration that capacity of passengers and speed are important parameter for passenger ships relationship between deadweight and length overall, and number of passengers and speed is illustrated in Fig. 4.

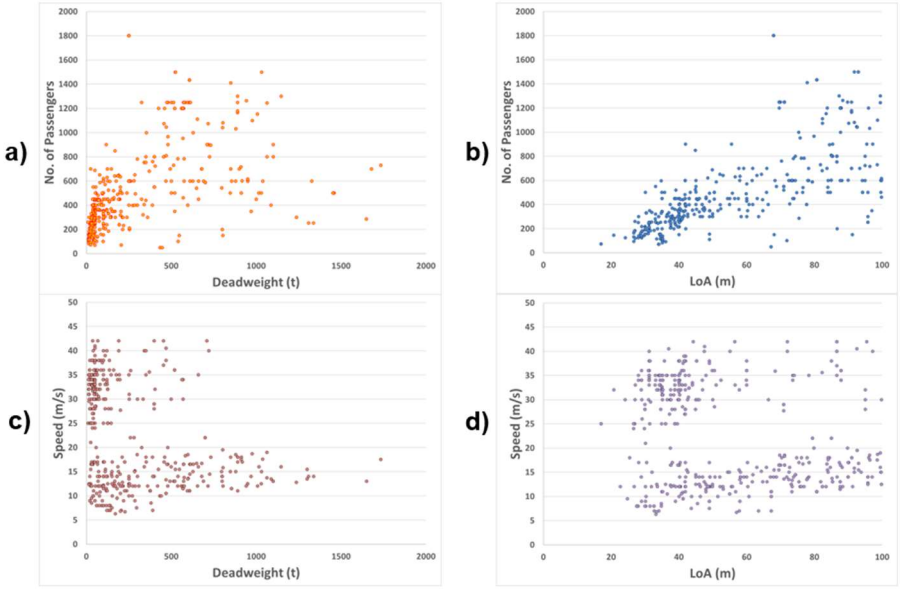

Fig. 4 – *(a) Deadweight vs Number of passengers, (b) Length overall vs Number of passengers, (c) Deadweight vs Speed, (d) Length overall vs Speed.*

Relationships between parameters shown on Fig. 3 and Fig. 4 do not give better understanding into ship particulars relation therefore further analysis are needed.

4. Overview of future design requirements and available solutions

Beside technical properties, the environmental regulations and the comfort requirements are mandatory to be considered in the design phase.

A Environmental regulations

The reduction of emissions generated by internal combustion engines represents one of the most important research topics in the marine sector. Exhaust gases released from the combustion of fossil fuel in marine engines consist of different components, such as carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_X), sulphur oxides (SO_X), hydrocarbons (HC) and particulate matter (PM), and their negative effects on the environment and on people are more pronounced when ships spend greater time near populated areas. The Paris Agreement is an international response to climate change, which aims to keep the global temperature rise below 2 °C, in comparison to pre-industrial level [10]. The shipping sector aims to reduce its Carbon Footprint (CF) by 40% by 2030, and by at least 70% by 2050 compared to 2008 [11]. CF is a relative measure of the total amount of CO_2 or

CO_2-eq emissions caused by indirect or direct activity or is accumulated over the life cycle of a product [12].

The International Maritime Organisation (IMO) decarbonization strategy defines three levels of measures to achieve the required GHGs reduction goal: short-term, mid-term and long-term measures [13], Fig. 5.

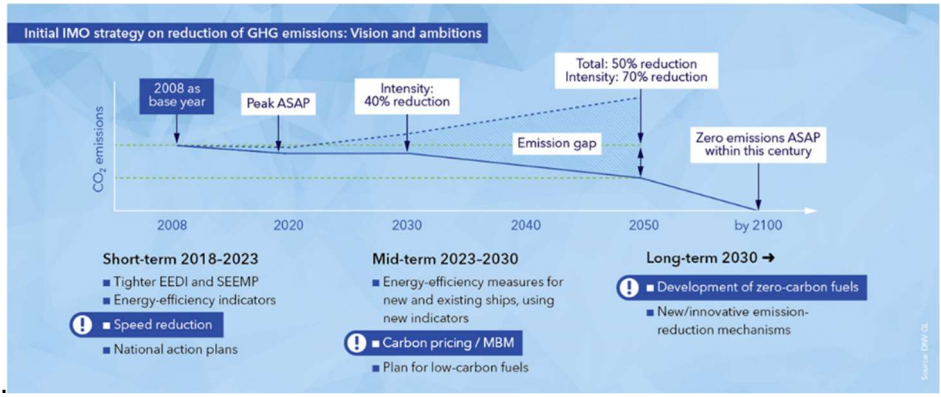

Fig. 5 – *The IMO strategy for the reduction of GHG emissions [14] (reproduced with the permission of Det Norske Veritas (DnV)).*

In the maritime sector, SO_X and NO_X emissions are controlled in Emission Control Areas (ECAs), in which emissions requirements are stricter than out-side these areas [15]. While SO_X emission is limited with the allowed content of sulphur in fuel, NO_X emission are regulated depending on the engine maximum operating speed [16]. Maritime sector has various technical and operative measures at disposal to reduce emissions. Bauman et al. [17] conducted extensive literature review on technologies, measures, and potential for reducing GHG emissions from shipping, Table 1. With combination of these measures, required emission reduction will be achieved thus fulfilling required environmental regulations imposed by IMO. The ships of the future intended to operate in this area should be designed to cope with these requirements. It is worthy to mention studies performed by the authors dedicated to the alternative powering options for small short-sea [18],[19],[20],[21], and inland [22], [23], [24], vessels, trying to identify those ones that will comply to future regulation framework.

Table 1 – *Measures and potential effect on energy efficiency and emission reduction (CO2) [17]*

Type of measure	Main measures reviewed	Potential for CO_2 reduction
Hull design	Vessel size	4-83 %
	Hull shape	2-30 %
	Lightweight materials	0.1-22 %
	Air lubrication	1-15 %
	Resistance reduction devices	2-15 %
	Ballast water reduction	0-15 %
	Hull coating	1-10 %
Power and propulsion system	Hybrid power/ propulsion	2-45 %
	Power system/ machinery	1-35 %
	Propulsion efficiency devices	1-25 %
	Waste heat recovery	1-20 %
	On board power demand	0.1-3 %
Alternative fuels	Biofuels	25-84 %
	LNG	5-30 %
Alternative energy sources	Wind power	1-50 %
	Fuel cells	2-20 %
	Cold ironing	3-10 %
	Solar power	0.2-12 %
Operation	Speed optimization	1-60 %
	Capacity utilization	5-50 %
	Voyage optimization	0.1-48 %

B Comfort regulations

Noise and vibration problems are inherent to all ships due to a number of engines and devices needed for their operation [25], Figs. 6 and 7:

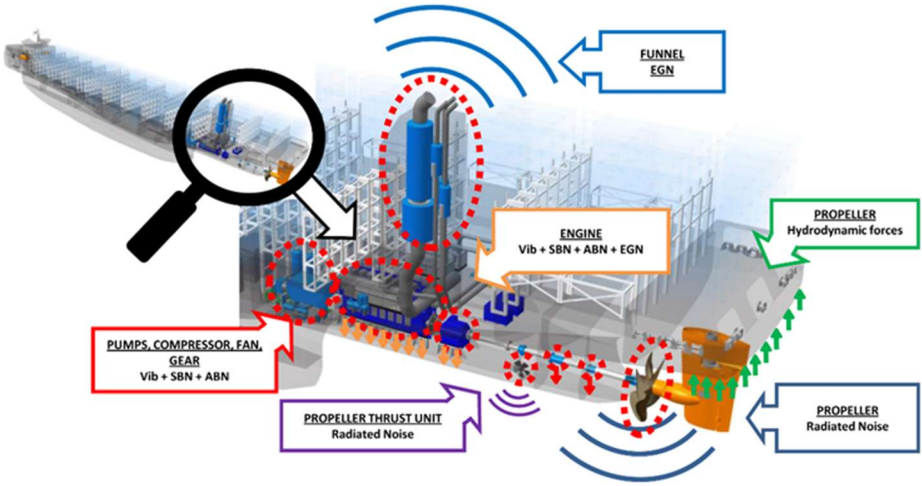

Fig. 6 – *Main noise sources on board [26].*

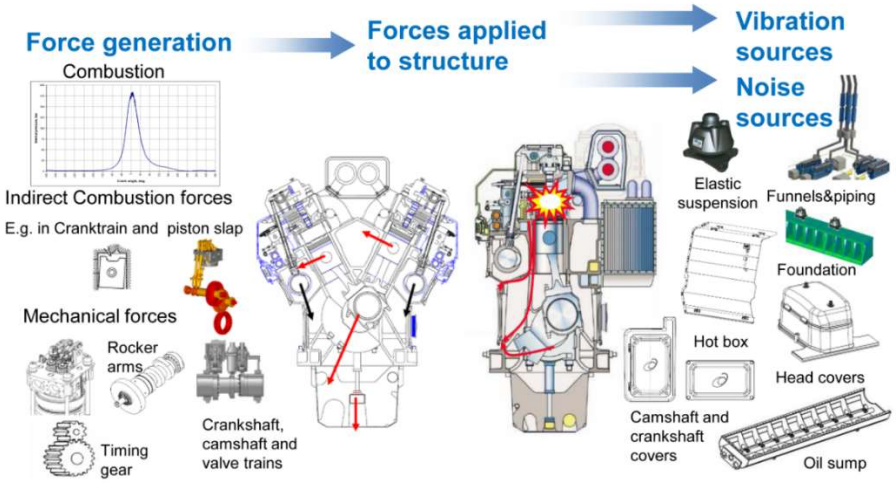

Fig. 7 – *Excitation forces generated by the engine interacting with ship structure external emitters [26].*

Classification Societies have included in their rules, comfort classes for passengers and crew accommodation. Passenger comfort is very important and subjected to penalties if ship does not fulfil requirements. Table 2 provides ratings requested by Classification Societies from 1 to 3, where 1

stands for "high" and 3 for "acceptable" comfort. Table 3 shows comfort class criteria related to sound installations for passenger cabins [27].

Similarly, to noise, classification societies have vibration standards associated with the comfort class notation.

Table 2 – *Sound pressure levels (dB(A)) in passenger accommodation [27]*

Location	DNV			BV			LR	
	CRN (1)	CRN (2)	CRN (3)	1	2	3	1	2
Top grade	44	47	50	45	50	50	45	50
Standard cabins	49	52	55	50	55	55	45	50
Public rooms	55	58	62	55	60	65	55	60
Open decks	65	65	70	65	70	75	65	70

Table 3 – *Comfort class criteria related to sound installation RW (dB)*

Location	DNV	BV	LR
Between top grade cabins	46	42	45
Between standard cabins	41	40	45
Between cabins and standard public rooms	55	55	55
Between cabins and show rooms	65	65	-

Noise and vibrations can be controlled by altering source of noise and vibration, conveying medium, and receiver. By employing appropriate software in design phase, noise levels based on sound propagation from machinery, propeller, and wave slap sources via air-borne and structure-borne paths, can be calculated and evaluated, and various treatment options can be explored, including resiliently mounting equipment, adding absorptive insulation and/or damping materials, etc [5]. Regarding vibrations, by implementing different technologies on the source (engine) and increasing its quality (and simultaneously cost) vibration velocity can be reduced thus increasing comfort class [5].

5. Concluding remarks

In the current practice, the ship design is generally approached with the aim of keeping building-cost at the minimum, often forcing low-cost designs and low value-added market solutions. This is particularly true for small pas-

senger vessels designed for short-sea shipping. Small shipyards cannot sustain the high costs of innovation. In this paper, the length is selected as the relevant quantity of all passenger ships registered in the Mediterranean countries, and by utilizing IHS Fairplay database, technical properties of selected ships are obtained and analysed. After conducting analysis of technical properties of small passenger vessels in the Mediterranean, it is found that there is relatively high scattering between ship dimensions, capacity, and power systems among the analysed vessels. As explained in the paper, it is important to take into account stricter regulations regarding emissions and comfort at design phase. Environmental requirements can be fulfilled increasing ship energy efficiency by employing technologies, and measures for reducing harmful emissions from shipping, which regularly impose additional investment costs. Noise and vibrations, produced by ship engines and devices needed for ship operation, are restricted by comfort regulations. In order to get the best possible comfort in passenger spaces both excitation source and transmission path must be included in investigation and results would be most satisfactory if mitigation technologies would be applied upon both of them.

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References

[1] Gelesz, P.; Karczewski, A.; Kozak, J.; Litwin, W.; Piatek, L. Design methodology for small passenger ships on the example of the ferryboat Motlawa 2 driven by hybrid propulsion system. Polish Maritime Research 2017, 24, 67-73.

[2] Pettersen, S.S.; Rehn, C.F.; Garcia, J.J.; Erikstad, S.O.; Brett, P.O.; Asbjørnslett, B.E.; Ross, A.M.; Rhodes, D.H. Ill-structured commercial ship design problems: the responsive system comparison method on an offshore vessel case. J. Ship Prod. Des. 2018, 34, 72-83.

[3] Gianni, M.; Bucci, V.; Marino, A. System simulation as decision support tool in ship design. Proceedia Computer Science 2021, 180, 754-763.

[4] Zwaginga, J.; Stroo, K.; Kana, A. Exploring market uncertainty in early

ship design. International Journal of Naval Architecture and Ocean Engineering 2021, 13, 352-366.
[5] N. Vladimir, A. Bakica, M. Perčić, I. Jovanović: Modular approach in the design of small passenger vessels for Mediterranean, Journal of Marine Science and Engineering, Vol. 10 (1), 2022., 117.
[6] https://www.imo.org/en/OurWork/Safety/Pages/PassengerShips.aspx /[accessed April 05, 2017].
[7] IHS Fairplay: World register of ships—WROS manual, 2015.
[8] https://www.fsb.unizg.hr/kmb/100/110/kmb111.htm [accessed April 05, 2017].
[9] Mediterranean Map/List of Mediterranean Countries. https://www.mappr.co/thematic-maps/mediterranean-countries/, [accessed December 1, 2021].
[10] https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement [accessed November 05, 2021].
[11] IMO. Marine Environment Protection Committee (72nd session), http://www.imo.org/en/MediaCentre/MeetingSummaries/MEPC/Pages/Default.aspx; 2018 [accessed 19 October 2021].
[12] Wiedmann T, Minx J. A Definition of Carbon Footprint. In: Pertsova CC. Ecological Economics Research Trends, Hauppauge NY: Nova Science Publishers; 2008, p. 1-11.
[13] DNV. Achieving the IMO decarbonization goals. https://www.dnv.com/expert-story/maritime-impact/How-new-builds-can-comply-with-IMOs-2030-CO2-reduction-targets.html, (accessed June 24, 2021).
[14] DNV. Energy Efficiency Existing Ship Index (EEXI) https://www.dnv.com/maritime/insights/topics/eexi/index.html, (accessed October 14, 2021).
[15] Chen, L.; Yip, T.L.; Mou, J. Provision of Emission Control Area and the impact on shipping route choice and ship emissions. Transportation Research Part D: Transport and Environment 2018, 58, 280-291.
[16] Emission Standards: IMO Marine Engine Regulations. https://dieselnet.com/standards/inter/imo.php#s, (accessed November 1, 2020).
[17] Bouman, Evert A., et al. "State-of-the-art technologies, measures, and potential for reducing GHG emissions from shipping–A review." Transportation Research Part D: Transport and Environment 52 (2017): 408-421.
[18] Perčić, M.; Vladimir, N.; Fan, A. Life-cycle cost assessment of alternative marine fuels to reduce the carbon footprint in short-sea shipping: A case study of Croatia. Applied Energy 2020, 279, 115848.

[19] Ančić, I.; Perčić, M.; Vladimir, N. Alternative power options to reduce the carbon footprint of ro-ro passenger fleet: A case study of Croatia. Journal of Cleaner Production 2020, 271, 122638.
[20] Perčić, M.; Vladimir, N.; Jovanović, I.; Koričan, M. Application of fuel cells with zero-carbon fuels in short-sea shipping. Applied Energy 2022, 309, 118463.
[21] Jovanović, I.; Vladimir, N.; Perčić, M.; Koričan, M. The feasibility of autonomous low-emission ro-ro passenger shipping in the Adriatic Sea. Ocean Engineering 2022, 247, 110712.
[22] Perčić, M.; Ančić, I.; Vladimir, N. Life-Cycle Cost Assessments of Different Power System Configurations to Reduce the Carbon Footprint in the Croatian Short-Sea Shipping Sector. Renewable & Sustainable Energy Reviews 2020, 131, 110028.
[23] Perčić, M.; Vladimir, N.; Fan, A. Techno-economic assessment of alternative marine fuels for inland shipping in Croatia. Renewable & Sustainable Energy Reviews 2021, 148, 111363.
[24] Fan, A.; Wang, Z.; He, Y.; Perčić, M.; Vladimir, N.; Yang, L. Decarbonising inland ship power system: Alternative solution and assessment method. Energy 2021, 226, 120266.
[25] Carlton, J. S., and D. Vlasic. "Ship vibration and noise: some topical aspects." Proceedings of the 1st International Ship Noise and Vibration Conference. 2005.
[26] Tudor, H. Techno-economic assessment of new marine engine development with high noise and vibration performance. Master Thesis, UNIZAG FSB, Zagreb, Croatia, 2017.
[27] Blanchet, A.: Comfort class and passenger ships. InterNOISE Conference, Nice, France, 2000.

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Short report

MASS Level III – Exploration of Current Issues from an Operational Point of View*

Darijo Mišković

Abstract: Despite all efforts to ensure the safety of ships, available statistics show that the human factor remains the biggest problem in the maritime industry. The desire to improve the safety of ships and the related protection of the environment has been at the heart of the Maritime Autonomous Surface Ships (MASS) concept, which is supported by the International Maritime Organisation (IMO). Although the concept itself seems feasible in principle, there are still a number of open questions from an operational point of view. Furthermore, the economic feasibility of the concept is unknown. This paper addresses questions to which there are currently no answers.

Keywords: Ship safety, System reliability, Maintenance, Human factor, Risk

1. Introduction

The fact that more than 80% of the world's goods are transported by sea underlines the importance of international maritime transport [1]. Stopford [2] notes that the shipping industry is often seen as the lifeline of the global economy. In the past, the shipping industry has had to deal with a high number of accidents and incidents at sea caused by human error. The situation is still similar today, with almost 66% of all accidents caused by human error [3].

In addition to human error, organisational factors have also been identified as one of the problems. The industry has responded to the above problems in different phases over the last two decades: a) International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW); b) International Safety Management Code (ISM), which was later added to the SOLAS Convention chapter IX; and c) Maritime Labour Convention (MLC).

The main objective of the 1978 STCW Convention, which was later amended several times, is to promote "the safety of life and property at sea through the consensual establishment of international standards of training,

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certification and watchkeeping for seafarers" [4] (p.4). In other words, the real objective behind STCW was the need to establish universally accepted training standards for seafarers, as there was no agreement on this subject in the past. After the accident of the "Herald of the Free Enterprise" in 1986, organisational problems came to the surface, especially the question of safety culture. The aim of the ISM Code is to promote and improve safety culture in the maritime industry [5], i.e. to improve work place safety [6]. Numerous studies have recognised that a 'good' safety culture is the leading indicator of 'good' safety outcomes (e.g. [7, 8]).

Nevertheless, the International Maritime Organisation (IMO) openly states that the ISM Code only offers general guidelines to achieve the set goals [9] and that the real work of improvement has to be done by the shipping companies themselves. The last attempt to improve human factors was made in 2006 with the Maritime Labour Convention (MLC). The MLC aims to ensure comprehensive rights for seafarers in relation to working and living conditions, focusing on occupational safety and health (OSH) issues. OSH is defined as "the anticipation, recognition, evaluation and control of hazards arising in, or from, the workplace that could impair the safety, health and well-being of workers" [10] (p.3). Given the regulations in place for maritime transport, the shipping industry can be considered one of the most regulated industries in the world.

At the same time, the shipping industry has undergone significant changes with regard to the increasing automation and digitalisation of the ship and related ship systems. It was expected that the new standards would validate general human capabilities and reduce the occurrence of human errors [11]. However, numerous studies have pointed out the side effect of technology on the human factor [12-15]. Despite the above-mentioned regulations and new technologies introduced in the shipping industry, the situation regarding human error remains unchanged.

With the aim of improving safety on ships, the current approach goes in two directions (phases): unmanned ships and autonomous ships. What both concepts have in common is the exclusion of seafarers from the ships. The benefits of these measures can be seen in the reduction of crew operating costs (salaries, food costs, travel costs...), fuel consumption and pollution [16].

However, there are still a number of unanswered questions that may ultimately create new challenges or risks for the maritime industry. Without adequate solutions, the proposed measures for unmanned vessels may have significant consequences not only for shipping but also for related industries.

2. MASS approach

The introduction of concepts for unmanned and autonomous vessels has attracted everyone's attention. For example, classification societies have set out their views on the subject in the form of guidelines [17-20].

Global standards and regulations for the shipping industry are set by the International Maritime Organisation (IMO). Therefore, the IMO is responsible for introducing new regulations, in this case for unmanned and autonomous vessels, so that they can fulfil their purpose in a safe and environmentally friendly manner. In 2018, the IMO has started to look at the introduction of autonomous and remotely operated ships by involving all maritime countries in the regulatory scope exercise. For the purposes of the regulatory scoping exercise, the term 'Maritime Autonomous Surface Ships (MASS)' is used and defined as "a ship which, to a varying degree, can operate independently of human interaction" [21]. This definition explains the end result, an autonomous ship. At the same time, it was concluded that this progress should be made in phases; hence the levels in autonomy are also defined (Table 1).

Table 1 – *MASS levels of autonomy*

Level 1	*Ship with automated processes and decision support*	*Seafarers are on board to operate and control shipboard systems and functions. Some operations may be automated and at times be unsupervised but with seafarers on board ready to take control.*
Level 2	*Remotely controlled ship with seafarers on board*	*The ship is controlled and operated from another location. Seafarers are available on board to take control and to operate the shipboard systems and functions.*
Level 3	*Remotely controlled ship without seafarers on board*	*The ship is controlled and operated from another location. There are no seafarers on board.*
Level 4	*Fully autonomous ship*	*The operating system of the ship is able to make decisions and determine actions by itself.*

Source: adopted from [21]

The first level is common to all ships, meaning that these ships are manned and modern propulsion and navigation systems are used. Levels two and three mean that the vessel is controlled from a remote location, usually the Shore Control Centre (SCC). The operators of the SCC are responsible for navigation and all other aspects of the operation.

The key difference between these levels is that level two vessels are manned; the crew's role is to take control and resolve issues at all times. At level three, the responsibility for vessel control, related operations and problem solving should rest solely with the SCC operators. Level four vessels will be controlled by artificial intelligence and remote communication [22, 23].

In addition, the MASS concept will have varying degrees of impact on related industries such as ship design and shipbuilding, including port infrastructure development and cargo handling. Cooperation and communication between all stakeholders involved will also be crucial to the success of the concept.

It is undeniable that at some point all four ship types will coexist. A corresponding regulation does not yet exist, but that is not the scope of this paper.

3. Maritime safety and related risks

Traditionally, maritime safety can be divided into several different components. Ship safety is a part of maritime safety that focuses on the ship itself and its operational use [24].

The operational use of the ship, in turn, is associated with a whole range of risks. Most of these risks are caused by organizational and technological actions. To manage these risks, safety management system is used, which aims to control the probability of an undesirable event as well as its consequences. This task is one of many tasks performed by the ship's crew. Furthermore, there are other safety issues that are related to the operation of the ship in all circumstances, especially monitoring and control tasks. In addition, the required maintenance of the vessel and its equipment is of utmost importance for successful operation, while saving time and company resources.

3.1. Preconditions for a safe vessel

Considering the unmanned vessels, one can conclude that they face similar or even the same safety problems as conventional vessels. The basic problems are related to the marine environment, the movements of other vessels in the vicinity and the operation of the vessel itself.

What distinguishes unmanned vessels from conventional ships is the prediction and response to situations that arise. In unmanned vessels, the response to such situations is transferred from the ship's crew to the operator in the control centre ashore, who monitors the situation and makes decisions based on data from connected sensors. It is therefore clear that the networked systems required for remote operation may pose new risks that need to be considered before the system is developed and commissioned.

However, answers to the basic elements for the safe operation of unmanned vessels are required:

- Preparation of valid voyage plan and ensuring readiness of the vessel;
- Execution of the voyage plan and navigation;
- Cargo management;

- Ensuring the seaworthiness and safety of the vessel in heavy weather;
- Safe response and adaptations to the critical events;
- Responding to unauthorised intrusion into vessel systems (security and cyber security);
- Interventions related to search and rescue operations.

3.2. Reliability of navigational/safety equipment

Conventional ships rely heavily on the ship's crew as a resource for immediate rectification of faults as well as for carrying out preventive maintenance programmes while the ship is underway. This allows for the use of cheaper on-board systems and machinery that require frequent maintenance and have lower reliability.

The lack of a permanent ship's crew severely limits the possibilities for on-site monitoring and preventive and corrective maintenance of the ship's equipment during the voyage. This means that systems that are important for operation and safety must be designed so that they can be maintained remotely or are resistant to failure. As for monitoring and controlling the condition of machine systems, Jalonen et al. [24] emphasise the trend towards remote monitoring and control from shore centres, often operated by the manufacturer itself. In addition, the condition of important equipment other than the main machinery should also be monitored.

Felski and Zwolak [25] examined the hazards posed by the specific nature of unmanned vessels and find that unmanned vessels pose a risk to the safety of other sea users, the cargo and ultimately to themselves. They conclude that unmanned vessels should be tested under real traffic conditions, considering limitations of situational awareness sensors and self-diagnostic systems.

A recent study [26], looking at the safety equipment required for autonomous vessels, found critical components that can contribute to failure (e.g. route planning, voyage management, collision avoidance and situational awareness) only in good weather and daylight operations. According to their findings, the main problems are related to:

- Autonomous Navigation System (ANS) hardware, software and power supply;
- Echo sounder system;
- Electronic Chart Display and Information System (ECDIS);
- Microphone.

Backup is required for the above systems to increase reliability. As for the other various systems and sensors, they are not critical in good weather and daylight.

Felski and Zwolak [25] emphasize the navigational aspects, noting that positioning should be done by multiple sources and that redundant sensors should be present, especially with regard to monitoring speed and water depth, all with the aim of ensuring a high level of data accuracy.

3.3. Shore Control Centre (SCC) operator

In line with the IMO proposal for unmanned vessels, which states: "Remotely controlled ship without seafarers on board: the ship is controlled and operated from another location - there are no seafarers onboard"[21], the conclusion is straightforward; control of vessel should be from another location, i.e. from a shore-based control centre (SCC). In this context, human and/or technical factors need to be considered. According to [27], the future SCC operator will control six vessels simultaneously and make decisions.

This imply that the operator will rely heavily on technology and that information overload may affect the assessment of the decision-making process. In such a scenario, loss of situational awareness is a real possibility.

Furthermore, the issue of documenting operations on remotely operated vessels is still unexplored [28]. The same author states that the gap between the operator's core tasks and safety management needs to be addressed in future research.

The most important issue is the question of operator skills, i.e. the requirements of the operator's post requirements. From the available literature, it can be concluded that there are currently no regulations for the qualification of unmanned vessel operators. According to Mallam et al. [29], future requirements could include "a traditional seafaring education, certification and at sea experience, to non-seafarers who have a computer science background with coding skills, to video game enthusiasts comfortable with command and control of virtual agents and virtual worlds"(p.7).

Felski and Zwolak [25] state that work should be done in the near future to clarify the theoretical and practical requirements and that open discussions between all stakeholders are essential to address this issue.

3.4. Economic Impact of Unmanned Vessels

Ziajka-Poznańska and Montewka [30] conducted a literature review on the economic aspects of MASS vessels and concluded that great effort has been put into the costs associated with construction and operation, including the development of appropriate economic models for the aspects of operating a single as well as a fleet of MASS vessels. They believe that there are still some uncertainties that may affect the associated costs. The authors note that the "immaturity of the technology" and the various concepts of vessels and fleets may still have a significant impact.

Furthermore, the results of their study indicate that proper financial models for MASS vessels are lacking and uncertainties may influence cost estimates.

The costs of potential casualty events involving one or more vessels and of later-stage salvage operations are still unknown. The associated costs for cyber security and insurance rates for the MASS vessels are also unknown.

4. Conclusions

The concept of developing unmanned vessels certainly has its merits: reducing accidents caused by human error, saving on crew costs, reducing fuel consumption and, finally, contributing to environmental protection.

However, there are a number of unknowns behind the concept, mainly reflected in the reliability of the machinery, communication and navigation equipment. Furthermore, it is justified to question the human factor, even if it will be located in the onshore centre.

Finally, the economic impact in terms of price and associated costs is unknown. In light of the above, it can be concluded that there are a number of unknowns that may affect the purchase price of the vessel itself, associated equipment and insurance. In any case, it can be assumed that all associated costs will be passed on to the final price of the transport service, i.e. to the shipping company's customer and consequently to the price of the cargo itself. Therefore, one can only conclude that it is necessary to carry out a series of studies that will provide adequate answers to the current questions.

References

[1] United Nations Conference on Trade and Development (UNCTAD). Review of Maritime transport 2019. United Nations, Geneva, 2019. https://unctad.org/system/files/officialdocument/rmt2019_en.pdf (Accessed 18 January 2021).

[2] M. Stopford, Maritime Economics. London: Routledge, 2009.

[3] C. Hetherington, R. Flin, and K. Mearns, “Safety in shipping: The human Element”, Journal of Safety Research 37(4), pp. 401-411, 2006. https://doi.org/10.1016/j.jsr.2006.04.007

[4] International Labour Organisation (ILO). Recruitment and retention of seafarers and the promotion of opportunities for women seafarers. https://www.ilo.org/wcmsp5/groups/public/---ed_dialogue/---sector/documents/meetingdocument/wcms_664163.pdf?cv=1&session-id=76d91d65d9c14d808210c1f5ef46ca7e (Accessed 19 April 2022).

[5] P. Anderson, "Cracking the Code – the Relevance of the ISM Code and Its Impacts on Shipping Practices." The Nautical Institute, London, 2003.

[6] International Maritime Organization (IMO). Revised Guidelines On The Implementation Of The International Safety Management (ISM) Code By Administrations. https://wwwcdn.imo.org/localresources/es/OurWork/HumanElement/Documents/A%2030-Res.1118%20-%20English.pdf (Accessed 18 October 2019).

[7] M.S. Christian, J.C. Bradley, J.C. Wallace, and M.J. Burk, "Work place safety: a meta-analysis of the roles of person and situation factors". Journal of Applied Psychology, 94(5), 1103–27, 2009. Doi: 10.1037/a0016172

[8] D. Zohar, "Thirty years of safety climate research: reflections and future directions". Accident Analysis & Prevention, 42(5), 1517–1522, 2010. Doi: 10.1016/j.aap.2009.12.019

[9] International Maritime Organization (IMO). Maritime safety. https://www.imo.org/en/OurWork/Safety/Pages/default.asp (Accessed 21 January 2021).

[10] Guidelines for implementing the occupational safety and health provisions of the Maritime Labour Convention, 2006. International Labour Office Geneva, 2015.

[11] O. Turan, R.E. Kurt, V. Arslan, S. Silvagni, M. Ducci, P. Liston, J.M. Schraagen, I. Fang, and G. Papadakis, "Can we learn from aviation: safety enhancements in transport by achieving human orientated resilient shipping environment", Transportation Research Procedia 14, pp. 1669–1678, 2016. https://doi.org/10.1016/j.trpro.2016.05.132

[12] H. Dhami, and M. Grabowski, "Technology impacts on safety and decision making over time in marine transportation", Proceedings of the Institution of Mechanical Engineers, Part O: Journal of Risk and Reliability 225(O3), pp. 269-292, 2011. https://doi.org/10.1177/1748006XJRR359

[13] J.U. Schröder-Hinrichs, E. Hollnagel, and M. Baldauf," From Titanic to Costa Concordia—a century of lessons not learned", WMU Journal of Maritime Affairs 11, pp. 151–167, 2012. https://doi.org/10.1007/s13437-012-0032-3

[14] D, Mišković, T. Bielić, and J. Čulin, "Impact of Technology on Safety as Viewed by Ship Operators", Transactions on Maritime Science, Vol. 1; 51-58, 2018. Doi: 10.7225/toms. v07.n01.005

[15] European Maritime Safety Agency (EMSA). Annual Overview of Marine Casualties and Incidents 2019. http://www.emsa.europa.eu/news-a-press centre/externalnews/item/3734-annual-overview-of-marine-casualties-andincidents-2019.html (Accessed 02 December 2019).

[16] H-C. Burmeister, W.C. Bruhna, Ørnulf J. Rødsethb, and Thomas Porathec. "Can unmanned ships improve navigational safety?", Transport Research Arena 2014, Paris, pp. 1-8.

[17] Guidelines for Autonomous Shipping. Available online: https://www.bureauveritas.jp/news/pdf/641-NI_2017-12.pdf (Accessed on 15 January 2020).

[18] Autonomous and Remotely Operated Ships. Available online: http://rules.dnvgl.com/docs/pdf/dnvgl/cg/2018-09/dnvgl-cg-0264.pdf (Accessed on 15 January 2020).

[19] Ship Right Procedure—Autonomous Ships. Available online: https://www.lr.org/en/latest-news/lr-definesautonomy- levels-for-ship-design-and-operation/ (Accessed on 15 January 2020).

[20] Guidelines for Autonomous Cargo Ships. Available online: https://www.google.com.hk/search?safe=strict&source=hp&ei=1aweXvm0JtvmwQPM2pvABQ&q=Guidelines+for+Autonomous+Cargo+Ships%3B+CCS%3A+&oq=Guidelines+for+Autonomous+Cargo+Ships%3B+CCS%3A+&gs_l=psyab.3...33i160l5.28.28..700...0.0..0.135.135.0j1.....0....2j1..gws-wiz.z4POokU6tCs&ved=0ahUKEwi58_qFYTnAhVbc3AKHUztBlgQ4dUDCAU&uact=5 (Accessed on 15 January 2020).

[21] IMO (International Maritime Organization). Working Group Report in 100th Session of IMO Maritime Safety Committee for the Regulatory Scoping Exercise for the Use of Maritime Autonomous Surface Ships (MASS). IMO Document MSC 100/WP.8. Dated December 7th 2018. IMO: London https://www.imo.org/en/MediaCentre/MeetingSummaries/Pages/MSC-100th-session.aspx (Accessed on 15 January 2020).

[22] X. Chen, S. Wang, C. Shi, H. Wu, J. Zhao, and J. Fu. "Robust Ship Tracking via Multi-View Learning and Sparse Representation." Journal of Navigation 72 (1): 176–192, 2019. https://doi.org/10.1017/S0373463318000504

[23] E. Jokioinen, "Remote and autonomous ships-the next steps: Introduction". Rolls-Royce, Buckingham Gate, London: The Advanced Autonomous Waterborne Applications (AAWA). 2016:4-14.

[24] R. Jalonen, R. Tuominen and M. Wahlström, "Safety of Unmanned Ships. Safe Shipping with Autonomous and Remote Controlled Ships", Aalto University publication series SCIENCE + TECHNOLOGY 5/2017. http://urn.fi/URN:ISBN:978-952-60-7480-1 (Accessed on 15 November 2020).

[25] A. Felski, and K. Zwolak, "The Ocean-Going Autonomous Ship—Challenges and Threats", J. Mar. Sci. Eng. 2020, 8, 41. doi:10.3390/jmse8010041

[26] P. Lee, V. Bolbot, G. Theotokatos, E. Boulougouris, and D. Vassalos, "Fault Tree Analysis of the Autonomous Navigation for Maritime Autonomous Surface Ships", Proceedings of the 1st International Conference on the Stability and Safety of Ships and Ocean Vehicles, Glasgow, Scotland, UK, 2021.

[27] A. Komianos, "The autonomous shipping era. Operational, regulatory, and quality challenges", TransNav Int. J. Mar. Navig. Saf. Sea Transp. 12; 335–348, 2018.

[28] K.V. Størkersen, "Safety management in remotely controlled vessel operations", Marine Policy, 130; 104349, 2021, 1-7, 2021. https://doi.org/10.1016/j.marpol.2020.104349

[29] S.C. Mallam, N. Salman and A. Sharma, "The human element in future Maritime Operations – perceived impact of autonomous shipping", Ergonomics, 63:3, 334-345, 2020. Doi: 10.1080/00140139.2019.1659995

[30] E. Ziajka-Poznańska, and J. Montewka, "Costs and Benefits of Autonomous Shipping—A Literature Review. Appl. Sci. 2021, 11, 4553. https://doi.org/10.3390/app11104553

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[1] G. Eason, B. Noble, and I. N. Sneddon, "On certain integrals of Lipschitz-Hankel type involving products of Bessel functions," Phil. Trans. Roy. Soc. London, vol. A247, pp. 529–551, April 1955.
[2] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp. 68–73.

[3] I. S. Jacobs and C. P. Bean, "Fine particles, thin films and exchange anisotropy," in Magnetism, vol. III, G. T. Rado and H. Suhl, Eds. New York: Academic, 1963, pp. 271–350.
[4] [K. Elissa, "Title of paper if known," unpublished.
[5] R. Nicole, "Title of paper with only first word capitalized," J. Name Stand. Abbrev., in press.
[6] Y. Yorozu, M. Hirano, K. Oka, and Y. Tagawa, "Electron spectroscopy studies on magneto-optical media and plastic substrate interface," IEEE Transl. J. Magn. Japan, vol. 2, pp. 740–741, August 1987 [Digests 9th Annual Conf. Magnetics Japan, p. 301, 1982].
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