Impressum

EDITORIAL OFFICE
Transactions on Maritime Science
Faculty of Maritime Studies
Ruđera Boškovića 37,
21000 Split, Croatia
www.toms.com.hr
office@toms.com.hr

PUBLISHER
Faculty of Maritime Studies
Ruđera Boškovića 37,
21000 Split, Croatia
office@pfst.hr

DESIGN
Offstudio, Zagreb, Croatia
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Abstracting/Indexing:
Web of Science (Emerging Sources Citation Index)
Scopus
Hrčak
Index Copernicus
TRID (the TRIS and ITRD database)
BMT | Marine Science and Technology
Google Scholar
Digitale Bibliothek Braunschweig
INSPEC

Published twice a year.
Printed on acid-free paper (print ISSN 1848-3305).
ToMS online (ISSN 1848-3313) offers free access to all articles.
www.toms.com.hr

Transactions on Maritime Science (ToMS) is a scientific journal with international peer review which publishes papers in the following areas:

~ Marine Engineering,
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The journal is published in English both as an open access journal, and as a classic paper journal (in limited editions).

ToMS aims at presenting major maritime research all over the world, particularly focusing on the Mediterranean area. Articles will be double-blind reviewed by three reviewers. ToMS also promotes scientific collaboration with talented students at a beginning of their scientific careers. These papers also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, book reviews and workshops in the fields of maritime science.

The views and opinions expressed in the papers are those of individual authors, and not necessarily those of the ToMS editors. Therefore, each author will take responsibility for his or her contribution as presented in the paper.

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Contents

From Editor-in-Chief: Working at Home

Igor Vujović

This issue is specially dedicated to the ongoing pandemic, due to which employees in higher education have encountered an unprecedented challenge. Observing the necessary preparations to implement distance learning in the university routine, they are now facing a more demanding work. Distance learning includes self-learning of new applications and tools, preparations for on-line lectures, recording of video lectures, and record of student attendance. It leads to one-to-one learning, which is infinitely more demanding than lecturing ex-cathedra. The most problematic segment is examination on-line, which depends on the student's honesty, and it is bound to present a completely new experience, both for teaching staff and students. However, as life goes on, a new Journal issue is about to be released, demanding even more difficult tasks from the Editorial team. We can say: "Of course we will publish the best submitted papers. Of course it will be on time. Of course we are already working virtually in the Open Journal System (OJS)." However, it is not quite the same.

We already have science, education, institutional, administrative jobs on-line, as well as working at home. Issues are being published, but the following question arises: Is our future virtual?

Despite this very challenging situation, I would like to express my gratitude to our reviewers for their eagerness to finish reviews on time, to the authors willing to do experiments, research the topics, write manuscripts, and for the opportunity they choose our Journal to publish the work. Lastly, I would like to thank the Editorial team for the extra effort they have put in carrying out their tasks to finish this issue.

I would like to announce that this issue contains ten papers.

The first paper introduces the procedure for stochastic fatigue analysis of typical midship models with direct load transfer applied, whereby an oil tanker is studied.

The second paper deals with the purpose of developing a methodology for justifying the selection of the fleet replenishment project of a shipping company, based on peculiarities of the cargo flow structure, and considering the possibility of slow steaming ships operation.

The third paper studies the purpose of the research as twofold: to explore and analyze the most common service failures and implemented recovery strategies in Turkish third party logistics service industry and examine their impact on business relationships.

The fourth paper examines the impact of supply on production results in the shipbuilding industry. The purpose of the simulation of its impact on the production process is the avoidance of possible mistakes that could not only weaken a company's competitive position, but endanger its viability as well.

The following paper shows that ERASMUS can produce international collaboration. The results of the research show that the number of passengers in the port of Rijeka has been increasing over the past few years, which indicates that Rijeka is developing as a cruising destination.

The sixth paper discusses the competitiveness of the Northern Sea Route as a shorter maritime route between Asia and Europe.

The seventh paper is aimed at trying to evaluate the port-city relationship from its onset, taking into account the challenges of port 4.0.

Authors from Mexico and South Africa wrote the eight paper. Their article deals with cross-cultural and cross-disciplinary virtual engagement aimed at matching human-computer interaction design principles with contemporary integrated navigation information systems.

The ninth paper's results in an evaluation of current navigational simulator Transas NTPRO 5000 ability of realistic training in search operations by radar have been presented.

The last paper presents the results obtained from PhD research in maritime zone surveillance included in the scientific projects.

Remaining true to our mission to preserve the Croatian cultural heritage, this issue of ToMS brings you two poems by Izvor Oreb, written in the idiom of the Island of Korčula. The contribution comes in a bilingual form, in an inspired translation of Mirna Čudić Žgela, our long-standing collaborator. As a special bonus for the readers of the electronic edition, Klapa Vela Luka performs one of the poems set to music (available on Youtube).

ToMS encourages contributions in the fields of ocean engineering, marine engineering, and marine electrical engineering.

As always, we hope that the papers we publish will encourage your cooperation.

Please, note that the journal is not liable for the contents of papers and contributions. Rather, it is the authors' obligation to obtain all permissions requisite for publication.

In the end, I should mention that the previous issue was co-financed by the Ministry of Science and Education of the Republic of Croatia through University of Split funding of science.

I wish you all well.

Editor-in-Chief

Procedures of Fatigue Analysis by Supporting Direct Load Application on Midship Sections

Ozgur Ozguc

Fatigue evaluation of ship structures using direct calculation methods to calculate fatigue loads are standard practice today. There are several numerical codes available for use in analyses of these fatigue loads. In addition to the varying degrees of computational complexity associated with fatigue prediction methods, the inherent uncertainties of these procedures are also large. This paper introduces the procedure for stochastic fatigue analysis of typical midship models with direct load transfer applied, where an oil tanker is considered. It also covers a comparison of the results with the component-based approach included in the DNVGL Class Note 30.7: "*Fatigue Assessment of Ship Structures*". The "real" case analysis includes both internal pressure loads from tank fluids as well as external pressure adjusted for wet and dry surfaces in the waterline area, according to DNVGL Class Note 30.7. Local fine mesh models of fatigue details have been analysed using the sub-modelling technique. The procedure performs well on a typical midship model apart from the file sizes of the generated load transfer files. With 25 wave periods and 12 different headings, the analysed 3-cargo-hold model (1/2 + 1 + 1/2) in the midship area had to be split into four super elements in order to get the analysis through finite element analyses. The procedure is suitable for vessels where warping (torsion) is of less importance. The described procedures are supported by a developed tool to be used in the analysis procedures. Three details of local fine mesh models such as deck erection butt weld, longitudinal stiffener through web-frame, and bottom erection butt weld have been analysed. The results have been compared with the component-based approach. For some of the details there are comparable results, but for others the results vary significantly. The typical trend is that the details heavily influenced by the external pressure (side longitudinal) give less comparable results than e.g. a detail in the main deck mainly influenced by global loads. A comparison of the effect of reducing versus not reducing the pressure amplitude in the waterline on the fatigue life has also been performed and discussed.

KEY WORDS

~ Fatigue assessment
~ Stochastic method
~ Component-based approach
~ Finite element analysis
~ Midship section

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doi: 10.7225/toms.v09.n01.001

1. INTRODUCTION

Precise assessment of the fatigue of ship structures is an important part of structural integrity. In critical locations of ocean-going ships, fatigue cracks can occur earlier than expected, as a result of accumulated fatigue damage. In certain practical cases, the data set required for accurate estimation of fatigue damage can be obtained either through numerical simulation or direct measurement, but in practice the size of the above data set is often limited and not large enough for accurate calculation of the direct fatigue damage.

Mao et al. (2014) conducted a comparative analysis that used different traditional direct fatigue calculation methods for two container vessels. The amount of fatigue damage calculated using these methods has been compared with that obtained from full-scale measurements. Most of the direct calculation approaches examined have yielded similar fatigue damage predictions. The procedure using non-linear hydrodynamic analysis of the time-domain and the finite-element approach provided and recommended fair and conservative results of fatigue damage.

Parihar et al. (2017) adopted an approach to assessing stress transfer function based on the direct application of moments such as vertical bending, horizontal bending, and torsional moments calculated by a frequency-domain-based sea-keeping code. Multipoint Constraint (MPC) approach was used for bending moment application. Comparison was made of the structural responses measured using direct application of the bending moments (Method 1) and the panel pressures (Method 2). The role of stress transfer assessed was employed for analysing spectral fatigue. In addition, the study produced a technique for determining spectral fatigue using direct application of moments of bending.

Xiang-chun et al. (2006) used a spectral method that was considered the most reliable although the procedure was complicated and time-consuming. Critical technical items such as wave pressures and inertial forces due to loads, stress extraction and the RAO stress calculation have been addressed. In addition, four key technical details - loading application, displacement boundary condition, calculation of RAO stress, and fatigue stress extraction were addressed in detail. The resolutions were effective and efficient, which could guide the engineers to perform spectral fatigue analysis more precisely and more quickly where the NASTRAN FE solver was employed.

Kozak and Górski (2011) have applied a number of approaches to estimating the fatigue life of the hull, whose structural elements have been provided. In practice, certain procedures based on nominal stress were applied to "hot-spot" stress or notch stress, which constituted the basis for the determination of fatigue life using the design curves of σ-N. The current proposals were critically computed and their drawbacks are presented in this study.

Wang and Shao (2019) addressed three methods for calculating accumulated fatigue damage to ship structures on the basis of a direct analysis. The methods applied were in accordance with a short-term distribution, a long-term distribution based on a short-term distribution, and a major stress calculation. For each procedure, the corresponding formulations and flow charts were presented. The findings revealed that the accumulated fatigue damage calculated varies and a great deal of attention should be paid to each.

Gaidai et al. (2019) have contributed to the development of novel fatigue prediction methods that have made more efficient use of the limited data available. Continuous stress time series covering almost two years of duration have been computed. Rainflow counting method was subsequently employed for the evaluation of accumulated fatigue damage. Efficient tail-extrapolation technique has been proposed to accurately predict fatigue damage. The proposed technique used the available data more efficiently than the estimation of direct fatigue.

Niemi et al. (2018) provided several hints regarding stress determination and interpretation in finite element models and discussed the choice of suitable finite elements with respect to structural hot-spot stress analyses, and covered shell as well as solid elements. Three methods of deriving structural hot-spot stresses were explained and discussed in detail such as the through-thickness stress linearisation at the hot-spot, the surface stress extrapolation to the hot-spot, and the determination of the structural hot-spot stress at a certain point in front of or below the hot-spot. Finally, detailed hints were given regarding the choice of the element type and size as well as stress evaluation in case of coarse and fine finite element meshes, supplemented by some remarks on the weld modelling when using shell elements in the fatigue assessment.

Magoga (2019) provided validation of spectral fatigue analysis (SFA) against test results, followed by a review on the sensitivity of fatigue damage to various parameters sustained in a naval HSLC. Furthermore, fatigue analysis was affected by uncertainty in input parameters and modelling. It was discovered that fatigue damage was most sensitive to significant wave height, although the relative importance of the speed and direction increased when operating conditions were taken into account. The work was related to the long-term management of naval ship structures.

Currently in the rules for fatigue evaluation of structures exposed to intense alternating service loading the Stress-Life (S-N) criteria, versions of the nominal stress approach, hot-spot stress approach and notch-stress approach were suggested based on the use of the stress range as a representation of the present damage.

Petinov and Guchinsky (2018) examined the criteria and procedures for assessing the fatigue properties of structures, accompanied by a series of approximations and uncertainties. According to these researchers, the strain-life and inelastic strain energy requirements for fatigue failure and approaches may provide a physically and mechanically more accurate procedures, specific with intrinsic sources of approximations. The essence of approximations in the methods was briefly commented and the fatigue evaluation techniques and implementations were provided with feasible means of improvement.

Bardetsky and Lee (2016) applied a new comprehensive analytical procedure for predicting crack propagation under sea-wave loading by spectral fatigue analysis, beam theory, fracture mechanics and an equivalent stress intensity factor (SIF) range concept. The analytically obtained SIF range was validated by the FE modelling of the damaged vessel undergoing dynamic sea-wave loading. The analytical procedure for predicting crack propagation has been demonstrated for a typical, modern 170,000 DWT bulk carrier in full load condition. The findings of this work could be utilized to guide rational decision-making when assessing the residual strength of a vessel for the transit voyage from the site of the accident to a repair facility.

Parunov et al. (2013) used finite element (FE) method to calculate stress concentration factors (SCFs) using shell elements, which were then compared with their specified values according to classification societies' guidelines. The FE analysis has been used for various configurations of the details that may appear in practice. A simplified procedure for calculating fatigue life has been used and the differences in calculated fatigue life due to the differences in SCFs have been evaluated. The methodology for calculating SCFs was then verified on the basis of the FE analysis of the details of the derived hot-spot stress target and of the corrected SCFs. The effect of SCF correction on fatigue life was discussed. Specific methods were considered for extrapolating stresses to the weld foot, and the resulting SCFs were compared with the values provided by the classification societies' regulations. The study findings may be used in the process of harmonization of ship structural rules and in analyses of fatigue reliability.

González (2016) examined the key characteristics of the most popular fatigue analysis methodologies, and highlighted the drawbacks and uncertainties involved. Further, developments in reliability-based approaches have been suggested for a more accurate assessment of the fatigue of ship unloaders.

Fricke (2015) addressed various approaches, which highlighted their advantages and limitations. In this relation, the troublesome distinction between crack initiation and propagation phases was addressed, followed by considerations of other parameters that have a major impact on the fatigue actions of welded joints but are regarded differently in approaches, such as plate thickness and stress gradient effects, multiaxial stress conditions, welding-induced distortions and residual stress. In conclusion, ways to improve the fatigue behaviour of the welded structures have been addressed, either during design by reducing stress concentration or during manufacturing by improved quality, post-welding treatment or by special material characteristics.

Kim et al. (2009) performed a fatigue strength evaluation for a container vessel's side shell longitudinal connections, using both the hot-spot stress and structural stress methods. A consistent procedure of computing extrapolated hot-spot stress for design purposes based on converging hot-spot stress was described and current fatigue guidance was evaluated. Fatigue capacity predicted by both methods, i.e. hot-spot stress and structural stress approaches, at hot-spot locations of the typical ship structure was compared and discussed.

Fatigue damage reduces the structure's load-bearing capacity and can lead to leakage, leading to pollution, cargo mixing or gas accumulating in enclosed spaces, in severe cases; such structural damage could potentially lead to catastrophic failure or total vessel loss (Ozguc, 2017). Ship longitudinals are significant structural components in the ship's side shell construction. The wave loads cause major dynamic stresses below the mean water level in the side shell. This has resulted in a number of fatigue cracks in the welded connections between side longitudinal stiffeners and transverse frames and ship bulkheads (Ozguc, 2018).

This paper introduces the procedure for stochastic fatigue analysis of typical midship models with direct load transfer applied, in which an oil tanker is considered. It also covers a comparison of the results with the component-based approach included in the DNVGL Class Note 30.7. The "real" case analysis includes both internal pressure loads from tank fluids as well as external pressure adjusted for wet and dry surfaces in the waterline area according to Det Norske Veritas, DNVGL Class Note 30.7: "Fatigue Assessment of Ship Structures". Local fine mesh models of fatigue details have been analysed using the sub-modelling technique. The procedure performs well on a typical midship model apart from the file sizes of the generated load transfer files. With 25 wave periods and 12 different headings, the analysed 3-cargo-hold model (1/2 + 1 + 1/2) in the midship area had to be split into four super elements in order to get the analysis through SESTRA software. The procedure is suitable for vessels where warping (torsion) is of less importance. The described procedures are supported by Excel spreadsheets to be used in the analyses' procedures. Three details (local fine mesh models) have been analysed. The results have been compared with the component-based approach described in DNVGL Class Note 30.7. For some of the details there are comparable results, but for others the results vary significantly. The typical trend is that the details heavily influenced by the external pressure (side longitudinal) give less comparable results than e.g. a detail in the main deck mainly influenced by global loads. A comparison of the effect of reducing versus not reducing the pressure amplitude in the waterline on the fatigue life has also been performed and discussed.

2. SELECTION OF FATIGUE ANALYSIS METHODS

The analysis procedure is adopted on an oil tanker, and its principle dimensions are listed in Table 1 below.

Table 1.
Main particulars of the oil tanker analysed.

Length over all	340 m
Length between perpendiculars	325 m
Breadth	56 m
Depth	28.8 m
Draft	22.3 m
Deadweight	307,400 tons

The most sophisticated method is full stochastic (spectral) analysis. The full stochastic (spectral) analysis employs both global and local finite element models to determine the stress response and may be used for any kind of structure. As basis for the stochastic fatigue analysis, a linear frequency domain wave load analysis is carried out to determine load transfer functions for external pressures and vessel motions. Global integrated responses such as vertical and horizontal bending moments and shear forces are also calculated. From the load transfer functions, the stress transfer functions are determined by either a component stochastic or a full stochastic approach.

In the component stochastic method the stress transfer functions are established by the load transfer function multiplied with a unit load stress factor for each load component. The load components typically include global wave bending moments, external and internal pressures. The combined stress response is found by a complex summation of the stress transfer functions for each individual load component.

This paper introduces the procedure for component stochastic fatigue analysis of midship models with direct load transfer applied on a typical DNVGL NAUTICUS HULL midship model, where the model used is an oil tanker vessel. The model consists of 44,556 nodes and 76,623 elements with four elements between transverse frames.

The procedure offers a substantial reduction in time when considering a full stochastic calculation of fatigue life in the midship area. The procedure performs well on a typical midship model apart from the file sizes of the generated load transfer files. With 25 wave periods and 12 different headings, the analysed midship 3D cargo hold model (1/2 + 1 + 1/2) had to be split into four super elements in order to get the analysis through SESTRA.

The "real" case analysis includes both internal pressure loads from tank fluids as well as external pressure adjusted for wet and dry surfaces in the waterline area according to DNVGL Class Note 30.7. Local fine mesh models of fatigue details have been analysed using the sub-modelling technique. The described procedures are supported by developed tool to be used in the analysis procedures.

The analysis showed that the procedure will be resource demanding using the current DNVGL NAUTICUS standard for mesh on the midship model. After several alterations, the model was divided into 4 super elements and the number of periods analysed was reduced to 25, resulting in a reduction of 96 load cases.

It is proposed that the same person performs the hydrodynamic analysis and the fatigue analysis in order to ensure that the necessary calculations are performed without too many iterations. Using internal pressure, pressure reduction in the waterline and a local finite element model of the detail investigated, WADAM has to be run 6 times, where WADAM is based on a 3D sink-source (diffraction-radiation) method coupled to the Morison equation. It has a useful capability of allowing viscous forces to be incorporated in the modelling, which is important for the roll motion of a vessel. Using the same person for both analyses will also reduce the amount of time used to move files back and forth, which can also be time consuming with files of the mentioned size.

Three details of local fine mesh models such as deck erection butt weld, longitudinal stiffener through web-frame, and bottom erection butt weld have been analysed. The results have been compared with the component based approach described in DNVGL Class Note 30.7. A comparison of the effect of reducing versus not reducing the pressure amplitude in the waterline on the fatigue life has also been performed and documented.

The procedure for full stochastic fatigue analysis on a midship model has been tested with simplified fatigue procedure, which is implemented on the Nauticus hull model. The analysis was performed without internal tank pressure, and no local finite element model of fatigue critical details were made.

In order to see how the procedure works in a "real" case in the production line, the "oil tanker" model previously used for component-based fatigue calculations was used. The "oil tanker" is a 1/2+1+1/2 tank model with swash bulkheads at its ends modelled according to the current DNVGL NAUTIUCUS HULL standard with one element between stiffeners and four elements between frames, as shown in Figure 1.

The oil tanker studied in this paper has 11 segregated tanks within the modelled midship area. In addition, the large centre tank is divided in two with a swash bulkhead, which is not heavily perforated. This means that the centre tank has to be treated as two separate tanks, i.e. the midship model essentially consists of 12 tanks.

The 12 headings and 25 wave periods have been employed in the analysis. The wave environment is the World Wide scatter diagram and the Pierson-Moskowitz (PM) spectrum has been used. The hydrodynamic panel model is in millimetres and, therefore, the World Wide scatter diagram has to be modified so that the wave heights are in millimetres in order to get consistency in the analysis procedure.

In addition to the midship model, three local fine mesh models have been used as the basis for fatigue calculations, one detail in the deck (butt-weld), one detail in the ship side (side longitudinal) and one detail in the bottom (butt-weld).

The comparison between three types of analysis have been performed. The full stochastic procedure with correction of the pressure in the waterline has been compared with the same procedure without waterline pressure correction and with component-based approach. The comparison has been performed for all three local fine mesh details.

The loads applied to the models consist of section loads (representing loads from the parts of the vessel not modelled), local pressure from waves and fluid in the tanks and inertia forces

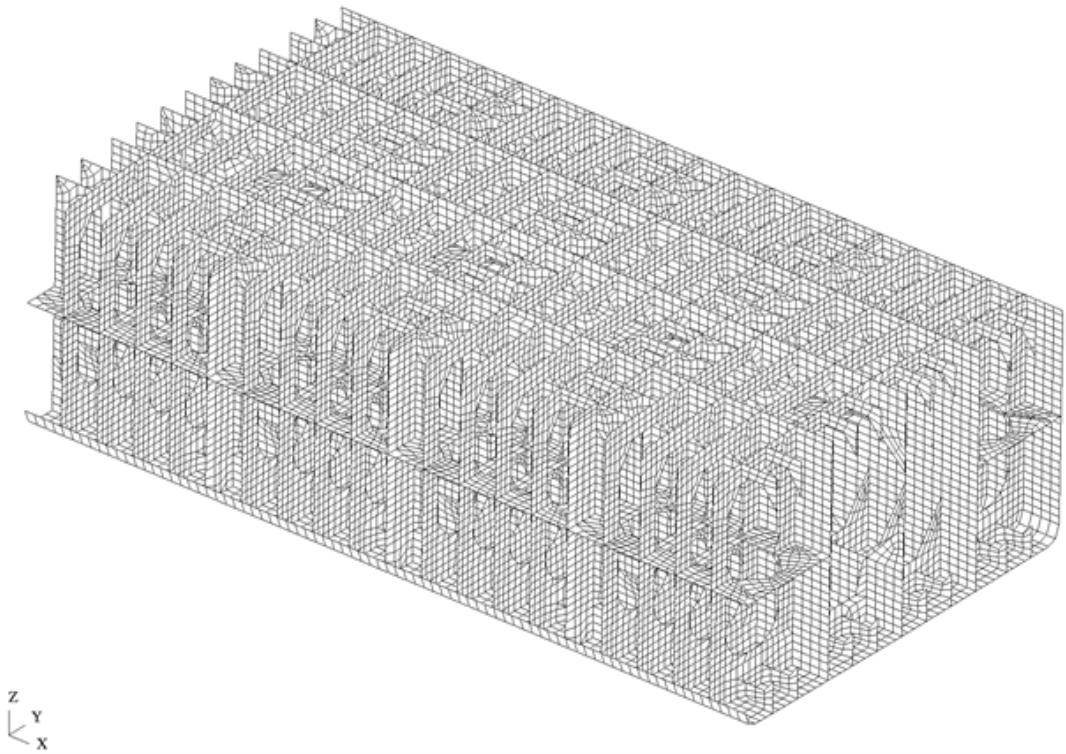

Figure 1.
Finite element midship model of oil tanker - deck and side removed.

from accelerations. On the local models, displacements from the midship model are transferred to the boundaries to represent the global deflections, and external as well as internal pressures from WADAM are transferred to represent the local loads.

Stresses from the finite element model are automatically extracted by STOFAT fatigue module in the SESAM tool. The transfer function is presented as the amplitude only when printed. The maximum stress will always be used as STOFAT module does not consider directionality when choosing principal stress, as described in DNVGL Class Note 30.7, which again will result in conservative results when calculating the fatigue life of a given detail.

Only external pressure was used as local loads, and no local fine mesh models were made for fatigue calculation purposes. The second part will look into this and, in addition, there will be a comparison between the results achieved with the full stochastic method and the component-based method.

The following supplementary tools are being developed.

- *Pressure Reduction*

Developed to modify the water line pressure to account for the wet and dry areas, according to the DNVGL Class Note 30.7 "Fatigue Assessment of Ship Structures".

- *Sectional Force*

Developed to include the sectional forces at the end of the structural midship model to account for loads from not-included structure.

- *Merge FEM Files*

Developed to merge the load interface files from the external pressure analysis and internal pressure analysis. Necessary because of large files from separate analysis.

3. HYDRODYNAMIC ANALYSIS

The hydrodynamic analysis has to be performed in two or three steps depending on whether internal tank pressures are needed or not. The panel model and mass distribution model should be made according to present procedures for the considered load conditions. Usually two load conditions are adequate and should represent the most frequent conditions in which the vessel will operate, but if it is difficult to relate the vessels lifetime to only two, extra load conditions should be considered.

In order to utilize the new feature with extrapolating and adjusting the pressure profile in the waterline region, the structural model has to be run as panel model in hydrodynamic analysis to get the panel numbers and definition. All panels that

might get pressures from the changed water line wave profile must have hydro-pressure applied in a tool (e.g. PREFEM, etc). From the hydrodynamic analysis (e.g. WADAM, etc), all the panel information must be stored in the spreadsheet for waterline pressure alteration.

After having made the panel model and the mass model, sectional loads and external pressure must be calculated; both can be calculated in the same hydrodynamic analysis. Section forces for several cuts must be calculated within the boundaries of the midship model in order to assure that the load balance should accordingly be verified in the next stage (e.g. CUTRES, etc). Typically, 7-10 cuts are needed for a proper verification of the transferred forces in addition to the two cuts, which must correspond with the midship model ends.

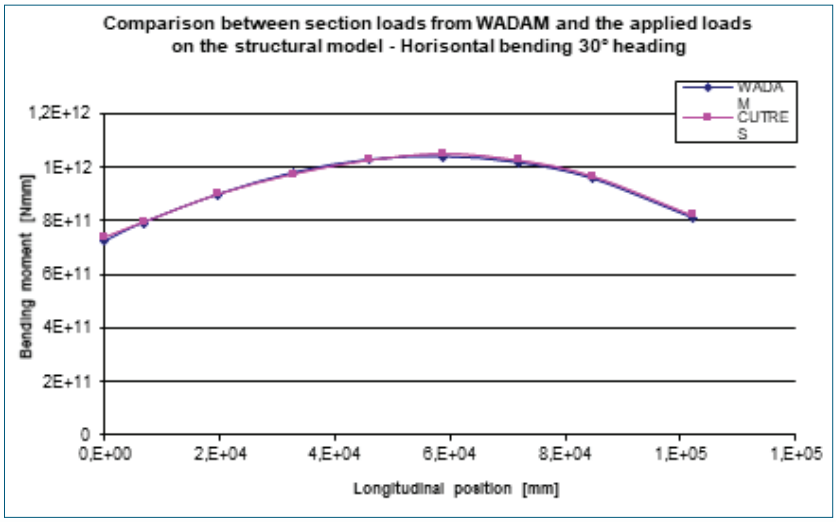

Figure 2.
Comparison between horizontal moment in WADAM and CUTRES.

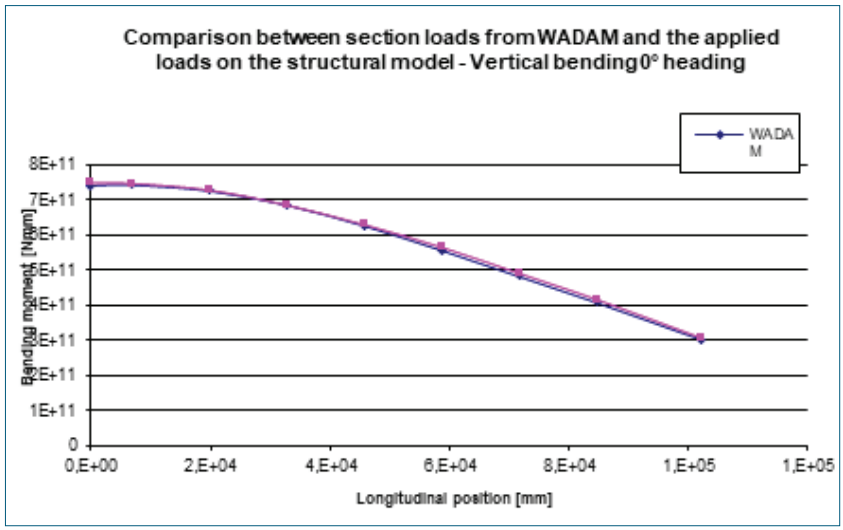

Figure 3.
Comparison between vertical moment in WADAM and CUTRES.

As seen from Figure 2 and Figure 3, there is a good agreement between the horizontal bending and vertical bending moment from WADAM and CUTRES. Typically, the difference is in the order of 0 % to 1.5 %.

If the tank pressure option is necessary, WADAM has to be run a third time. All the tanks must be defined in PREFEM with a separate load case number starting on load case number 2. All the surfaces which will receive pressures must be defined with hydro dummy pressure cards, with no hydro dummy cards defined on the hull for external loads.

The load interface files from the second and third WADAM analyses must be kept apart as they will get the same names. Prior to the structural analysis, the load interface files from the external and internal pressures must be merged. Together with the structural interface files, they work as the input to the structural analysis.

WADAM allows the option to integrate the section loads (vertical bending moment etc.) from two different directions. It is of great importance that the direction is known for the application of the sectional loads to the finite element model. The sign convention between WADAM and PREFEM is shown in Figure 4.

If local fine mesh models are used for describing the details, WADAM must be run again if the local model is to have internal tank pressure. The local model must be included in the midship model (or another model which describes the tank volume) in order to have a proper description of the tank volume. Otherwise, the internal pressure mapped on the local model will not be correct.

For external pressure, a restart of WADAM according to standard procedure is sufficient to transfer pressure to the hull plates. If the local model is in the waterline region, the pressure profile must be changed on the local model as well.

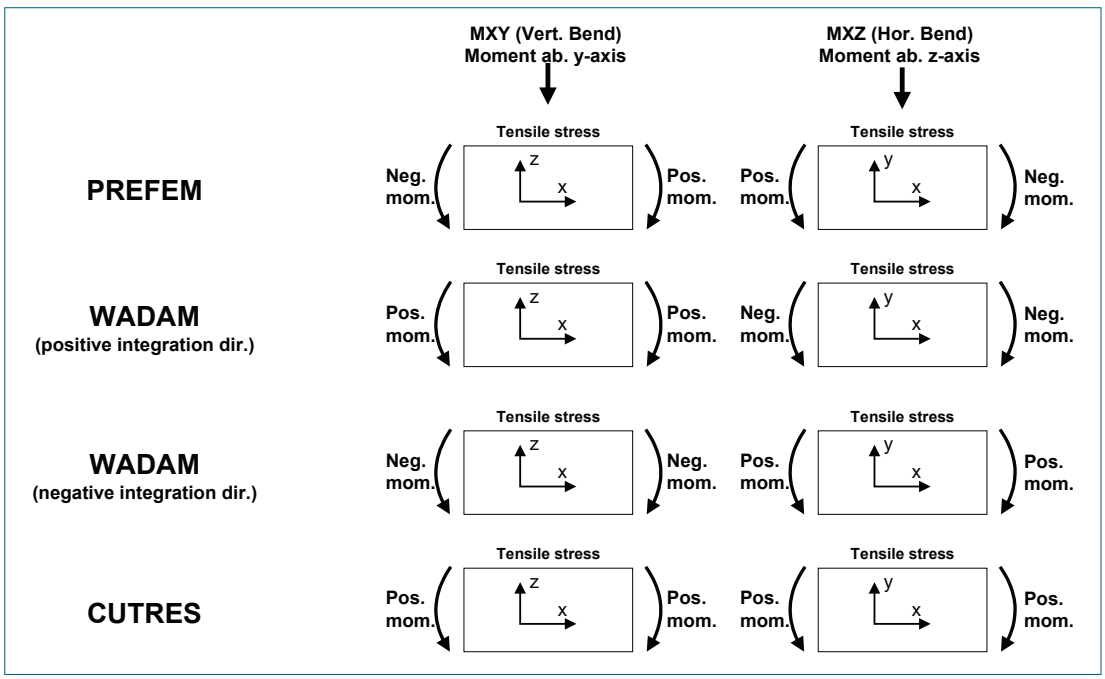

Figure 4.
Sign convention in different SESAM software programmes.

4.STRUCTURAL ANALYSIS

For the oil tanker, the structural midship finite element model had to be divided into four separate super elements, as seen in Figure 5.

First, the finite element model was divided into two parts, but the same problems occurred even with the split file option. Then, the number of wave periods was reduced from 33 to 25, but still the file sizes were too large. Finally, the model was divided into four parts with the split file option, and this allowed the analysis to be completed. The file can be reduced significantly if the results from only a selection of super elements are required and not all, in this case, four.

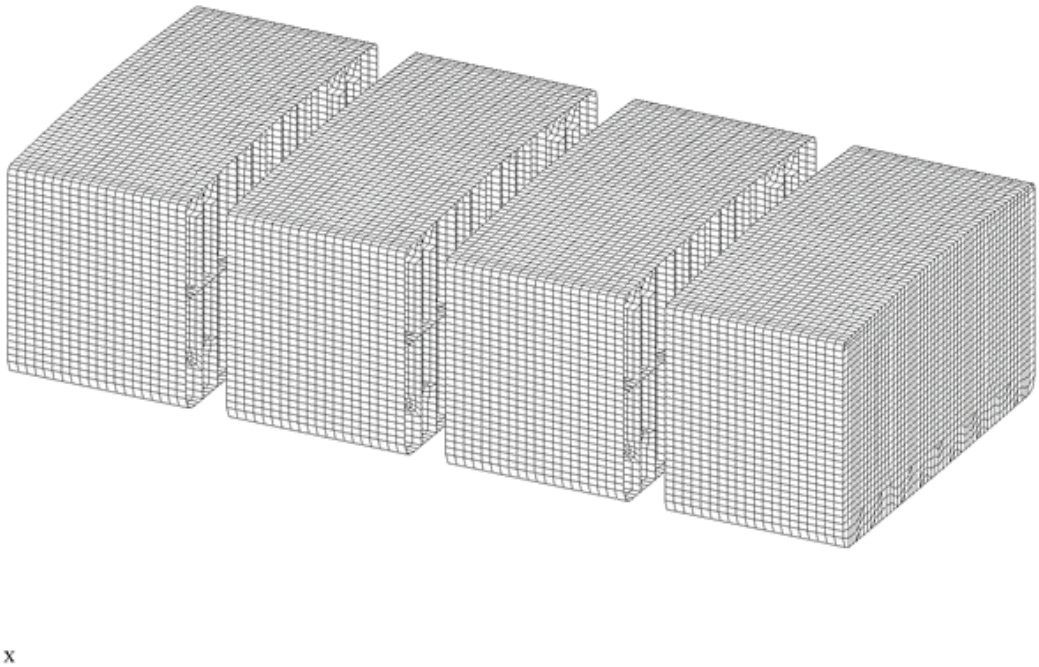

Figure 5.
Separation of "oil tanker" for final analysis.

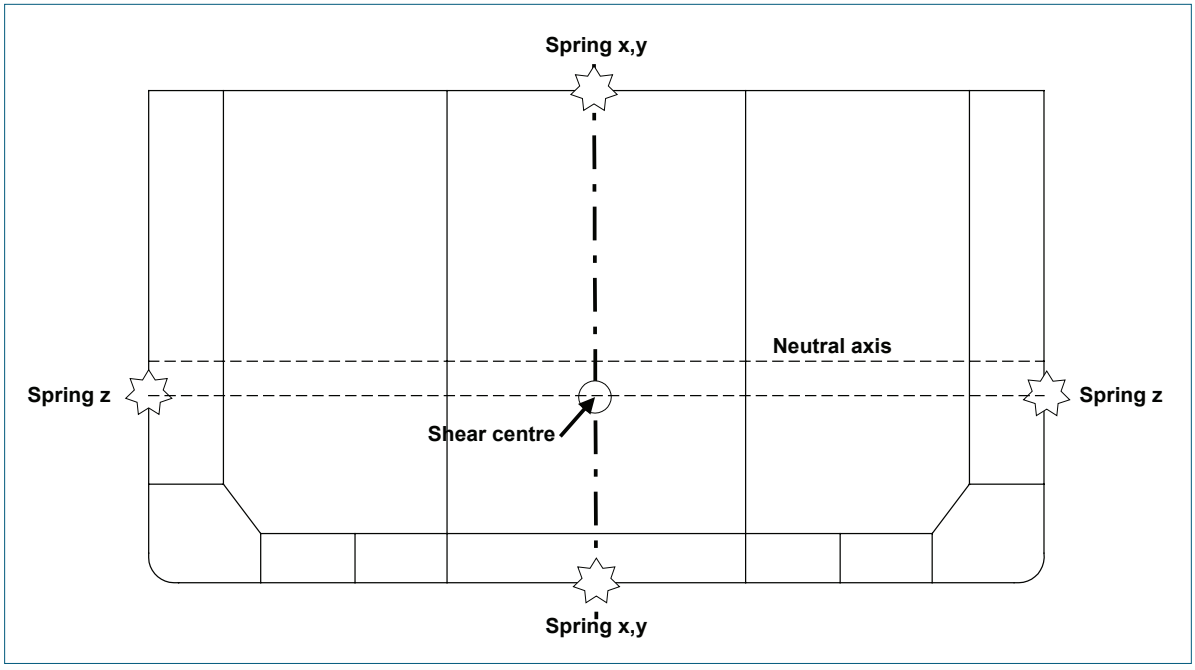

Figure 6.
Midship model spring locations (concentrated springs).

The midship finite element model was made according to DNVGL NAUTICUS standard, with four elements between the transverse frames and one element between the longitudinal stiffeners. 4-node shell elements were used to describe the plates, and 2-node beam elements were used to describe the longitudinals and secondary stiffening. Longitudinal, vertical, and axial springs were applied to the ends of the model in order to avoid singularities due to the small unbalance which will always be present in structural analysis with direct transfer of loads. Rigid body dependencies were used at the ends to get the sectional loads transferred. Applying rigid body dependencies at the ends results in that the cross section will always move a stiff plane and it is, therefore, not necessary to apply springs which are distributed according to the shear stiffness of the cross section. It is adequate to apply springs in accordance with Figure 6 and Table 2, but the spring stiffness should in any case be small. 1/1,000 of the real stiffness is proposed.

It is noted that if any other boundary conditions than rigid body dependencies for all degrees of freedom are used, other spring definitions may have to be used.

Table 2.
Spring location.

Type	Location	Description
Springs x	Centreline, deck + (inner) bottom	Spring constants to be such that an axial force give zero moment about the neutral axis.
Springs y	As springs x	Spring constants to be such that a transverse force give zero moment about the horizontal axis through the shear centre.
Springs z	Ship sides	Vertical location of less importance.

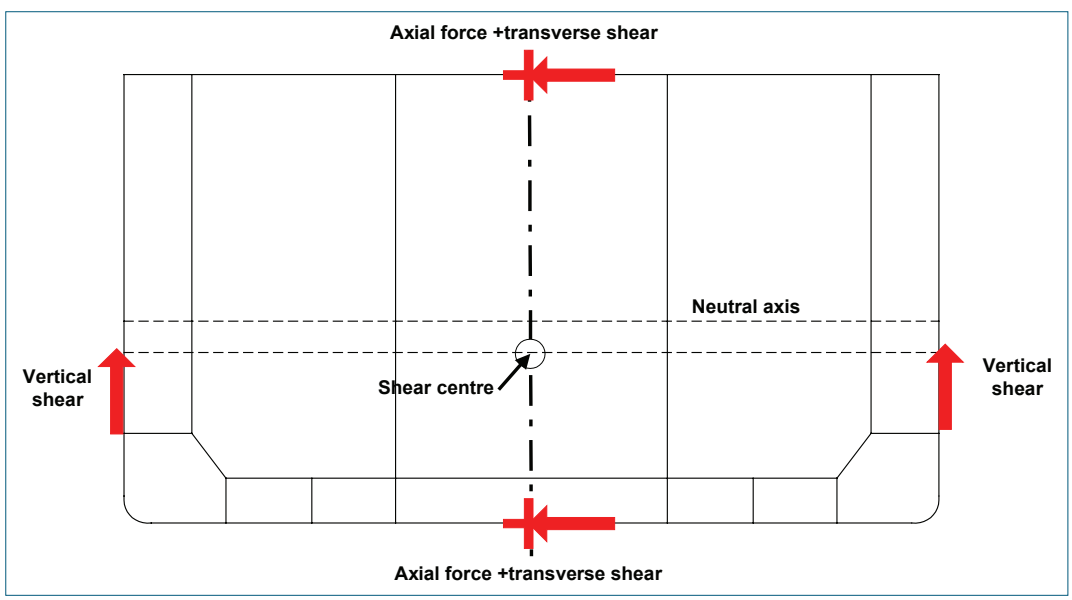

Figure 7.
Midship model load application.

The applied loads are section loads combined with pressure and inertia forces. The section loads are applied at the ends of the finite element model, and are defined as point loads at specific points, as shown in Figure 7 and Table 3.

The section loads are necessary in order to include the effect from the structure and loads not modelled in the midship model. It is important that the point loads are applied to the model so that they do not introduce any extra unwanted bending moment etc.

External pressure forces are applied to the hull, while inertia forces are accelerations working on the mass of the model, including both tank fluids and steel mass.

Table 3.
Force location.

Type	Location	Description
Axial force	Centreline, deck + (inner) bottom	Force to be such that an axial force give zero moment about the neutral axis.
Transverse shear	As axial force	Force to be such that a transverse force give zero moment about the horizontal axis through the shear centre.
Vertical shear	Ship sides	Vertical location of less importance.

Prior to the structural analysis, the external pressure from the hydrodynamic analysis is modified according to the procedure described in DNVGL Class Note 30.7. From the hydrodynamic analysis, it is therefore necessary to calculate the long-term pressure (daily level, 10-4) at the waterline based on all the headings included. The amplitude of the intermittent wet and dry area on the hull can then be found and the pressure will be adjusted in this area through a spreadsheet custom-made for this procedure.

Due to the fact that both the internal pressure and external pressure will work on the same panels, but on opposite sides for the hull plates, the load files from the two WADAM analysis (internal and external loads) must be merged. If both external and internal loads are taken from the same WADAM analysis (same L*.FEM file), the panels with both external and internal loads will be altered with the procedure for changing the pressure profile in the waterline area. It is noted that these numbers are for the midship model divided into four separate parts.

5. FATIGUE ANALYSIS

The stochastic fatigue analysis is performed with DNVGL SESAM software STOFAT module. The input to STOFAT is the result file from the structural analysis, containing all the stress data, together with either interactive input or a batch file input of control parameters such as exposure time, S-N curve, local SCF's, scatter diagram, wave spectrum etc.

Fatigue checks can be performed on both the elements and hot-spots. The element check will report the worst position on the element (highest fatigue damage), while the hot-spot check will report the damage for both the extrapolation points at t/2 and 3t/2 as well as for the hot-spot itself. If the damage at a given node is required, e.g. at t/2, simply specify two or more of the points used for extrapolation at the considered node. The Principal stress is calculated based on the extrapolated component stresses, but only the absolute maximum stress value is used.

6. COMPARISON OF INTERNAL PRESSURE BETWEEN MIDSHIP MODEL AND LOCAL MODEL

A comparison between the internal pressure transferred from WADAM to the midship model and the local model has been performed. Since there is a significant difference in the mesh density between the two models, a perfect match cannot be achieved, but it should be comparable with respect to both pressure amplitude and pattern.

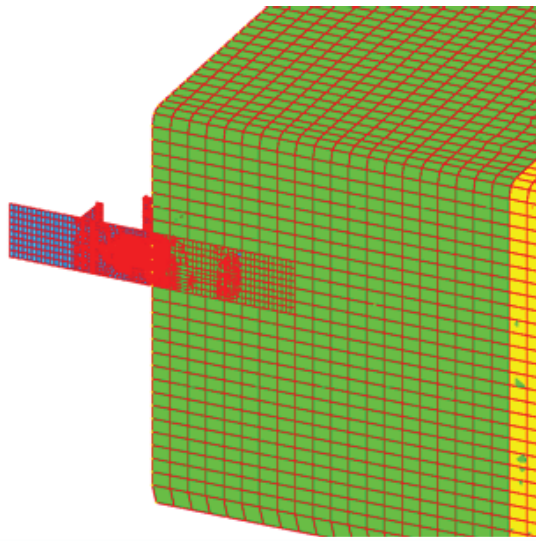

Figure 8.
Local model as part of midship model.

In order to transfer internal pressure to the local models, a part of the midship model will have to be included, as seen in Figure 8. This is in order for WADAM to determine the volume on the tanks for which the internal pressure is to be calculated.

From Figure 9, it can be seen that both the pattern and the pressure amplitudes for both PX (pressure in longitudinal direction) and PY (pressure in transverse direction) matches well between the midship model (left) and the local model (right). The figure represents a part of the transverse bulkhead - side shell connection for longitudinal 11.

A similar agreement between the midship model and the local model can be seen in Figure 10 for beam seas.

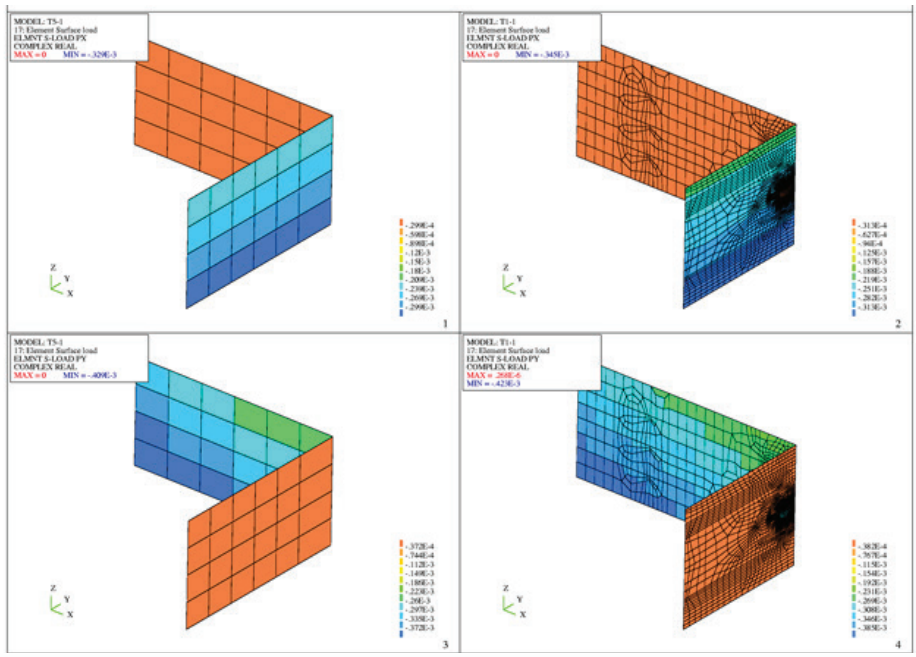

Figure 9.
Pressure comparison for the load case with Heading 0°, and Period 16.5 s.

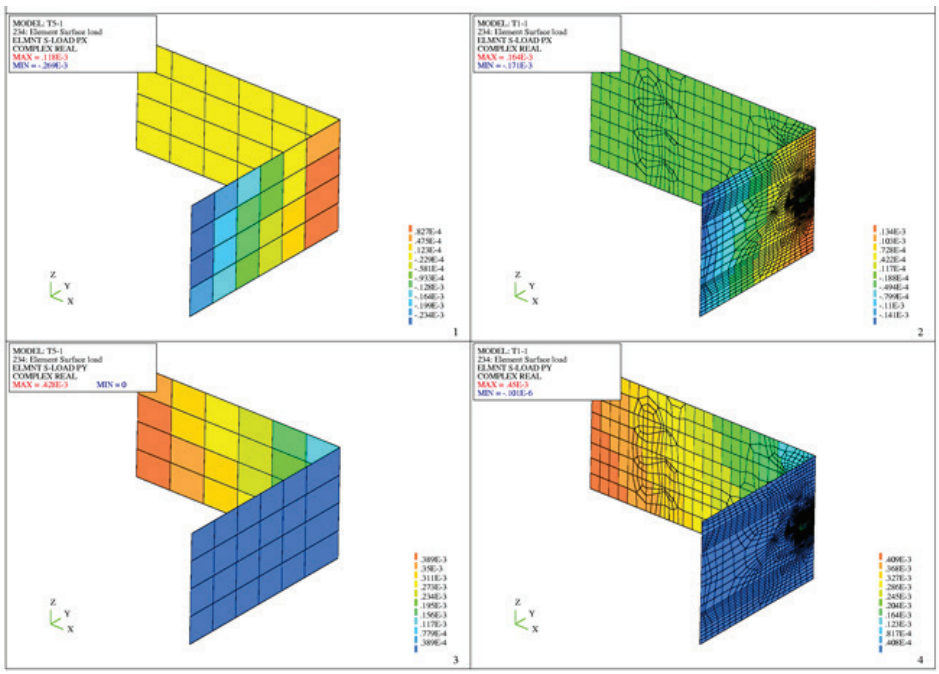

Figure 10.
Pressure comparison for the load case with Heading 270°, and Period 11.5 s.

7. COMPARISON OF RESULTS FROM COMPONENT-BASED AND FULL STOCHASTIC FATIGUE ANALYSIS

Three local models have been analysed with both the component based approach and the direct application approach on the midship model with external pressure reduction in the waterline region. For comparison reasons, the direct application approach on the midship model has also been used without the pressure reduction in the waterline region.

8. DECK ERECTION BUTT WELD

The first detail is a deck erection butt with a mouse-hole, as shown in Figure 11, the second is a typical stiffener through web-frame connection, as illustrated in Figure 13, and the third is a bottom erection butt with a mouse-hole, in Figure 15. Only the fully loaded condition has been analysed, and the wave environment is taken as the World Wide scatter diagram from DNVGL Class Note 30.7. It is further assumed that the vessel will operate for 20 years in the same condition.

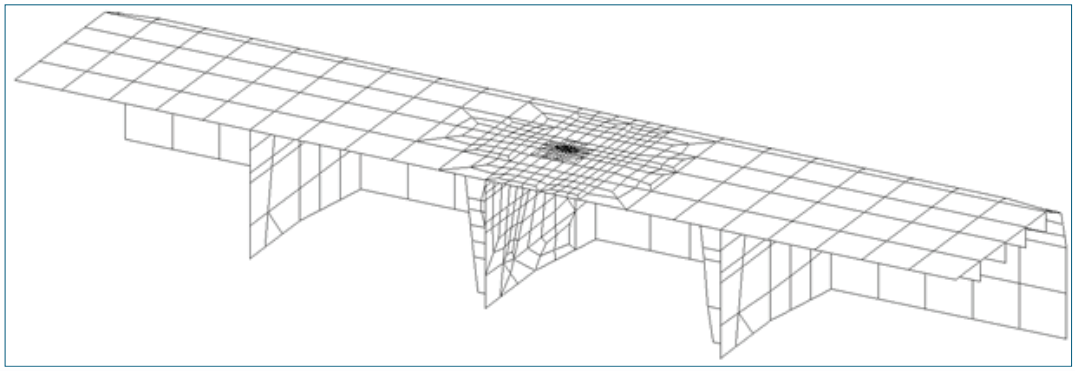

Figure 11.
Local model of deck erection butt weld.

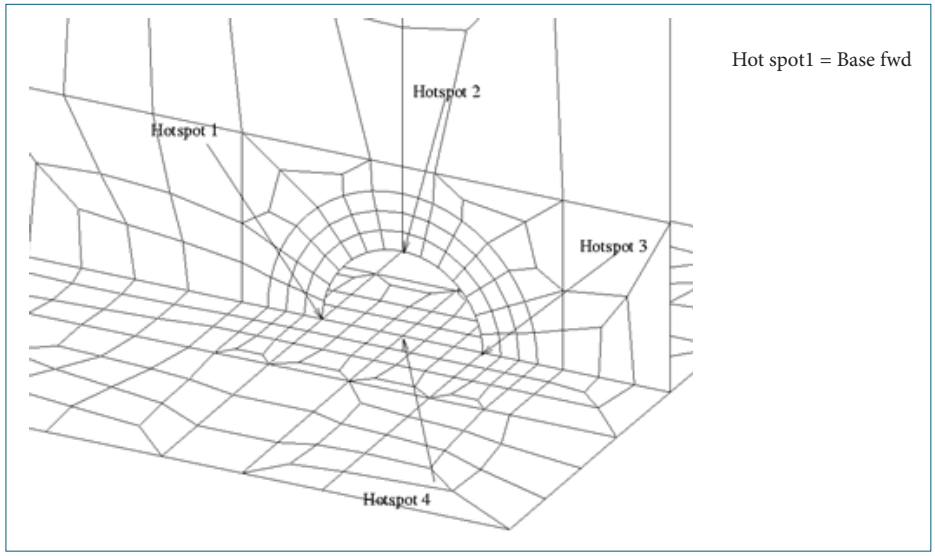

Figure 12.
Hot-spots analysed for deck erection butt weld.

The results for the deck erection butt show a generally good agreement between the two methods. The calculated fatigue life is within 3 % difference between the two methods for the four hot-spots investigated. The effect of not reducing the pressure in the waterline area has little effect for details in the deck area.

The good agreement between the two methods is most likely because the influence of local loads such as pressure forces are almost negligible, hence only global loads will contribute to the stress transfer functions.

Table 4.
Comparison between component-based and direct application - deck erection butt weld.

Deck erection butt weld

	Component-based		Direct with pressure adjustment		Direct without pressure adjustment	
	Damage	**Life (years)**	**Damage**	**Life (years)**	**Damage**	**Life (years)**
Base fwd	1.88 (a)	10.62	1.85 (b)	10.83	1.83 (c)	10.94
Mid	2.33 (a)	8.57	2.31 (b)	8.66	2.28 (c)	8.76
Base aft	2.16 (a)	9.26	2.12 (b)	9.45	2.09 (c)	9.55
Top	14.46 (a)	1.38	14.11 (b)	1.42	13.98 (c)	1.43
	Component-based		**Direct with pressure adjustment**		**Direct without pressure adjustment**	
	With	**Without**	**Component**	**Without**	**Component**	**With**
Base fwd	1.02 (a/b)	1.03 (a/c)	0.98 (b/a)	1.01 (b/c)	0.97 (c/a)	0.99 (c/b)
Mid	1.01 (a/b)	1.02 (a/c)	0.99 (b/a)	1.01 (b/c)	0.98 (c/a)	0.99 (c/b)
Base aft	1.02 (a/b)	1.03 (a/c)	0.98 (b/a)	1.01 (b/c)	0.97 (c/a)	0.99 (c/b)
Top	1.03 (a/b)	1.03 (a/c)	0.98 (b/a)	1.01 (b/c)	0.97 (c/a)	0.99 (c/b)

Note: The first set of numbers are the actual calculated fatigue damage and life. The second set is the ratio between the three different methods, where a, b and c refer to the letters in the first set of numbers.

9. SECTION LONGITUDINAL 19

For the longitudinal stiffener through the web-frame connection, the results are quite different. The variation of fatigue life is large for some of the investigated hot-spots, while it is quite small for others. At this stage, the reason is unclear as the longitudinal is situated below the area where the pressure in the water line is altered.

Table 5.
Comparison between components based and direct application - side long.

Side longitudinal 19

	Component-based		Direct with pressure adjustment		Direct without pressure adjustment	
	Damage	**Life (years)**	**Damage**	**Life (years)**	**Damage**	**Life (years)**
Heel	1.74	11.49	2.07	9.64	2.04	9.79
Toe	1.17	17.04	1.09	18.43	1.07	18.77
Lug	0.75	26.84	0.12	170.58	0.11	174.60
	Component-based		**Direct with pressure adjustment**		**Direct without pressure adjustment**	
	With	**Without**	**Component**	**Without**	**Component**	**With**
Heel	0.84	0.85	1.19	1.02	1.17	0.98
Toe	1.08	1.10	0.92	1.02	0.91	0.98
Lug	6.35	6.50	0.16	1.02	0.15	0.98

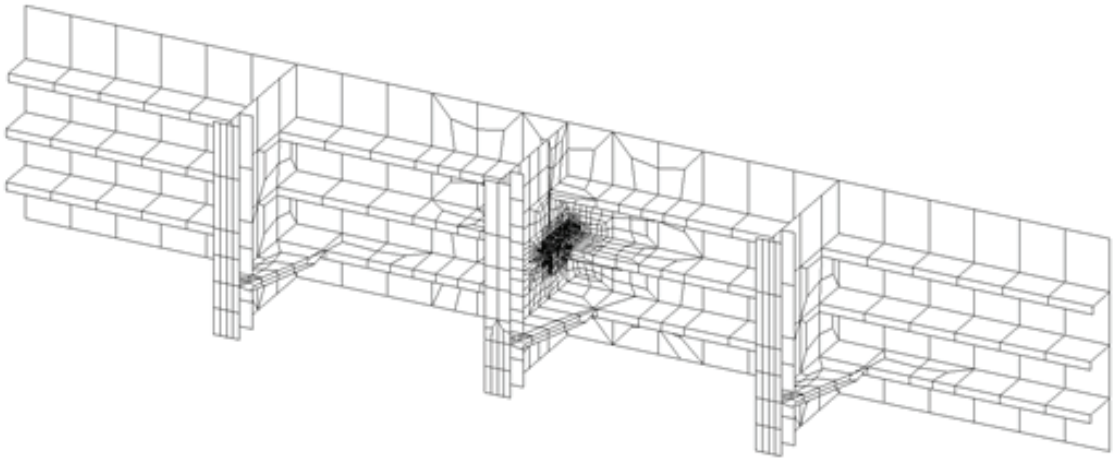

Figure 13.
Local model of stiffener through web-frame connection.

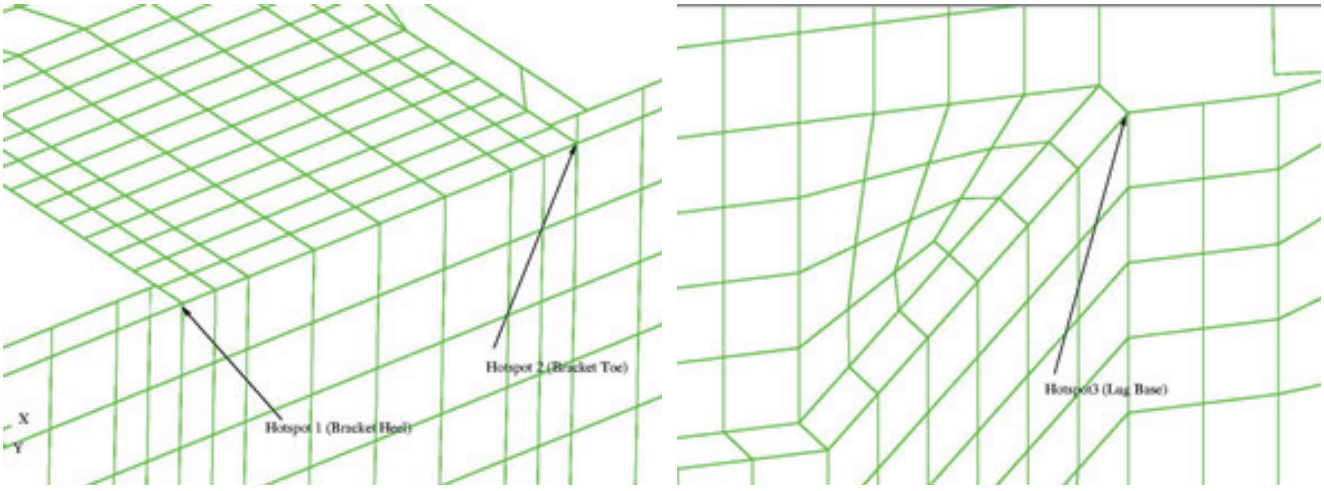

Figure 14.
Hot-spots analysed for section longitudinal 19.

10. BOTTOM ERECTION BUTT WELD

The hot-spots in the local model of the bottom erection butt-weld show a general trend. A slight increase in fatigue life from the component-based approach in the region of 5-10 % is calculated.

The difference is most likely due to a better description of the pressure distribution in the direct application method than in the component-based approach, as it is the calculated pressure and not a linearised distribution which is applied to the model.

Table 6.
Comparison between component based and direct application - bottom.

Bottom erection butt-weld

	Component-based		Direct with pressure adjustment		Direct without pressure adjustment	
	Damage	**Life (years)**	**Damage**	**Life (years)**	**Damage**	**Life (years)**
Base fwd	0.76	26.32	0.82	24.53	0.81	24.75
Mid	1.11	18.02	1.23	16.21	1.22	16.34
Base aft	0.85	23.53	0.92	21.63	0.92	21.82
Top	10.07	1.99	10.67	1.87	10.57	1.89
	Component-based		**Direct with pressure adjustment**		**Direct without pressure adjustment**	
	With	**Without**	**Component**	**Without**	**Component**	**With**
Base fwd	0.93	0.94	1.07	1.01	1.06	0.99
Mid	0.90	0.91	1.11	1.01	1.10	0.99
Base aft	0.92	0.93	1.09	1.01	1.08	0.99
Top	0.94	0.95	1.06	1.01	1.05	0.99

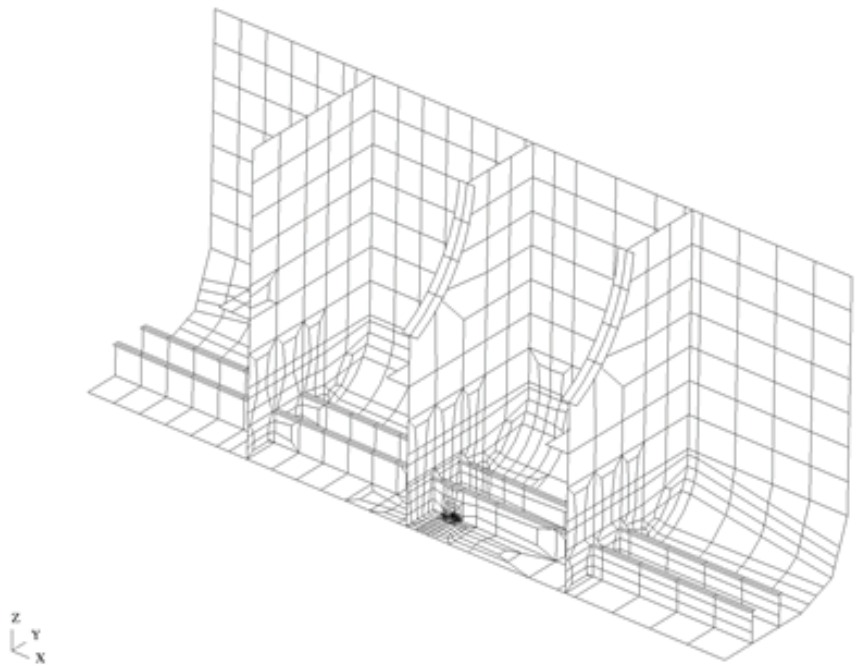

Figure 15.
Local model of bottom erection butt weld.

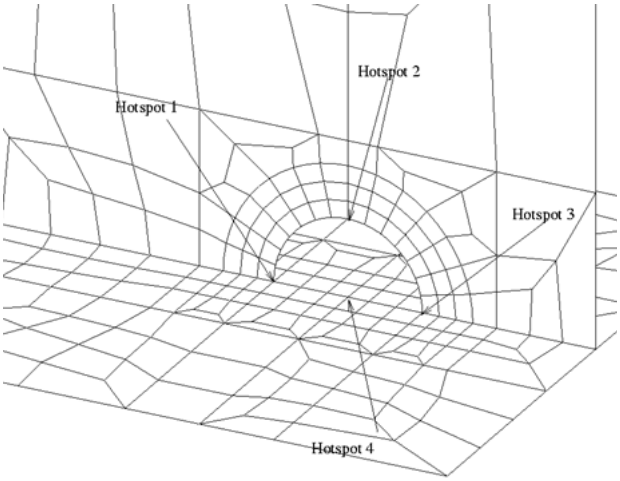

Figure 16.
Hot-spots analysed for the bottom erection butt weld.

11. CONCLUSION AND DISCUSSION

In general, it is found that the procedure is more robust towards input and user interpretation errors than other procedures such as component-based stochastic fatigue. The procedure offers a substantial reduction in time when considering a full stochastic calculation of fatigue life in the midship area. Typically, the fatigue calculation on a NAUTICUS midship model can be performed within 3-4 weeks after the finite element model is completed. The procedure is also very fast when considering several hotspots within one finite element model, as STOFAT module extracts the stress transfer functions automatically for each selected hot-spot.

The typical trend is that the details heavily influenced by the external pressure (side longitudinal) give less comparable results than e.g. a detail in the main deck mainly influenced by global loads. Using a typical Nauticus hull midship model, the procedure is a resource that is demanding in terms of computing capacity. The load interface files will become large, especially if internal tank pressure is necessary. Furthermore, the result file will become very large if the results for the whole midship model are required.

The following pros and cons have been developed and could be listed as:

Pros	Cons
• Large reduction in time spent on a full stochastic analysis fatigue analysis of the midship area.	• Resource demanding when using a typical cargo hold model according to Nauticus hull mesh standard.
• Phase relations between the various loads will always be correct; eliminates user interpretations.	• Necessary to have good interaction between hydrodynamic analyst and structural analyst.
• Contribution from not modelled structure taken into account as section forces at the midship model ends.	• Engineers/researchers would most probably be able to develop similar supplementary tool as described in the present study.
• Only one software for extracting stresses and calculation fatigue lives; user does not need to manually extract stresses for unit load cases.	• Not useful for screening of structures as load specific SCF's cannot be applied.
•The automatic generating of stress transfer functions enables the user to calculate the fatigue capacity for a large number of hot-spots rapidly.	•External pressure distribution in the waterline area not verified.
•A simpler concept to use; can use existing cargo hold finite element model.	•STOFAT module may be conservative for details that do not have consistent principal stress paths.

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Effectiveness Assessment of Non-Specialized Vessel Acquisition and Operation Projects, Considering Their Suitability for Oversized Cargo Transportation

Oleksiy Melnyk, Mykola Malaksiano

At present, shipowners have to take active measures to improve the efficiency of their fleet to remain competitive on the freight market. In this respect, the development of a shipping company's fleet is immensely important due to the ability of such vessels to operate with maximum efficiency and flexibility when the structure of cargo flow is heterogeneous. At the same time, fuel expenses account for a considerable part of shipping company expenses. Fuel consumption greatly depends on ship speed. Therefore, the efficiency of maritime shipping can be greatly increased by choosing optimal speed. The purpose of this research is to develop a methodology for justifying the selection of shipping company fleet expansion projects based on cargo flow structure characteristics, considering the possibility of slow steaming ship operation. Net Present Value and Profitability Index were taken into account to compare the efficiency of acquisition and operation projects pertaining to ships with significantly different deadweight and market values.

KEY WORDS
~ Oversized cargoes
~ Tramp transportation
~ Vessel acquisition project
~ Optimal ship speed
~ Profitability index
~ Net present value

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doi: 10.7225/toms.v09.n01.002

1. INTRODUCTION

Relying on expanding bulk transportation capabilities and technological innovations, the design and operation of dry bulk ships have significantly developed since the invention of the first specialized dry bulk cargo vessel in the early 1950s. Technical changes in the speed, deadweight, lightweight and engines of main dry cargo vessel types have been tested and the trends identified have proven to be the consequences of technical improvements and economic factors alike. Owing to the growing competition in the freight market, shipowners are forced to take active measures to increase the efficiency of their fleets. In this respect, there is a need for a more profound analysis of freight flow structure trends and a more specific choice of fleet development strategies. The timely expansion of the fleet with vessels capable of operating as efficiently and as flexibly as possible under conditions of tough competition and uneven freight flow structure is immensely important. Currently, Ukraine exports significant volumes of bulk cargo to South-East Asia, and these volumes have a tendency to increase in the future. At the same time, South-East Asia is one of the world's main exporters of project cargoes. Therefore, the acquisition of vessels capable of effectively transporting bulk cargo from the Mediterranean and Black Sea countries to South-East Asian ports and heavy lift and

oversized (HL/OS) cargo in the opposite direction is a promising course of shipping company fleet development. Methods for choosing the most effective vessels for such circumstances should therefore be devised. The intentional reduction of vessel speed to decrease fuel consumption is a common way to cut expenses in the modern shipping market. Moreover, as shipping lines are struggling to remain profitable in the currently weak freight market, slow steaming proved to be a good way to reduce operative costs and increase net profit.

2. LITERATURE OVERVIEW

The basic principles of modern oversized project cargo transportation, stowage and securing technologies are proposed in (IMO, 2014). In (Petraška et al. 2017), the issues of criteria selection and evaluation of the routes of carriage of HL/OS cargo are considered. The tendency of change in the shipping market and ways to improve fleet operation efficiency on the changing freight market are studied in (Moutzouris et al., 2019; Liu et al., 2018; Kou et al., 2018). The relation between the ship's cost, net earnings and profit of ownership in the dry bulk shipping industry was examined in (Moutzouris et al., 2019). Paper (Liu et al., 2018) examines the effects of crisis on the bulk shipping market and assesses the volatility characteristics of specific vessel types. The game theory model developed in (Kou et al., 2018) to study the excess shipping capacities as form of strategic behavior of ocean carriers in response to overcapacity in the competitive market. This research explains the consistently low freight rate in shipping, and proposes potential strategies for shipping industry stakeholders that would contribute to the maintenance of a sound global logistics system in maritime transportation. In paper (Chen et al., 2010), the analysis of the profit potential of dry cargo ships depending on their technical characteristics is presented.

The development of a logit voyage chartering transaction conclusion management model, the substantiation of the choice of optimal means of cargo delivery and different commercial deal registration models were provided in papers (Petraška et al., 2017; Lapkina et al., 2016a; Onyshchenko et al., 2016). Paper (Petraška et al., 2017) proposed an algorithm for the assessment of HL/OS cargo transportation, that facilitates the selection of the most appropriate route of transportation in terms of cost and time. The algorithm enables the evaluation of HL/OS cargo transportation processes through the comparison of different modes of transportation, route segments, cargo transportation and cargo handling technology. Paper (Lapkina et al., 2016a) proposes a simulation model that allows cargo delivery scheme optimization in uncertain conditions.

The issue of optimum terms of purchase and sale of vessels and other equipment was considered in (Alizadeh et al., 2007; Lapkina et al., 2018a; Malaksiano, 2012; Kyriakou et al., 2018; Engelen et al., 2007; Lapkina et al., 2016b), taking into account the factor of uncertainty. The realization of trading strategies combining technical rules of trade with fundamental market analysis of dry bulk cargo sales was examined in (Alizadeh et al., 2007). The issue of optimal time to enter the shipping industry was studied in (Malaksiano, 2012; Bulut et al., 2013; Merikas et al., 2008). In (Lapkina et al., 2018b) issues of purchase and sale of oceangoing vessels and port handling equipment were studied taking into account both physical and moral deterioration.

One of the key shipping efficiency improvement methods is lowering fuel consumption by reducing ship speed. Papers (Wang et al., 2013; Wong et al., 2015; Doskocz, 2012; Wang ent al., 2012; Lapkina et al., 2019; Lee et al., 2015) examine the dependence of ship operation efficiency indicators on speed. In (Wang et al., 2013), the issues of applicability, optimality and efficiency of existent and newly proposed methods of reducing fuel consumption while simultaneously maintaining a certain level of operation were analyzed, taking into account the high cost of bunkers and emissions associated with their transportation. Paper (Wong et al., 2015) analyses slow steaming sustainability initiatives and the transition from the traditional discrete cost-based decision support model to new continuous utility models. The profitability of speed reduction and fuel consumption of seagoing bulk carriers was examined in (Doskocz, 2012). The study of optimal speed of container ships in each section of the route of each vessel in the liner shipping network, taking into account transshipment routes, was provided in (Wang et al., 2012). Papers (Lapkina et al., 2019; Lee et al., 2015) examined the correlation between bunkering costs, average time of cargo delivery and the profitability of ship operation.

The overview of publications indicates that research aimed at devising a methodology that would improve shipping performance by taking into account the characteristics of cargo flow structure and other features of ship operation is of great practical interest.

3. PROBLEM FORMULATION

The purpose of this paper is to develop a methodology that would justify the selection of shipping company fleet expansion projects based on the characteristics of the cargo flow structure, considering the possibility of slow steaming ships operation.

4. MATERIALS AND METHODS

The analysis of efficiency of long-term capital investments pertaining to the acquisition of ships is quite complicated. It involves extended time periods and requires comprehensive assessment of future conditions.

As Net Present Value (NPV) is an indicator used to determine the current value of all future cash flows generated by a project,

including the initial capital investment, it is used to assess investment project efficiency. For NPV of vessel acquisition and operation projects to be calculated, all cash flows connected with such projects must be estimated. The NPV of an acquisition and operation project is determined by the following formula

$$NPV=\sum_{i=1}^{T}\frac{F-R^{var}-R^{perm}-R_i^{loan}}{(1+p/100)^i}+\frac{I_{sale}}{(1+p/100)^i}-I_0^{own} \quad (1)$$

where T – vessel operation period, years;

F – average income earned by the vessel per year, USD;

R^{var} – average annual variable operation costs of the vessel, USD;

R^{perm} – average annual permanent operation costs of the vessel, USD;

R_i^{loan} – loan expenses for the i-th year, USD.

p – discount rate, %;

I_0^{own} – equity investment, USD;

I_{sale} – estimated cost of the vessel after operation period, USD;

To compare the efficiency of acquisition and operation projects of vessels having significantly different deadweight, market value and *NPV*, the Profitability Index (*PI*) (Hayes et al., 2011) must also be taken into account. This index is the ratio of all discounted cash flows and the initial vessel acquisition costs:

$$PI=\frac{\frac{I_{sale}}{(1+p/100)^T}+\sum_{i=1}^{T}\frac{F-R^{var}-R^{perm}-R_i^{loan}}{(1+p/100)^i}}{I_0^{own}} \quad (2)$$

Permanent operation costs include crew salaries, costs associated with vessel maintenance, as well as insurance premiums.

The average annual income of a ship is calculated using the following formula

$$F=\frac{\sum_{k=1}^{K}F_k}{\sum_{k=1}^{K}t_{p\,k}}\cdot T_{op} \quad (3)$$

where F_k – quantity of freight received by the vessel for a round trip on the k-th route, USD;

$t_{p\,k}$ – duration of the circular voyage on the k-th route, days;

T_{op} – operation running period in a year, days.

Average annual variable operation costs are equal to

$$R^{var}=\frac{\sum_{k=1}^{K}F_k(R_k^{fuel}+F_k\cdot r_{br}/100+R_{dues\,k}^{total})}{\sum_{k=1}^{K}t_{p\,k}}\cdot T_{op} \quad (4)$$

where R_k^{fuel} – total bunker costs per voyage on the k-th route, USD;

F_k – amount of freight per voyage on the k-th route, USD;

r_{br} – brokerage commission, %;

$R_{dues\,k}^{total}$ – total port dues for voyage on the k-th route, USD;

Total bunker costs per voyage on the k-th route are calculated using the following formula

$$R_k^{fuel}=r_{lub}\cdot C^{ifo}\cdot(q_{sail}^{ifo}\cdot t_k^{sail}+q_{serv}^{ifo}\cdot t_k^{serv})+ \\ +r_{lub}\cdot C^{mdo}\cdot(q_{sail}^{mdo}\cdot t_k^{sail}+q_{serv}^{mdo}\cdot t_k^{serv}) \quad (5)$$

where r_{lub} – lubricant consumption factor;

q_{sail}^{ifo} – fuel oil (IFO) consumption during running period, t/day;

q_{serv}^{ifo} – fuel oil (IFO) consumption during port period, t/day;

C^{ifo} – cost of (IFO 380), USD/t;

q_{sail}^{mdo} – diesel oil (MDO) consumption during running period, t/day;

q_{serv}^{mdo} – diesel oil (MDO) consumption during port period, t/day;

C^{mdo} – cost of diesel oil (MDO), USD/t;

t_k^{sail} – running period of a round trip on the k-th route, days;

t_k^{serv} – port period of a round trip on the k-th route, days;

Freight value per round trip on the k-th route is equal to:

$$F_k=Q_k^{gr}\cdot f_k^{gr}+F_k^{pr} \quad (6)$$

where Q_k^{gr} – estimated quantity of bulk cargo shipped per voyage in the forward direction, t;

f_k^{gr} – freight rate for bulk cargo in the forward direction, USD/t;

F_k^{pr} – lump sum freight rate for the carriage of oversized project cargo in the reverse direction, USD.

The cost of loan fund usage in the i-th year is determined by the following formula:

$$R_i^{loan}=I_{res\,i}^{loan}\cdot\frac{p}{100}+\frac{I_{init}^{loan}}{T} \quad (7)$$

where $I_{res\,i}^{loan}$ – balance of loan funds at the beginning of the i-th year, USD;

I_{init}^{loan} – total loan funds at the inception of the investment project, USD.

5. CALCULATED SHIP OPERATION EFFICIENCY INDICATORS, CONSIDERING THE VESSELS' POTENTIAL USE IN THE TRANSPORTATION OF OVERSIZED PROJECT CARGO

The calculation below includes several shipping company fleet expansion options involving the acquisition of various ship types, as well as an assessment of the efficiency of those ships providing that they transport bulk cargo in one direction, and oversized project cargo in the reverse direction. The main characteristics of five proposed vessels are presented in Table 1 (Vessel Database, 2020).

Table 1.
Main characteristics of proposed vessels.

	Vessel 1	Vessel 2	Vessel 3	Vessel 4	Vessel 5
Vessel type	general cargo ship	dry cargo ship	bulk carrier	bulk carrier	mpp/ heavy lift carrier
Year of construction	2006	2009	2003	2007	2011
Deadweight, t	6500	16800	28611	35000	32134
Draft, m	6.20	8.25	9.77	9.70	11.20
DWCC (D), t	6200	16000	27800	34151	31200
Cubic capacity (W), m3	8285	21648	35762	44183	39509
Net tonnage (NT), m3	2303	5507	10098	11251	10570
Gross tonnage (GT), m3	4655	11927	16980	22115	24025
LOA, m	118.60	148.00	169.26	193.84	193.90
Breadth , m	16.20	23.00	27.20	27.60	28.20
Depth, m	7.80	11.80	13.60	15.80	15.60
Hold structural non-uniformity coefficient	1.00	0.90	0.70	0.65	0.80
Hatch quantity and dimensions, m	3 25.2x12.6	4 16.4x17.0	5 13.5x16.0 19.18x17.6	5 18.8x18.2 21.0x18.0	8/12.64x15.4 25.28x12.8(2) 37.9x12.8(2) 31.6x12.8(2) 12.6x24.1
Hatchway opening coefficient	0.94	0.73	0.68	0.64	1.00
Number of decks and their square surface, m2	2/Shold-1005; Sm/d-952.5	2/Shold-1872; Sm/d- 1368	2 / Shold-2300; Sm/d-1564	2/Shold-2100; Sm/d- 1350	3 / Shold-2315; Sm/d - 3649. FL-832. Sm/d-2988
Permissible loads on tanktop/hatches, t	TT-12 / H-1.8	TT-16 / H-2.8	TT-17 / H-2.0	TT-18 /M/DECK-2.6	TT-22, TD-4.0 / M/DECK - 3.0
Quantity and SWL of ship cargo gears, t	NIL	2 x 40	4 x 30.5	4 x 25	Crane 1 - 50 mts; Cranes 2&3 350 (each) comb-700, Crane 4 -100
Structural features of open decks and adjacent areas	free open deck	cranes positioned portside	cranes positioned amidships on deck masthouses	cranes positioned amidships on deck masthouses	cranes positioned amidships

Laden condition speed, kn	13.0	11.0	12.0	13.0	15.5
IFO consumption at sea, t/day	6.0	8.2	13.0	19.0	35.5
MDO consumption at sea, t/day	1.1	1.5	0.1	0.2	1.5
IFO consumption in port, t/day	0.0	0.0	2.5	2.5	3.0
MDO consumption in port, t/day	1.0	1.5	0.1	0.2	0.5
Purchasing cost, thousand USD	4000	8000	9500	11000	15800
Selling cost, thousand USD	2300	6300	6100	7500	8100
Permanent expenses, USD/day	1100	1400	1700	1900	2500

For further calculations, consider the following routes: Shanghai-Odessa, Guangzhou-Yuzhniy and Qingdao - Chernomorsk. Types of oversized project and break-bulk cargoes planned to be transported from Chinese ports are given in Table 2.

Table 2.
Types of oversized project cargoes planned for transportation on specified routes.

Destination	Cargo code	Cargo type and dimensions	Weight
Shanghai - Odesa	B1	Oversized, maximum length 50-70 m	Lightweight
Guangzhou-Yuzhniy	B2	Oversized, maximum length 30-50 m	Heavy lift
Qingdao-Chernomorsk	B3	Break-bulk (includes equipment, small parcel loads, machinery)	Mixed

Vessel 1 is a general cargo carrier. This vessel type is suitable for transportation of both bulk and general cargo and is convenient enough for the transportation of long oversized cargoes of B1 type, with unit length of up to 70 m, loaded by deck. In addition, Vessel 1 can be loaded with break-bulk cargo of B3 type, such as various equipment and machinery with unit dimensions of up to 25 m in length and 12 m in width, as well as consignments that include 20 and 40-foot containers. Vessels of this type have sufficient hatchway opening to accommodate cargoes having the maximum length of over 20 m. Since clear whether deck and wide hatch openings allow cargo to be conveniently secured both on the deck and underdeck, this ship design offers different cargo stowage possibilities and securing methods. However, vessels of this type can neither carry cargo of excessive weight nor heavy lift cargo units, including as part of cargo lots. The second important limitation is the absence of cargo handling equipment onboard, restricting the vessel's ability to handle cargo with her own gears in ports where such gears are not available.

Vessel 2 is a dry cargo ship also known as general cargo carrier with boxshaped holds, equipped with deck cranes of sufficient lifting capacity, capable of carrying a wide variety of cargoes, including heavy lifts and oversized units. Like most vessels of this type, Vessel 2 has deck cranes conveniently located along the ship's side, each of which can lift up to 40t of B2 cargo and up to 70 t in paired operation. In addition, the characteristics of Vessel 2 allow B3 type cargo up to 17 m in length to be loaded into the ship's holds, and B1 type cargo to be stowed on the deck. Similarly, the allocation and transportation of cargo shipments containing containers is also not problematic. The disadvantage of this type of vessel is its substantial freight rate.

Vessel 3 and Vessel 4 are Handysize and Handymax bulk carriers, respectively. Their characteristics are almost similar, differing only in cargo capacity. Vessels of this type can be

used for the transportation of B2 and B3 cargoes. Some of their limitations are the weight of cargo units and the local strength of tank top deck or hatch covers. The majority of type 3 and type 4 vessels have cargo-handling facilities. Their shortcoming is the inaccessibility of musthouses, deck standers and superstructures, which, being located in the cross deck areas and on the main deck, may obstruct the handling of oversized cargoes over 18 m in length. Optimized cargo stowage arrangement on the decks of Vessel 3 and Vessel 4 could be similar to that of Vessel 1 and Vessel 2 (Figure 1), provided that the length of free space between the deck structures is not exceeded.

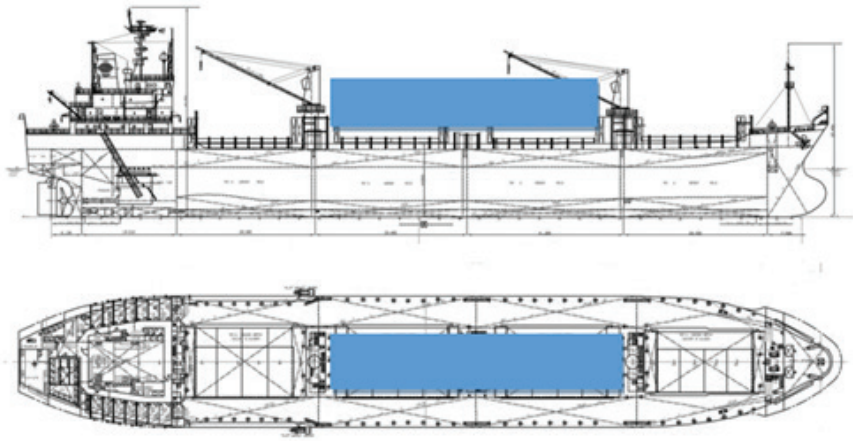

Figure 1.
Loading of B2 type cargo on the deck of Vessel 2.

As for B2 cargo, it should be noted that stowage is complicated by the location of cranes in the centerline of the vessel and the presence of deck mashouses between the holds. Therefore, hatch cover dimensions will be a limiting factor with respect to the length of intended cargo units. However, this problem can be solved by constructing separating platforms that allow cargo units to be lifted above the level of deck structures located on the cross decks and placed on hatch covers adjacent to them.

The overall breadth of such cargo unit, however, may not exceed the distance between the crane and the ship's side (Figure 2).

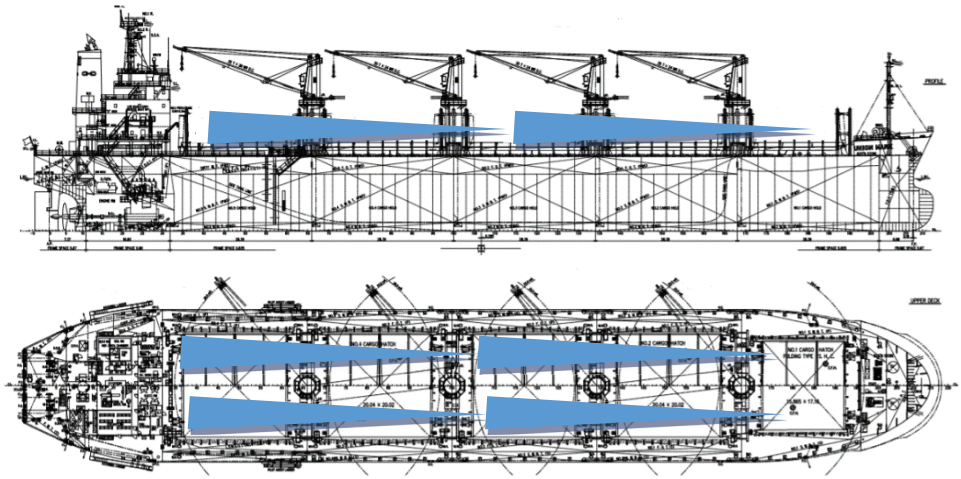

Figure 2.
Stowage of B1 type cargo on the deck of Vessel 4.

The majority of type 4 vessels are not equipped with square shaped holds, but rather have upper and lower hoppers used to trim bulk cargo. The upper inclined bulkheads form the upper topside tanks used for ballast waters. Lower hoppers forming slopes also function as double bottom ballast/fuel tanks. Such sloping bulkheads situated in the lower and upper parts limit the hold's full cubic capacity and leave only hatchway area available for break-bulk cargo stowage.

Construction elements of cargo holds that aggravate the stowage of cargoes such as break-bulk and equipment, containers and oversized units, as well as cargo requiring additional securing measures and methods, increase loading time and costs.

Vessel 4 type ships and similar bulk carriers having the deadweight of over 30000 t are usually not efficient for the carriage of oversized cargo since hatch dimensions do not facilitate the transportation of the majority of oversized cargoes in the holds, and even with the optimal stowage of deck cargo, the vessel remains significantly short shipped.

Multipurpose carrier, Vessel 5, is a specialized vessel for the transportation of a wide variety of commodities, including containerized, oversized and heavy lift cargoes. Vessel 5 has a number of important advantages over other proposed vessels, including cranes with sufficient single and combined lifting capacity, two heavy lift cranes each having the capacity of up to 350 t, providing tandem-lifting capacity up to 700 t. The specific construction of deck cargo areas allows the vessel to carry all groups of cargo according to the disposition requirements.

Table 3.
Average loading and unloading times (hours) of different types of oversized project cargo for proposed vessels, including preloading survey and cargo securing times.

	Oversized project cargo types		
	B1	B2	B3
Vessel 1	24 / 48	24 / 48	24 / 72
Vessel 2	72 / 120	96 / 144	120 / 192
Vessel 3	120 / 168	120 / 192	168 / 240
Vessel 4	168 / 336	168 / 336	240 / 360
Vessel 5	120 / 240	120 / 240	192 / 288

Table 4.
Lump sum freight rates for proposed vessels at the specified routes.

	Lump sum rate, thousand USD		
Proposed vessel	Shanghai - Odesa	Guandzhou-Yuzhniy	Qingdao-Chernomosk
Vessel 1	263.6	257.8	269.5
Vessel 2	438.7	427.7	449.6
Vessel 3	539.3	523.5	555.2
Vessel 4	555.3	539.0	571.6
Vessel 5	1243.5	1206.9	1280.1

Table 5.
NPV and PI results for proposed vessels at sea speeds.

Proposed vessel	NPV, thousand USD	PI
Vessel 1	733.15	1.92
Vessel 2	1669.97	2.04
Vessel 3	1819.21	1.96
Vessel 4	521.97	1.24
Vessel 5	1039.02	1.33

Table 3 shows loading and unloading times of different types of cargoes for the specified proposed vessels, determined based on the ships' characteristics and cargo shipping options. Loading and unloading times have a direct impact on the duration of ship handling in port t_k^{serv}.

Calculations have shown that the highest NPV was reached in the Vessel 3 acquisition project. At the same time, Vessel 2 had the highest investment efficiency, since this Proposed vessel's acquisition project had the highest PI value (Table 5). As the results presented in Table 5 were obtained at sea speeds, before making any conclusions about the expediency of purchasing any of the considered vessels, it would be reasonable to additionally research their efficiency indicators at different speeds.

6. JUSTIFICATION OF THE SELECTION OF OVERSIZED PROJECT CARGO TRANSPORTATION VESSEL, TAKING INTO ACCOUNT THE POSSIBILITY OF SLOW STEAMING OPERATION

The influence of speed on the values of proposed vessels' operation efficiency indicators was established using regression dependencies of fuel oil consumption on vessel speed (Table 6). Dependencies in Table 6 were obtained from actual statistical data from ships, using standard regression analysis methods.

The dependence of ship operation efficiency indicators on speed can be calculated using formulas (1), (2), that into account the dependence of fuel oil consumption on speed (Table 6). Table 7 shows *NPV* and *PI* values at different speeds.

Table 6.
Dependence of fuel oil consumption on ship speed.

Proposed vessel	Function describing the dependence of fuel consumption on vessel speed
Vessel 1	$q_{sail}^{ifo}(v) = 0.0104v^3 - 0.1984v^2 + 1.5098v - 2.73$
Vessel 2	$q_{sail}^{ifo}(v) = 0.0182v^3 - 0.2519v^2 + 1.3982v - 1.2984$
Vessel 3	$q_{sail}^{ifo}(v) = 0.0126v^3 - 0.0984v^2 + 0.3016v + 1.9468$
Vessel 4	$q_{sail}^{ifo}(v) = 0.0091v^3 - 0.0343v^2 + 0.2488v + 1.4179$
Vessel 5	$q_{sail}^{ifo}(v) = 0.0042v^3 + 0.0877v^2 - 0.2659v + 3.2776$

Table 7.
Dependence of NPV and PI on the speed of proposed vessels.

Ship speed, kn	Vessel 1		Vessel 2		Vessel 3		Vessel 4		Vessel 5	
	NPV, thousand USD	*PI*	*NPV*, thousand USD	*PI*	*NPV*, thousand USD	*PI*	*NPV*, thousand USD	*PI*	*NPV*, thousand USD	*PI*
5.0	-1154.7	-0.44	-517.7	0.68	-1453.7	0.23	-1972.5	0.10	-3600.0	-0.14
5.5	-851.2	-0.06	2.6	1.00	-882.4	0.54	-1415.4	0.36	-2779.0	0.12
6.0	-564.9	0.29	482.7	1.30	-356.9	0.81	-912.1	0.59	-2029.0	0.36
6.5	-297.5	0.63	917.6	1.57	121.2	1.06	-462.3	0.79	-1347.8	0.57
7.0	-50.3	0.94	1301.9	1.81	550.7	1.29	-65.9	0.97	-733.4	0.77
7.5	174.9	1.22	1629.1	2.02	930.0	1.49	277.4	1.13	-184.0	0.94
8.0	376.7	1.47	1892.6	2.18	1257.7	1.66	567.6	1.26	302.4	1.10
8.5	553.3	1.69	2084.7	2.30	1532.1	1.81	804.6	1.37	727.5	1.23
9.0	703.2	1.88	2197.4	2.37	1751.5	1.92	988.4	1.45	1092.9	1.35
9.5	824.5	2.03	**2222.0**	**2.39**	1914.4	2.01	1118.8	1.51	1400.3	1.44
10.0	915.8	2.14	2149.0	2.34	2019.0	2.06	1195.8	1.54	1651.1	1.52
10.5	975.2	2.22	1968.6	2.23	**2063.5**	**2.09**	**1219.2**	**1.55**	1846.8	1.58
11.0	**1000.9**	**2.25**	1670.0	2.04	2046.2	2.08	1188.6	1.54	1988.6	1.63
11.5	991.4	2.24	–	–	1965.4	2.03	1103.9	1.50	2078.0	1.66
12.0	944.8	2.18	–	–	1819.2	1.96	964.7	1.44	**2116.1**	**1.67**
12.5	859.3	2.07	–	–	–	–	770.9	1.35	2104.2	1.67
13.0	733.1	1.92	–	–	–	–	522.0	1.24	2043.2	1.65
13.5	–	–	–	–	–	–	–	–	1934.3	1.61
14.0	–	–	–	–	–	–	–	–	1778.5	1.56
14.5	–	–	–	–	–	–	–	–	1576.8	1.50
15.0	–	–	–	–	–	–	–	–	1330.0	1.42
15.5	–	–	–	–	–	–	–	–	1039.0	1.33

Figure 3 and Figure 4 show graphs of *NPV* and *PI* dependence on proposed vessel speed.

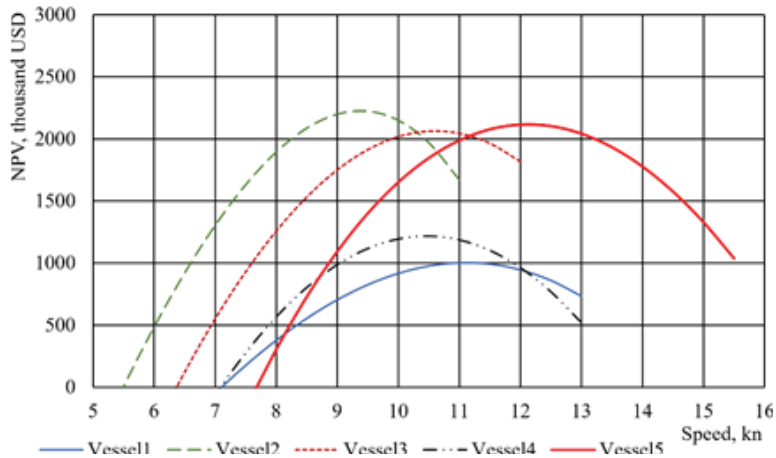

Figure 3.
Dependence of NPV on ship speed.

Figure 3 and 4 show the comparison of *NPV* and *PI* values for proposed vessel acquisition projects, at sea speeds and optimal speeds (Tables 5, 8). Figure 3 demonstrates that the highest NPV values are achieved in the acquisition projects and operation of the following vessels: Vessel 2, Vessel 5 and Vessel 3, provided that these vessels are used at optimal speeds specified in Table 8.

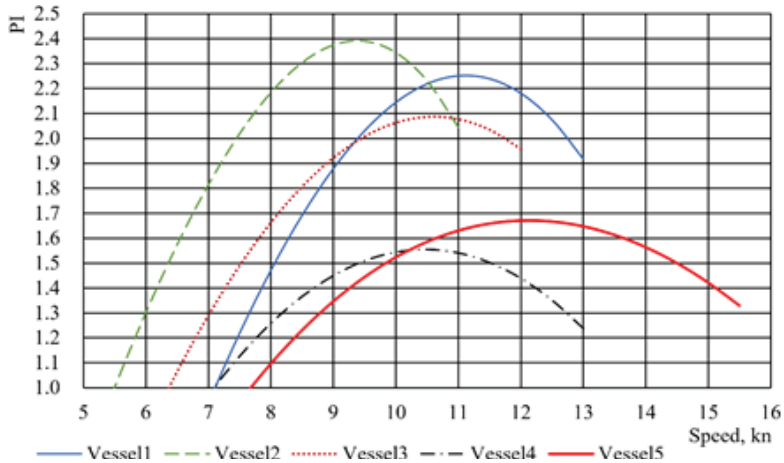

Figure 4.
Dependence of PI values on the speed of proposed vessels.

Maximum *NPV* and *PI* values for proposed vessels, that can be achieved at optimal speed, are presented in Table 8.

Table 8.
Maximum NPV and PI values at optimal speed.

Proposed vessel	Optimal speed, kn	Average running time in one direction, days	Maximum values at optimal speed	
			NPV, thousand USD	*PI*
Vessel 1	11.1	31.1	1000.94	2.25
Vessel 2	9.4	36.4	2222.00	2.39
Vessel 3	10.6	32.4	2063.50	2.09
Vessel 4	10.5	32.7	1219.17	1.55
Vessel 5	12.1	28.5	2116.14	1.67

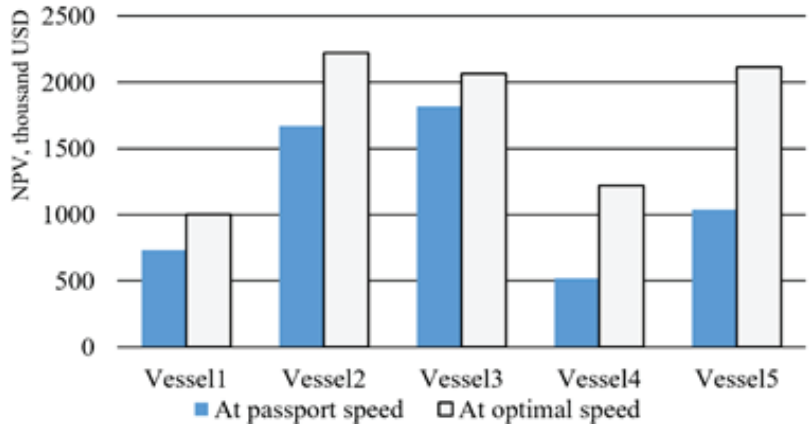

Figure 5.
Comparison of NPV values for proposed vessel acquisition projects at sea speed and optimal speed.

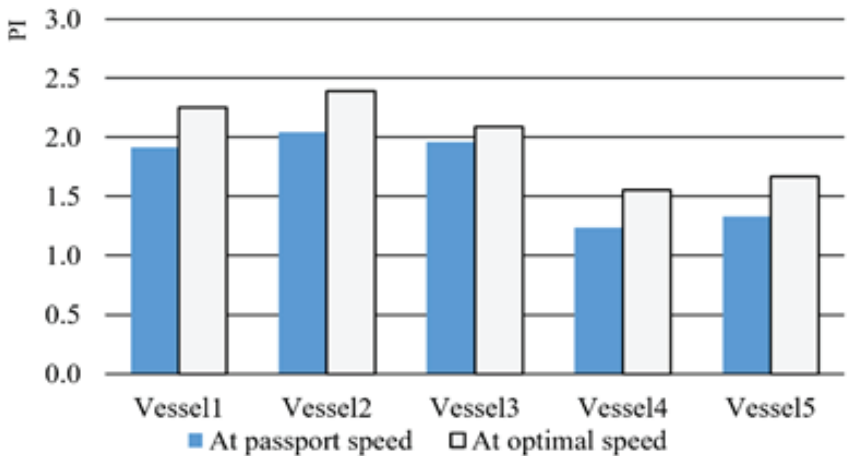

Figure 6.
Comparison of PI values for proposed vessel acquisition projects at sea speed and optimal speed.

Vessel 1 has the lowest maximum *NPV* among all proposed vessels (1001 thousand USD). In terms of efficiency of acquisition and operation of the considered vessels based on the profitability index, the most preferable projects are the acquisition of Vessel 2, Vessel 1 and Vessel 3 (with *PI* values 2.39, 2.25 and 2.09, respectively), i.e. vessels with low tonnage (Figure 4).

7. RESULTS AND DISCUSSION

The comparison of charts in Figure 5 and Figure 6 shows that at optimal speed, Vessel 5 has a sufficiently high *NPV*, only slightly different from the maximum *NPV* of Vessel 2 (2,116 vs. 2,222 thousand USD). However, the *PI* value of Vessel 5 is noticeably inferior to the *PI* values of all other considered vessels except Vessel 4, at any speed, since the acquisition of Vessel 5 requires a much higher capital investment than the acquisition of other proposed vessels. Therefore, in spite of the fact that Vessel 5 has the capacity to generate the highest freightage, the profitability of acquisition and operation of Vessel 5 is rather low even at optimal speed. By contrast, Vessel1 has high *PI* value, and her acquisition has very low *NPV* in comparison with other proposed vessels since the market value of Vessel 1 is much lower than the value of other vessels considered. In spite of her low freightage in comparison with other proposed vessels, the income to expenses ratio of Vessel1 is quite satisfactory at optimal speed. Thus, under the operational conditions of the considered vessels for the carriage of the specified cargoes at the stipulated routes, sailing at optimum speed, the highest *NPV* values were obtained for Vessel 5 and Vessel 2 acquisition projects (2,116 vs. 2,222 thousand USD). However, the project of acquisition of Vessel 5 is noticeably inferior to the project of acquisition of Vessel 2 in terms of the investment performance index *PI* (1.67 vs. 2.39).

When choosing the most appropriate vessel, attention should also be paid to the range of speeds at which she can be optimally used. If a vessel can be used optimally at a wide speed range, the shipping company can be more flexible in the coordination of freight rates and delivery terms in the future, due to its ability to operate efficiently at multiple speeds, which is very important in the unstable freight market conditions.

8. CONCLUSION

In most cases, the structure of cargo flows is heterogeneous with the number of peculiarities in each individual case. Therefore, the achievement of maximum efficiency in cargo transportation requires the characteristics of the existing cargo flow structure to be taken into account. In this respect, the development of quantitative methods for the justification of the selection of optimum vessel type for operation under the stipulated conditions is of great practical interest.

The paper proposes a methodology for the justification of the selection of a vessel for bulk and oversized cargo transportation, given the possibility of slow steaming operation. In some instances, shipping companies have limited own resources, and debt financing entails significant additional costs. This is particularly true of fleet development of Ukrainian shipping companies. Therefore, the efficiency of investments into own fleet development was assessed using the PI indicator as the main criterion for choosing a vessel acquisition and operation project.

Calculations have shown that the efficiency of maritime shipping could be significantly improved by choosing optimal ship speed. It was also shown that under conditions of heterogeneous cargo flow structure, the use of large tonnage bulk carriers and specialized vessels designed for transportation of oversized cargoes is less effective than the use of mini bulk carriers with the capacity of under 10000 t deadweight.

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An Analysis of Service Failures and Recovery Strategies in the Turkish Third Party Logistics Service Industry

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Service literature indicates that both service failure and service recovery have a strong impact on the business relationships between service providers and their customers. The purpose of this research is twofold: to explore and analyze the most common service failures and implemented recovery strategies in Turkish third party logistics service industry and examine their impact on business relationships. Critical Incident Technique (CIT) was used. Thus, information on critical incidents were collected from both third party logistics service providers (3PLs) and their customers, failures and recovery strategies were categorized and the impact of service failures and recovery strategies on future relationships between customers and 3PLs examined. The findings indicate that service failures are most frequently encountered in customer services and port operations and that symbolic service recovery is the most common recovery strategy implemented by third party logistics service providers. The findings also show that third party logistics service providers and carriers are the most common sources of failure in third party logistics services.

KEY WORDS
~ Service Failure
~ Service Recovery
~ Third Party Logistics Service Providers
~ Business-to-Business Relationships
~ Critical Incident Technique

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doi: 10.7225/toms.v09.n01.003

1. INTRODUCTION

The service market is steadily growing in industrialized countries and even though the products of service market actors are intangible and non-physical, they engage in physical distribution activities and make decisions (Ballou, 2004: 21). Furthermore, services are thought to account for up to 70-85 % of the GDP of developed nations (Johnston& Michel, 2008). Service industry tends to grow and develop in parallel with changes such as technological advancements, mobilization of knowledge, globalization and ever increasing competition, making it harder for businesses to survive (Özgüven, 2008).

Therefore, service markets are affected by the recent increase in competition between service companies (Payne, 1993). Since service provision implies interpersonal interaction and the involvement of customers in the service production process, the most likely consequence of the inability to standardize employee actions are service quality management problems (Öztürk, 2000). Considering the competitiveness levels and the aforementioned inability to standardize employee actions, sustaining high service quality is of paramount importance in service industries in general and in the third party logistics service industry in particular.

Furthermore, transportation and additional logistics services provided by 3PLs make up the economy of a country whilst transforming raw materials into finished goods using an effective international physical distribution system and a solid supply chain (Rojas, 2018). Likewise, the importance of supply chain sustainability and green image for profitability is frequently underlined by undisrupted supply (Russel et al., 2018). However, as more means of transportation or participants get

involved, coordination becomes a challenge with respect to the maintenance of service quality, speed and reliability (Dua and Sinha, 2019). Consequently, the crucial importance of 3PL service failures, which disrupt the supply chain and decrease the said effectiveness as a whole, is evident.

The need for expansion of B2B studies in the framework of service failure and recovery research was frequently emphasized. There has been no extensive research of switching behaviors in the B2B context, studies including both satisfied and dissatisfied customers after recoveries are few and finally, B2B service sector studies have not taken into account the relationship between customers and service providers (White and Yanamandram, 2007). This study aims to fill the aforementioned gaps in the relevant literature and present the most common service failures experienced by third party logistics service providers, most common recovery strategies of third party logistics service providers and the effects of these recovery strategies on B2B relationships between third party logistics service providers and their customers. The categorization of variables depending on the unique environment of third party logistics service providers is also presented.

Our research question focuses on the identification of 3PL service failures and our research objectives are to: (1) explore and analyze the most common service failures, (2) implemented recovery strategies in third party logistics service industry in Turkey and (3) investigate their impact on the related business relationships.

The purpose of this research is to determine the impact of service failure type, magnitude and frequency on the future relationship between 3PLs and their customers, identify the implemented service recovery strategy, whilst underscoring the differences between possible options and offer guidelines for 3PL professionals aimed at ensuring high customer satisfaction through efficient service failure and recovery management. The paper then explains the research methodology used, manner of data collection, reliability, data analysis and results, offers a conclusion, gives recommendations and ends with limitations and further research sections.

2. REVIEW OF LITERATURE ON SERVICE FAILURE AND RECOVERY STRATEGIES

Service failure management is mainly complicated due to the simultaneity of production and consumption (Michel, 2001) and the challenge of satisfactory recovery. The first implies that, when service failures actually occur, the presence and the involvement of customers in service production makes it almost impossible to recover from the failure without letting customers know something has gone wrong. Moreover, considering the high level of human involvement in many services and the simultaneity of production and consumption, the occurrence of service failures is also almost unavoidable (Boshoff and Leong,1998). It must be noted that both B2C and B2B have similar customer expectations and perceptions, implying that from the customer's point of view, the failure is still a result of a decision made by an individual (Chou et al.,2009). However, from the perspective of B2B services, critical incidents like service failures have greater impact since they usually have major economic consequences due to the multiplying effect (van Doorn and Verhoef, 2008). Moreover, B2B service failures have an amplified effect when compared to consumer markets (Hübner et al., 2018)

2.1. Failure Types

When the service provided fails to meet customer expectations, a service failure occurs (Halbheer et al., 2018). There are two different major types of failure: outcome failure (Grönroos, 1988; Parasuraman et al., 1991; Keaveney, 1995; Smith et al., 1999; Levesque and McDougall, 2000; Michel, 2001; Swanson and Hsu, 2009) and process failure (Grönroos, 1988; Parasuraman et al., 1991; Keaveney, 1995; Smith et al., 1999; Michel, 2001; Johnston and Michel, 2008). Outcome failure is when the customer does not receive the service paid for, whereas process failure refers to a disruption in the provision of the aforementioned service (Smith et al., 1999). The occurrence of an outcome failure is worse for the company since it is a core failure more likely to result in losing the customer than process failure. Outcome failure motivates the service provider to put more effort into recovery than process failure (Chou et al., 2009; Bitner et al., 1990; Hoffman et al., 1995; Keaveney, 1995; Mohr&Bitner, 1995; Grönroos, 1988; Parasuraman et al. 1985; Smith et al.,1999). In addition, it was highlighted "that service failure severity has a substantial adverse effect on consumer repurchasing behaviour" (Rai & Ozuem, 2019). The service failure severity denotes the intensity of the problem as perceived by the customer (Reis et al., 2019). And finally, the involvement of a third-party logistics (3PL) company in this failure situation is expected to cause significant change in customer responses. As high quality logistics services are means of company differentiation, failure to provide services of requisite quality is expensive for all partners in the supply chain, which is why literature on service failures should pay more attention to collaborative efforts than to single company situations (Oflaç et al., 2012). The most common service failures in the forwarding industry are related to documentation, information and communication, operations, equipment, booking and delivery services (Gidener Özaydın et al., 2015). Although reducing the failure rate to zero is optimal and cost beneficial, it is only valid when the benefit to be gained outweighs the costs of achieving a fail-safe service (Halbheer et al., 2018). In this case the importance of service recovery must be underlined.

2.2. Service Recovery

The significance of logistics service failure recovery is repeatedly emphasized (Andrejić & Kilibarda, 2017). As consumer habits have changed, they no longer quietly accept low quality services or failures in the highly competitive service environment, forcing service providers to develop contingency plans in case of failure (Migacz & Petrick, 2018).

Service recovery is basically the service provider's response to a service failure (Grönroos, 1988; Weun et al., 2004). It is the process whereby the satisfaction of the aggrieved customers with the company is regained, after a service has failed their expectations (Zemke and Bell, 1990). The importance of service recovery for post-failure customer satisfaction is well established (Bitner et al., 1990; Smith et al., 1999; Tax et al., 1998, Keaveney, 1995). Since service failures and failed recoveries are the foremost reason behind customers switching to other service providers (Keaveney, 1995), the importance of the issue becomes apparent. Besides, service recovery is crucial in the sense that satisfaction is a significant determinant of key outcome variables such as trust, commitment, word-of- mouth and long-term relationship (Bitner et al., 1990; Hart et al., 1990; Michel, 2001; Weun et al., 2004; Ok et al.,2005). Service recovery is both a means to enhance customer satisfaction at the transaction-specific level and a relationship tool; hence it is extremely important and plays a unique role in the service sector (Brown et al., 1996). Service recovery is significant since, poor customer retention has financial implications. Furthermore, financial implications of poor customer retention increase over time (Brinsmead,2007; Johnston and Michel,2008). Customer retention and loyalty are of crucial importance for service providers and the most effective way to ensure that loyalty is to provide a service that meets or exceeds the customer's expectations every single time. However, service delivery and its unique characteristics make it, at times, impossible to provide without fail. Even though service failure can be detrimental to loyalty, effective recovery may be sufficient for the customer to remain or even become more loyal than hey have previously been (Miller et al., 2000).

In addition, customers expect different recoveries depending on the severity of the experienced service failure and the recovery should match the service failure at hand (Smith et al., 1999; Levesque and McDougall, 2000; Craighead et al., 2004; Bradley and Sparks, 2012). When a service failure occurs, the level of recovery required to restore confidence depends on the magnitude of the failure. The severity of service failure also has a direct influence on the required recovery (Levesque and McDougall, 2000). Moreover, the smaller the magnitude of the service failure the greater the chance that recovery will have a positive impact on the customer's opinion (Smith et al.,1999). Consequently, service failures can be concluded to influence both the required recovery strategy to be implemented and the effectiveness of such recovery.

We must accept the fact that failures are undesirable yet inevitable, that whenever a failure occurs the speed and the way companies recover influence customer responses immensely (Swanson and Hsu, 2009; Smith et al., 1999; Chou et al., 2009) and that the company's response has the potential to either restore customer satisfaction and reinforce loyalty or aggravate the situation and cause it to lose the customer (Smith et al., 1999). The recovery chosen should be commensurate with service failure and meet customer expectations to avoid any mismatches and lost opportunities for customer satisfaction, loyalty and retention (Craighead et al., 2004). Service failure management should be an integral part of customer service rather than a reactive ad hoc process (Brinsmead, 2007). Recovery from service failure is an indelible part of the service provided, of utmost importance for maintaining excellence, a fundamental asset of the company and an opportunity to restore or even improve the relationship between the service provider and the customer (Flores and Primo, 2008; Hart et al., 1990; Swanson and Hsu, 2009; Ok et al., 2005). Whenever a recovery is well-managed, it provides additional capabilities, strengthens personal relations and increases confidence in the service provider, which is highly significant on B2B markets that 3PLs operate in (Hübner et al., 2018).

2.2.1. Recovery Time

Apart from choosing a recovery commensurate with its failure counterpart, the response time of the service provider company also plays an important role in post-failure outcome. A recent study on recovery dimensions has shown that in customers' eyes the speed of recovery is the first item on the agenda in the recovery context (Battaglia et al., 2012). As pointed out, the shorter it takes to address the issue at hand, the lesser the damage to customer satisfaction and loyalty (Craighead et al., 2004; Hart, et al., 1990). Likewise, it was stressed that speedy response was more likely to influence customers' justice evaluations when the experienced service failure was less severe (Smith et al., 1999; Battaglia et al., 2012).

The impact of the inability to provide services on time and delays in service recovery is evident in literature (Hart et al., 1990; Spreng et al., 1995; Tax et al., 1998; Zemke& Bell, 1990; Taylor and Baker, 1994; del Rio- Lanza et al., 2009; Battaglia et al., 2012). Short recovery response time refers to the ability to contain the problem quickly and thus restore the customer's piece of mind, since failures have a detrimental effect on customer's operations (Battaglia et al., 2012). Likewise, considering the importance of timeliness for the quality of the physical distribution service (Bienstock et al., 1996), it is clear that shorter recovery times will result in better outcomes for the service provider. Therefore, the sooner recovery takes place, the higher the level of anticipated customer satisfaction after service recovery

(Boshoff,1997). Moreover, the importance of identifying failures and implementing recoveries in the shortest period possible has been stressed in both B2C and B2B contexts (Bell and Zemke, 1987; Boshoff, 1999; Miller et al., 2000; Craighead et al., 2004).

2.2.2. Recovery Types

Literature identifies three recovery types: symbolic recovery (Bagozzi, 1975; Bell and Zemke, 1987; Bitner et al., 1990; Brown et al., 1996; Boshoff, 1997; Boshoff and Leong, 1998; Smith et al., 1999; Miller et al., 2000; Boshoff, 1999; Levesque and McDougall, 2000; Zhu et al., 2004; Johnston and Michel, 2008; Swanson and Hsu, 2009; Bradley and Sparks, 2012), utilitarian recovery (Bagozzi, 1975; Bitner et al., 1990; Brown et al., 1996; Boshoff, 1997; Boshoff and Leong, 1998; Smith et al., 1999; Miller et al., 2000; Boshoff, 1999; Levesque and McDougall, 2000; Zhu et al., 2004; Johnston and Michel, 2008; Swanson and Hsu, 2009; Bradley and Sparks, 2012) and mixed recovery (Boshoff, 1997; Boshoff and Leong, 1998; Miller et al., 2000; Levesque and McDougall, 2000; Swanson and Hsu, 2009). Symbolic service recovery is recovery that does not have an economic outcome for the customer. Symbolic service recovery includes symbolic exchange such as an apology. However, it needs to be emphasized that process service failures require symbolic service recovery since it is commensurate with the service failure experienced (Smith et al., 1999). Another approach also calls symbolic service recovery process recovery (Zhu et al.,2004). Utilitarian service recovery has an economic outcome for the customer after service failure, in the form of compensation, discount etc. Utilitarian service recovery is required in case of outcome (core) service failure. Since outcome service failure results in economic loss for the customer, recovery which involves economic gain is required to restore balance to the relationship (Smith et al., 1999). As mentioned above, another approach considers utilitarian service recovery outcome recovery commensurate with its failure counterpart (Zhu et al., 2004). Mixed service recovery means the application of two or more of the above mentioned service recoveries, e.g. a combination of one symbolic and one utilitarian or two symbolic and one utilitarian recovery, etc. The main point is that both recovery types are simultaneously applied within a single recovery effort and the choice depends on the type of the service failure at hand (Chou et al.,2009). Customer perception of the buyer-seller relationship with the service provider has an immense impact on their recovery strategy expectations, which may shed a light on why some customers are satisfied, while others are not after a similar recovery following failure. If service provider considers his relationship with the customer good, he is willing to put more effort into maintaining it and hence in the recovery attempt. Service recovery effort is perceived as high if a "mixed recovery strategy" is used. Mixed recovery strategy could consist of a combination of utilitarian strategy (discount, compensation, expense share) and an additional symbolic strategy (apology, assistance, correction) (Chou et al.,2009). The four proposed outcomes of service failures and subsequent recovery are improved relationships, weakened relationships, adjourned relationships and relationships that are not influenced by the service failure and recovery (Edvardsson, 1992).

3. RESEARCH METHODOLOGY: CRITICAL INCIDENT TECHNIQUE (CIT)

The Critical Incident Technique (CIT) was first brought to attention in 1954 in the Psychological Bulletin by Flanagan.

"*The critical incident technique consists of a set of procedures for collecting direct observations of human behavior in such a way as to facilitate their potential usefulness in solving practical problems and developing broad psychological principles*".

This technique provides steps for collecting observed incidents with "high significance and meeting systematically defined criteria". These "criteria" are defined as "any observable human activity that is sufficiently complete in itself to permit interferences and predictions to be made about the person performing the act", besides, for an incident to be "critical" it "must occur in a situation where the purpose or intent of the act seems fairly clear to the observer and where its consequences are sufficiently definite to leave little doubt concerning its effects" (Flanagan, 1954). Furthermore, critical incidents are "special, problematic, sensitive or directly unpleasant" and "can arise anywhere" and "occur even in the best of companies" (Edvardsson,1998). There are no strict data collection rules, as any rules have to be modified and adjusted to the specific situation at hand.

The advantages of the CIT are: respondents' perspective is described in their own words (Edvardsson,1992), it reflects the normal way service customers think (Stauss,1993), obtainment of unequivocal and very concrete information (Stauss and Weinlich, 1997), increased knowledge, usefulness for explaining or describing a phenomenon (Bitner et al.,1990), flexible set of rules (Flanagan, 1954, Gremler, 2004), possibility of interaction between all possible components (Koelemeijler,1995), no need for hypothesis and room for developing concepts and theories (Olsen and Thomasson,1992), accurate and in-depth record of events (Grove and Fisk,1997), rich set of data (Gabbott&Hogg,1996), more in-depth and detailed data than in typical customer satisfaction research (Bitner et al.,1994), easy adaptation to understand the experiences of others (Burns et al., 2000), powerful and vivid insight into a phenomenon (Zeithaml & Bitner, 2003) and suggests practical areas of improvement to managers (Stauss, 1993: Odekerken-Schröder et al. 2000).

Although the benefits of the CIT method are considerable, it has also received some criticism from scholars. Drawbacks and limitations of the CIT are: its reliability and validity (Chell,

2004), possible misinterpretation or misunderstanding of the stories (Edvardsson, 1992), design that may be flawed by recall bias (Michel, 2001), bias through consistency factors or memory lapses (Singh and Wilkes, 1996), possible low response rate due to respondents not being familiar with or not wanting to spend time to tell a complete story when describing the critical incident (Edvardsson and Ross 2001, Johnston,1995), problems may also arise as result of ambiguity associated with category labels and coding rules within a particular study (Weber1985)

However, the advantages outweigh possible drawbacks of the method, and the importance of the CIT method in service research is undeniable, as the technique has become a tool for reflecting customer perceptions of quality and customer satisfaction (Edvardsson and Roos, 2001). CIT may reveal a new dimension of service failures in the B2B context or contribute to the existing ones (Lockshin & McDougall, 1998). Moreover, the second most popular research topic in CIT studies is service failure and recovery (Gremler, 2004; Craighead et al., 2004). Recent applications of CIT in service literature include (Bitner et al., 1990, Hoffman et al., 1995; Edvardsson, 1998; Johnston, 1995; Youngdahl and Kellogg, 1997; Lockshin & McDougall,1998; Dasu and Rao, 1999; Swanson and Hsu, 2009; Miller et al., 2000 and Craighead et al., 2004; Chung-Herrera et al., 2004; Kelley et al., 1993; Keaveney, 1995; Lewis & Spyrakopoulos, 2001; Reynolds & Harris, 2005).

3.1. Sampling and Data Collection

The data collection tool was developed in the pre-testing phase. Initially, 20 in-depth interviews (10 with third party logistics service providers and 10 with customers) were conducted with third party logistics service providers and their customers between August 06-14, 2015, in which CIT was used to identify service failures and recovery strategies. Information on a total of 38 service failure and recovery incidents were collected by means of personal interviews with third party logistics company managers and information on a total of 36 service failure incidents from export and import companies. The data obtained were used in the pre-testing phase of the study.

The average duration of in-depth interviews was approximately 60 minutes, depending on the number of incidents shared by the managers. During the in-depth interviews, each respondent recounted a personal experience of an entire episode of service failure, mistake or problem, actions taken by customers and recovery actions of the service provider in the third party logistics industry. The measuring scale was a likert type 2 – item 10-point scale with anchors of "1" (min) to "10" (max) (Caceres and Paparoidamis, 2005; Swanson and Hsu, 2009).

This study took into account both the customers' and the service providers' points of view in the analysis of service failures and recovery strategies, since B2B service encounters are dyadic (Solomon et al., 1985). The population of the study are export and import companies (also called shippers in the logistics industry) as customers and third party logistics service providers in Turkey. In order to capture service providers' point of view on service failures and recovery strategies in third party logistics services, managers or employees of third party logistics service provider companies were also included in the research. A list of 406 third party logistics companies in Turkey obtained from the Association of International Forwarding and Logistics Service Providers (UTIKAD) was examined in detail. Though the authors attempted to reach all the companies, they were forced to reduce the sample to 235 third party logistics companies located in Turkey due to the non-availability of contact information. A total of 110 service failure incidents have been collected from 70 (29.7 %) third party logistics companies located in Turkey. In this study, both the personal interview and the survey questionnaire were structured around the model of cause, course and result of the incident (service failures and recoveries) being reported. This model is especially widely used in research on negative critical incidents such as service failures (Edvardsson, 1992, Edvardsson, 1998; Bejou and Palmer, 1998; Bejou et at., 1996).

The convenience sampling process was used to select the sample from the population of customer companies. A total of 150 questionnaires were e-mailed to the customers of service providers. Information on a total of 115 service failure and recovery incidents have been obtained from 81 (54 %) export and import companies using third party logistics services. Critical incidents related to service failures and recoveries have been collected from the managers or employees of logistics departments of customer companies.

3.1.1. Reliability

Reliability is a key component in analytical methods due to the possible effect of subjectivity. In CIT studies employing content analytic methods, reliability assessment usually focuses on the judge's ability to consistently classify incidents into the same categories. The most commonly reported statistic relating to the reliability of CIT studies is the percentage of agreement. In this kind of research, reliability could include discussion on both intrajudge and interjudge reliability, however, in this study, intrajudge reliability concerned with the consistency of a judge's categorization decisions over time (Weber, 1985) was employed. Interjudge reliability is defined as "the degree to which two or more judges agree that a given observation should be classified in a particular way" (Perrault and Leigh, 1989). Reliability is assessed by means of reliability indices used and the size of statistics reported. The purpose of reliability indices is to verify the likelihood that various judges would have classified given critical incidents in a similar way.

The author and an academician who has a background in the logistics industry independently classified all the service failures collected both from the customer companies and third party logistics provider companies. The differences and discrepancies in the classifications were identified, discussed and resolved by the coders. In this study, interjudge agreement on the classification of service failure incidents was 85 % for customer companies and 90 % for third party logistics service provider companies.

4. DATA ANALYSIS

Each third party logistics company was requested to have employees from three different departments, including Marketing and Sales, Operations and Documentation, and Accounting, to fill out the questionnaire form. A total of 110 service failure and recovery incidents were collected from third party logistics companies. Two of these incidents were excluded from analysis since the data did not meet the critical incident criteria defined in the study. A total of 115 service failure and recovery incidents were collected from customer companies by email and internet survey. Seven incidents collected from customer companies were excluded due to missing critical information and inability to meet the critical incident criteria defined in the study.

The number of incidents that are or should be included in CIT is always open for debate. Flanagan (1954) recommends that "no new incidents should appear in the last 100" collected incidents. A total of 225 service failure incidents have been collected via e-mail in a four-month period between September and December 2015. As mentioned above, nine incidents were excluded and 216 service failure incidents included in the analysis; 108 service failure incidents from shipping companies and 108 service failure incidents from 3PL's. As this study is conducted in a B2B setting and context, the total number of incidents collected from shippers and 3PL's was deemed satisfactory.

The aforementioned gaps in the B2B service failure and recovery research, such as: the aftermath of service failures in 3PL services, studies including both satisfied and dissatisfied customers after recovery and the relationship between customers and service providers, have not been taken into account in the B2B service sector. Edvardsson's (1992) cause, course and result approach was adapted to this study, with the addition of new variables highlighted in the service failure and recovery literature and the apriori model was proposed.

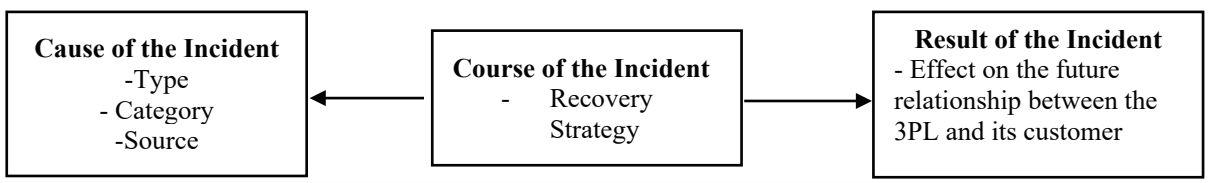

Figure 1.
Analytical Model of Research.

The first stage of critical incident analysis in this study consisted of inductive delineation of major groups that could collectively account for all the incidents and finding general answers to main research purposes and questions. In order to establish the initial classification scheme, the author and an academician reviewed a sample of service failure incidents in third part logistics services.

The analysis began with the careful scrutiny of service failure incidents collected from customer companies and third party logistics service providers. In the study, the author and an academician, acting independently from each other, classified service failures and recovery strategies into a number of categories. Two successive clustering processes conducted by two coders resulted in major categories. Having reached a consensus on the main categories, the process of category delineation within the groups was initiated. Using an iterative process, two coders read, sorted, reread and combined service failure incidents on category labels. Service failure incidents were classified into main categories and subcategories. The examples of service failure categories from both perspectives are presented. In addition to classifying critical incidents by source and nature of service failures, they were also classified by the magnitude of the mistake as perceived by the respondent. The course of service failure incidents/service recovery strategies was also classified into main categories and subcategories. Finally, the results of service failures and recovery strategies were included in the study.

4.1. Cause of the Incident

The first part of the model includes types, categories and sources of failures from both perspectives. The second part includes recovery strategies from both perspectives and the last part presents the impact of the incident on the relationship between 3PLs and their customers. Table 1 clearly shows that the majority of incidents shared by respondents are outcome failures, which was to be expected due to the complexity and time sensitivity of the logistics activities.

Table 1.
Failure Types: Customer Perspective vs. 3PL Perspective.

	Customers		Logistics Service Providers		
Failure Types	**Count(N)**	**Per. (%)**	**Count(N)**	**Per. (%)**	**Total**
Process	15	13,9	47	43,5	62
Outcome	93	86,1	61	56,5	154
Total	**108**	**100**	**108**	**100**	**216**

Table 2. shows failure categorization from the customer perspective. The majority of failures are customer service and operations failures. The second most common failure shared by customers pertains to port operations. These failures are failures with the highest magnitude and frequency. The highest recovery satisfaction is associated with customer service and operations failures which are also the quickest recoveries. Incidents regarding marketing/ sales and finance/accounting failures have the longest recovery response time.

Table 2.
Failure Categories: Customer Perspective.

Failure Categories	**Count (N)**	**Per. (%)**	**Cum. Per. (%)**	**Fail. Magn.***	**Fail.Freq.****	**Recov. Satis.*****	**Recov. Respon.******
Customer Service/ Operation	67	62	62	7.22	5.98	5.53	5.29
Documentation	12	11.1	73.1	7.16	4.91	2.83	6.08
Finance/ Accounting	5	4.6	77.8	7.4	2.8	4.4	7
Marketing/ Sales	3	2.8	80.6	8.3	3	1.6	10
Port Operations	21	19.4	100	7.85	6.8	4.23	6.14
Total	**108**	**100**					

* 1= minor 10= major
** 1= very frequent 10= very rare
*** 1= very dissatisfied 10= very satisfied
**** 1= very quick 10= very slow

Table 3, which presents failure categorization from both the customer and the 3PL perspective, reveals that the most common failures are customer service and operations related failures, followed by port operations failures. The longest recovery response time is again associated with marketing and sales related failures. As the slowest recovery was rated 5 by 3PLs, whereas the fastest recovery was rated 5.29 by the customers, there is clearly a discrepancy between recovery responsiveness perceptions of the two parties. The customers perceive the recovery as slower and are not as satisfied as 3PLs think (see Table 4). Though recovery satisfaction levels are much higher in 3PL perception, both parties have a similar perception of failure magnitude.

Table 3.
Failure Categories: 3PL Perspective.

Failure Categories	Count (N)	Per. (%)	Cum. Per. (%)	Fail. Magn.*	Fail. Freq.**	Recov. Satis.***	Recov. Respon.****
Customer Service / Operation	52	48.1	48.1	7.34	6.46	7.44	4.26
Documentation	17	15.7	15.7	7.88	6.35	7	4.47
Finance/ Accounting	7	6.5	70.4	8	5.42	8.42	3.85
Marketing/ Sales	7	6.5	76.9	8	3.5	6.57	5
Port Operations	25	23.1	100	7.2	4.96	7.44	3.88
Total	**108**	**100**					

* 1= minor 10= major
** 1= very frequent 10= very rare
*** 1= very dissatisfied 10= very satisfied
**** 1= very quick 10= very slow

Table 4.
Failure Source Classifications: Customer Perspective vs. 3PL Perspective.

Customer Perspective				3PL Perspective			
Failure Source	**Count (N)**	**Per. (%)**	**Cum. Per. (%)**	**Failure Source**	**Count (N)**	**Per. (%)**	**Cum. Per. (%)**
Railway Operator	0	0	0	Railway Operator	1	0.9	0.9
Lashing Company	0	0	0	Lashing Company	1	0.9	1.8
Carrier	32	29.6	29.6	Carrier	33	30.6	32.4
Customer	1	0.9	30.6	Customer	31	28.7	61.1
Customs Broker	1	0.9	31.5	Customs Broker	1	0.9	62.0
Government Bodies	1	0.9	32.4	Government Bodies	1	0.9	62.9
Haulier	5	4.6	37.0	Haulier	5	4.6	67.6
3PL	62	57.4	94.4	3PL	20	18.5	86.1
Network Member	1	0.9	95.4	Network Member	8	7.4	93.5
Port	2	1.9	97.2	Port	4	3.7	97.2
Warehouse Operator	3	2.8	100.0	Warehouse Operator	3	2.8	100.0
Total	**108**			**Total**	**108**	**100**	

4.2. Course of the Incident

The course of the incident is the recovery strategy implemented by the 3PL as a reaction to a service failure. From both perspectives, the most commonly implemented recovery strategies are symbolic recovery strategies (see Table 5). These recovery strategies include apology, assistance and correction activities undertaken by service providers. From the customers' perspective, the second most common course is no recovery, whereas 3PL perspective suggests that utilitarian recovery strategies are the second. Nonetheless, in a total of 40 incidents, both the customers and 3PLs agree that there was no recovery.

Table 5.
Recovery Classification: Customer Perspective vs. 3PL Perspective.

Customer Perspective				3PL Perspective			
Recovery Classification	**Frequency**	**Per. (%)**	**Cum. Per. (%)**	**Recovery Classification**	**Frequency**	**Per. (%)**	**Cum. Per. (%)**
Mixed	12	11.1	11.1	Mixed	10	9.3	9.3
No recovery	26	24.1	35.2	No recovery	14	13.00	22.2
Symbolic	51	47.2	82.4	Symbolic	56	51.9	74.1
Utilitarian	19	17.6	100	Utilitarian	28	25.9	100
Total	**108**	**100**		**Total**	**108**	**100**	

4.3. Result of the Incident

As previously mentioned, the result of the incident is the effect of failure and recovery on the relationship between 3PLs and their customers. The relationship categories are based on Edvardsson's (1992) study and are as follows: not influenced, adjourned, improved and weakened (see Table 6). Both parties hold that the majority of relationships are not influenced by service failure and recovery. However, customers' perspective indicates adjourned relationships as the second largest group, whereas 3PL's perspective suggests that improved relationships are the second largest group. The difference could perhaps also be related to the different perceptions of failure magnitude, frequency and recovery satisfaction level by the two parties.

Table 6.
Relationship after Service Failure and Recovery: Customer Perspective vs. 3PL Perspective.

Customer Perspective				3PL Perspective			
Relationship with 3PL	**Frequency**	**Per. (%)**	**Cum. Per. (%)**	**Relationship with customer**	**Frequency**	**Per. (%)**	**Cum. Per. (%)**
Not influenced	48	44.4	44.4	Not influenced	58	53.7	53.7
Adjourned	25	23.1	67.6	Adjourned	6	5.6	59.3
Improved	3	2.8	70.4	Improved	25	23.1	82.4
Weakened	32	29.6	100	Weakened	19	17.6	100
Total	**108**	**100**		**Total**	**108**	**100**	

5. DISCUSSION

This research examined service failures and recovery strategies implemented by 3PL's in the logistics services from both the customers' and 3PLs' perspectives. Service failures and recovery strategies were analyzed using CIT. Although CIT has been widely used in consumer markets, there are only limited examples of its use in the field of B2B services. This study therefore fills the gap in the relevant literature. CIT was also found to be useful in the analysis of service failures and recovery strategies in the B2B services setting.

Literature shows that consumer markets have relatively more relational failures, whereas B2B failures are mostly output failures since the focus is on the result. After data collection through CIT and analysis, failure types were categorized from the customers' point of view. Outcome failures account for 86.1 % (93) and process failures for 13.8 % (15). This is mostly due to the time sensitivity of logistics services and the likelihood that the customers will remember the worst of the worst. From the 3PL perspective, process failures account for 43,5 % (47) and outcome failures for 56,5 % (61). There are more process failures from the 3PL perspective; this may be due to the fact that these failures are perceived as less important or that 3PLs' total awareness of the process is greater than the customers'. Even though in service settings customers are involved in the service provision process, they may not be fully aware of all the details. Hence,

unlike the literature suggests, 3PL service providers may conceal failures from the customers if they manage to fix them before the customers become aware of their existence.

CIT also provided sufficient information for the classification of failure categories. Likewise, Durvasula et al., (2000) examining maritime transport recovery strategies and customer satisfaction, also found CIT a useful method for effective service development in B2B services. Whereas past research mostly focused on the customers' side of the service failures, rarely taking into account the service providers', this study took the dyadic approach, taking into account both the customers' and the 3PLs' perspectives to get the whole picture and increase the reliability and validity of B2B services. The aforementioned failure categories are customer service and operation, documentation, finance and accounting, marketing and sales and port operations. The most frequently observed failure categories from both perspectives are: customer service and operations, port operations and documentation, owing to the nature of the logistics services provided by 3PLs. The majority of services provided by 3PLs include customer interaction and there are a multitude of documents and port operations involved, including loading, transfer, carrier activities, transit times etc.

From both perspectives, service failures with the highest magnitude are associated with marketing and sales, finance and accounting. Therefore, 3PLs must be aware of the importance of these departments and related activities, since any disruption is perceived by customers as highly important. The lowest levels of satisfaction after recovery are likewise associated with marketing and sales failures from both perspectives.

On the recovery side, the most common recovery strategy from both perspectives is symbolic recovery. This is probably due to its simplicity. Symbolic recovery includes apology, correction and assistance. These include apologizing to the customers for service failures, trying to get extra time for loading from the carrier, arranging extra air cargo to outweigh the negative outcomes of delay etc. However, the analysis showed no evidence that recovery strategies affected the relationship between 3PLs and their customers after service failure and recovery, but suggest that they affected recovery satisfaction instead. Although from both perspectives the highest level of satisfaction after recovery is perceived in customer service and operation and finance and accounting failures, this may be due to the fact that these failures call for utilitarian recovery which is associated with higher customer satisfaction.

Recovery responsiveness should also be taken into account, as customer service and operations and documentation failures are perceived by customers to be dealt with the fastest, which may be why they resulted in the highest recovery satisfaction in line with the literature. Likewise, the slowest recovery in customers' perception was associated with marketing and sales and finance and accounting failures, though satisfaction levels here differ. As mentioned above, since finance and accounting failures require utilitarian recovery, recovery satisfaction is higher. However, symbolic recovery after marketing and sales failures is insufficient, since magnitudes are perceived to be the highest in these two domains. Consequently, the findings are compatible with the literature in the sense that, to satisfy customers, higher magnitude failures require utilitarian recovery.

In addition, the following sources of failures have been identified and categorized: railway operator, lashing company, carrier, customer, customs broker, government bodies, haulier, 3PLs, network members, ports, warehouse operators. The customers perceive carriers and 3PLs as the most common failure sources, whereas 3PLs focus on carriers, 3PLs and customers as failure sources. The absence of customers as a failure source from the customers' perspective may be due to the external attributions of the customers with respect to failures.

From both perspectives, relationships mostly remain unaffected after the failure and recovery process, which may be due to oligopolistic competition in this sector and the consequent lack of alternatives or to the importance of long lasting relationships for the ease of doing business. Two of the most important findings here are that customers indicated that 25 (27 %) incidents resulted in the termination of the relationship, whereas 3PLs only mentioned 6 (6.5 %). Moreover, according to 3PLs, 25 (27 %) incidents resulted in improved relationship, whereas the customers only mentioned 3 (3.2 %). The reason behind this discrepancy may be the reluctance of 3PLs to share such information or the desire of customers to stress the importance of these incidents.

6. RECOMMENDATIONS

Most of the CIT research on services focuses on B2C services like banking, hospitality, restaurant, airline travel, retail and public transport, with special emphasis on encounters and interactions. However, this research analyzed third party logistics service failures and recoveries and contributed to the B2B service literature. Service failure classifications of 3PL services and B2C services are similar in the sense that the timeliness of recovery is crucial. On the other hand, 3PL services differ from B2C services with respect to customer involvement, customer professionalism, focus on the end result and level of complexity due to the number of parties involved in logistics services. Focus on the end result and the level of professionalism of both parties in 3PL services could also explain why there are fewer process failures. These findings correspond to the findings of Lockshin and McDougall (1998) on wine retail sale, where service outcomes in industrial markets were generally outcome issues like delay or damage.

Whereas previous studies on consumer services focused on the impact of service providers' employees on customer satisfaction or dissatisfaction and provided an insight

into that dimension of service failures and recovery, this study focuses on negative critical incidents that have an impact on customer satisfaction or dissatisfaction with all 3PL services, rather than focusing solely on service failures attributable to 3PL employees. These critical incidents have also been examined from the aspects of failure magnitude, failure frequency, recovery responsiveness and customer satisfaction. Although service literature suggests that distribution channels and service delivery are short, in its examination of 3PL service failures and recoveries this study takes into account many actors contributing to the service delivery process in 3PL services, such as hauliers, carriers, customs brokers, ports, logistics network members, warehouse operators, government bodies, etc., demonstrating that logistics services can be disrupted by parties other than the customer and the service provider and thus contributing to B2B service literature and 3PL literature.

The conclusion of the study is that the majority of 3PL service failures are caused by carriers. 3PLs should therefore be more careful in their selection and evaluation of carriers they work with and keep in mind that 3PLs are responsible to customers just as carriers are responsible to 3PLs.

CIT revealed that the majority of 3PL service failures can be attributed to customer services and operations and this is where 3PL employees are most involved. Therefore, 3PLs could use employee performance evaluations, employee training, employee and customer interaction monitoring and the enforcement of strict rules to maintain service quality, provide seamless, sustainable services to their customers and nurture their relationship in between.

Likewise, 3PLs should pay more attention to their complaint management and claim handling procedures to improve customer service quality and customer satisfaction. Effective complaint handling and analysis will also allow 3PLs to efficiently identify the most problematic areas and dimensions of service quality, and implement recoveries in a timely manner. Although shipping lines and their agents have complaint handling departments, 3PLs usually do not. The formation of such a department would be beneficial for service quality and customer satisfaction.

On the other hand, customers are encouraged to use supplier performance evaluation systems to evaluate the performance of 3PLs they work with. Customers could then use these systems to choose high quality service providers. Customers are also advised to renew their contract or change the 3PLs that do not provide services of the required quality.

Moreover, the utilization of advanced information technologies that enable seamless information exchange between parties with minimum human error will help prevent miscommunication and documentation related failures. Both 3PLs and shipping lines were found to be heavily investing in information and communication technologies in order to avoid or minimize such failures.

Furthermore, 3PLs should adopt a rather proactive approach to service recovery and form quality management and quality improvement systems within the organization. The causes of service failures must be identified using quality systems and the required improvements carried out. Likewise, employee attitudes towards customers and their job competency should be improved to guarantee high service quality and customer satisfaction.

Owing to their complexity, logistics service failures are unavoidable, especially those regarding damage and delay. Therefore, obtaining liability insurance for such failures can be an effective way for 3PLs to both recover from failures and gain customers' trust.

Moreover, the social relevance of this study is that the lower number of 3PL service failures will reduce negative environmental impact caused by recurring activities, reduce carbon footprint and the waste of vital human and monetary resources. Impact on the governments is also significant considering they are responsible for providing and maintaining infrastructure used in logistics services. If not complete elimination, then a decrease in the number of unwanted service failures will allow these resources to be put to other use and possibly increase the quality of life for the stakeholders involved and contribute to the overall sustainability of the logistics macro-system.

7. FUTURE RESEARCH

Due to the complexity of 3PL services, there are a great many actors contributing to the provision of third party logistics services, such as: ports, customs brokers, governmental bodies, hauliers, ocean carriers, railway operators, airlines and others, depending on the nature of the service. The perspectives of all these actors should be explored to evaluate the overall logistics service system and increase objectivity.

Besides, although this research is, in a way, dyadic, for the full effect of the actual perceptions of the customers and 3PLs to be captured, a strictly dyadic research is required. A strictly dyadic relationship can be achieved only if research focuses on a single 3PL and its customers, and a single failure. Even though this study explored both perspectives, it did not exactly focus on both sides involved in certain failures.

Future studies should also look into critical incidents and 3PLs' complaint handling documents. Sample could be bigger and comparison could be made with other countries due to differences in logistics infrastructures and cultures. In addition, the same techniques should be used in other B2B service sectors to generalize findings. 3PL service failures and recoveries could also be examined using experimental methods.

Some of the limitations of other CIT studies are also applicable to this study, e.g. customers or 3PL employees could misunderstand some of the qualitative and quantitative questions in the questionnaire or experience memory lapses. However, the same could be said of any marketing research, especially qualitative ones.

Other limitations of this research are sample size and national scope. This study was conducted as a cross-sectional study and the constraints associated with cross-sectional data may be overcome by longitudinal studies on 3PL service failure and recovery. Considering the long-term nature of purchasing decisions in B2B environments, longitudinal studies may be carried out to gain a wider understanding of failures and recoveries in 3PL services.

Moreover, this study classified 3PL service failures according to the general departmentalization of 3PLs. Future studies could also consider classifications based on logistics service phase or process, to identify the phase in which the majority of service failures occur, and suggest areas of improvement to 3PLs. Finally, future research may look further into the impact of these failures on sustainability and resource management.

APPENDIX A

Critical Incident Data Collection Form for Service Failures and Recovery Strategies in Logistics Services: Customer Perspective

Critical Incident Technique focuses on analyzing the events that are categorized as out of the ordinary between suppliers and customers. The purpose of this research is to investigate the logistics service failures, the utilized recovery strategies and how these effect the relationship between 3PLs and their customers. The name and titles of the related parties will be handles confidentially and only used for academic purposes. Thank you for your participation.

I.

Please describe a critical incident you experienced with your the logistics service provider within the last year in detail. (What did you say after the failure? What caused this failure to happen? How did your supplier react)

(a) Please rank the importance/ magnitude of this service failure with regard to the damage it caused. (1: minor;10 major)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

(b) Please specify how frequently you encounter this service failure (1: always; 10: rarely)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

II.

(a). As the customer please explain in detail how the service provider handled the situation and what kind of actions were taken in order to recover from it.

(b). Please explain how you reacted against this incident in detail.

(c). Please rank how you evalute your satisfaction was regarding the way the failure was handled? (1: very weak; 10: very well)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

(d) How long did it take to recover (1: very short; 10: very long)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

III.

(a). How did this incident effect your business relationship with your service provider?

Adjourned Weakened Not Influenced Improved

☐ ☐ ☐ ☐

(b). How did this incident effect your business relationship with your service provider?

Adjourned Weakened Not Influenced Improved

☐ ☐ ☐ ☐

IV.

(a).Please specify this service provider's significance to your company with regard to transaction size. (1: not significant; 10:very significant)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

(b). How many years have you been working with this service provider?

less than 1 1-3 4-6 7-10 more than 10

☐ ☐ ☐ ☐ ☐

APPENDIX B

Critical Incident Data Collection Form for Service Failures and Recovery Strategies in Logistics Services: Logistics Service Providers' Perspective

Critical Incident Technique focuses on analyzing the events that are categorized as out of the ordinary between suppliers and customers. The purpose of this research is to investigate the logistics service failures, the utilized recovery strategies and how these effect the relationship between 3PLs and their customers. The name and titles of the related parties will be handles confidentially and only used for academic purposes. Thank you for your participation.

I.

Please describe a critical incident you experienced with your customer as the logistics service provider within the last year in detail. (What did you say after the failure? What caused this failure to happen? How did your supplier react)

(a) Please rank the importance/ magnitude of this service failure with regard to the damage it caused. (1: minor;10 major)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

(b) Please specify how frequently you encounter this service failure (1: always; 10: rarely)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

II.

(a). As the logistics service provider please explain in detail how you handled the situation and what kind of actions were taken in order to recover from it.

(b). Please explain how your customer reacted in detail.

(c). Please rank how you evalute your customers satisfaction was regarding the way the failure was handled? (1: very weak; 10: very well)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

(d) How long did it take to recover (1: very short; 10: very long)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

III.

(a). How did this incident effect your business relationship with your customer?

Adjourned Weakened Not Influenced Improved

☐ ☐ ☐ ☐

(b). How did this incident effect your business relationship with your service provider?

Adjourned Weakened Not Influenced Improved

☐ ☐ ☐ ☐

IV.(a).Please specify this customer's significance to your company with regard to transaction size. (1: not significant; 10:very significant)

1 2 3 4 5 6 7 8 9 10

☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐ ☐

(b). How many years have you been working with this customer?

less than 1 01-3 04-6 07-10 more than 10

☐ ☐ ☐ ☐ ☐

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Logistical Activities in the Function of Development of the Shipbuilding Industry

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This paper examines the impact of supply on production results in the shipbuilding industry. The shipbuilding industry is characterized by extreme complexity, as the integration of many other industries is required, and the industry's product itself is highly complex and expensive, requires a high degree of processing and subsequently yields significant revenue. Since numerous suppliers are involved in the production process, shipbuilding has a multiplicative effect on other industries. Logistics are one of the fundamental factors for the industry's efficient and effective operation. Supply is considered in this paper as it is nowadays a strategic decision that actively influences business success in the shipbuilding industry. The purpose of the simulation of its impact on the production process is the avoidance of possible mistakes that could not only weaken a company's competitive position, but endanger its viability as well. The simulation ends with a concrete example illustrating that time deviations (arrivals, withdrawal and complaints) increase the basic value of the order to a certain extent. This paper highlights the need to maximize the speed of response to customer needs through the synthesis of planning activities and business logistics, and to remain competitive in an increasingly demanding global market.

KEY WORDS
~ Shipbuilding industry,
~ Logistics,
~ Simulation,
~ Time deviation

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doi: 10.7225/toms.v09.n01.004

1. INTRODUCTION

Maritime economy consists of shipbuilding, fishing, the exploitation of the sea and seabed mineral resources, production industry, shipping, seaports, coastal tourism and various maritime services (maritime agencies, shipping banks, insurance etc.) (Žuvela, 2000). Shipbuilding is an intensive activity that requires the application of modern technology and encourages innovation in the production process, as a key factor of competitiveness that helps reduce costs (Kersan-Škabić, 2009). Although shipbuilding industry is the most important industry in all maritime countries, the shipbuilding market is characterized by fluctuations of supply and demand on the global level and large cyclical fluctuations in the shipbuilders' financial operations (Pašalić, 1996). One of the key factors for achieving efficiency and effectiveness in maritime and economic systems, and thus in the shipbuilding industry, are maritime logistics that enrich, integrate and validate the profiled structure of transport and economic systems (Zelenika, 2002). The ship, as the main product of the shipbuilding industry, is a highly complex and expensive product. It requires a high degree of processing, which subsequently yields significant revenue and has a multiplicative effect on other industries.

In general, shipyards are organized functionally, with the manufacturing sector organized by production stages. This

organizational structure, where shipyards strive to maintain a continuous production process with fixed production capacity is characteristic of Far Eastern shipbuilders (Perić Hadžić et al., 2013). However, the ultimate goal is to improve the end product by enhancing all elements of the value chain, which is defined as "a combination of nine generic activity values which result in a joint action by delivering the value to customers" (Porter, 1985). Nine generic security activities of the company are input logistics, operations, output logistics, marketing and sales, service, infrastructure companies, human resource management, research, technology and system development and procurement (Porter, 1985). All indicated activities are important in the planning stage as the key determinant of a shipyard's success. The intention is to create a solid basis for increasing business logistics efficiency. The efficient resolution of logistical problems in shipyards not only involves service minimization or maximization, but a compromise between these goals as well.

Coordination at the level of construction (project) - technology - supply is required as a prerequisite for achieving a high level of interaction between organizational elements: plan -construction-technology (PCT), supply and production. Owing to the variable nature of business structure and flows, supply is a key factor in the process of connecting and creating virtual structures (Segetlija, 2008). Thus, the sales value of the ship, as the product of the shipbuilding industry, confirms the importance of supply activities in the value chain. As improvement is becoming increasingly important in the shipbuilding industry, shipyards are seeking to improve the process of evaluation of the current state of their manufacturing process to stay competitive (Ozkok, 2013), and this process is largely related to supply. The economic efficiency of supply is measured on the basis of the value of generated effects and acquisition costs (Buntak et al., 2014). In line with the above, the topic of this paper are supply activities in the shipbuilding industry, with a simulation of their impact on the manufacturing process in the respective industry. The assumption was that greater flexibility and coherence of tactical and operational level planning create higher added value within the shipbuilding process through better management of business logistics. Simulation procedure was used as a way to manage product lifecycle to facilitate production planning or decision-making (Back et al., 2016). Simulation is a tool especially useful in the shipbuilding industry.

2. ROLE OF LOGISTICAL ACTIVITIES IN THE SHIPBUILDING INDUSTRY

The ship, as the final product of the shipbuilding industry, is extremely complex and specific, as it requires a large number of inputs, materials and equipment. The production process is time-consuming and consists of a large number of processes and sub-processes using many different technologies.

The customer, who appears at the very beginning of the process, plays an important role in the creation of this product. The buyer not only participates in the construction of the vessel financially, but is also very knowledgeable and seeks the highest quality fulfilment of his requirements. Consequently, buyers evidently have an active role in the supply of inputs necessary for production, and the complex relationship between the buyer and the supplier is illustrated in Figure 1. The basic interest of the buyers is to have their needs met at the lowest possible cost, while maintaining the functionality of all production processes without compromising the standard of the final product. The preconditions for success are therefore tact and optimization of the entire supply chain, combined with effective intra-organizational flexibility. In this context, the speed of an enterprise's response to change, which defines a company's performance, should not be neglected, since the factors and forces from the macro-environment of the company, which have the greatest influence on the formulation of the business strategy, usually relate to the immediate industrial and competitive environment (Thompson et al., 2008).

However, one of initial activities in the process of transformation of raw materials into finished products is planning, which must be flexible enough to accommodate any changes in the micro and macro environment. The efficiency of logistics of supply (LN) and logistics of production (LP) can be measured by various parameters. One of the most obvious and cost-effective parameters in shipbuilding is supply status, i.e. flow or turnover. In production activities like shipbuilding providing quality to the customer is directly related to the level of purchased material inputs.

Supply status, i.e. the status of delivery logistics, is indicative of the level of a shipyard's planning flexibility. There is certain coherence between activities within the organization and activities that precede or follow them. Otherwise, the causes of dysfunction in the process must be recorded and eliminated. When making a business logistics efficiency model, the following factors should be taken into consideration:

- level planning (flexibility of tactical and operational planning)
- supply logistics (SL)
- supply status
- production logistics (LP)

There should be an interconnection between two variables contained in the above-mentioned factors. The first variable independently constitutes the level of planning, i.e. the degree of flexibility between tactical and operational level planning. The second variable is business logistics efficiency, i.e. the synthesis of supply logistics (SL) and production logistics (LP), the indicator being supply status. The direct link between the indicator and flexibility planning activities (tactical and operational) confirms the basic hypothesis of this paper. All three levels (orders, supply,

activity) illustrated in Figure 2 are directly influenced by the flexibility of the planned level. Optimizing the interrelations of these levels, i.e. reducing costs while keeping process continuity at a competitive level, is paramount.

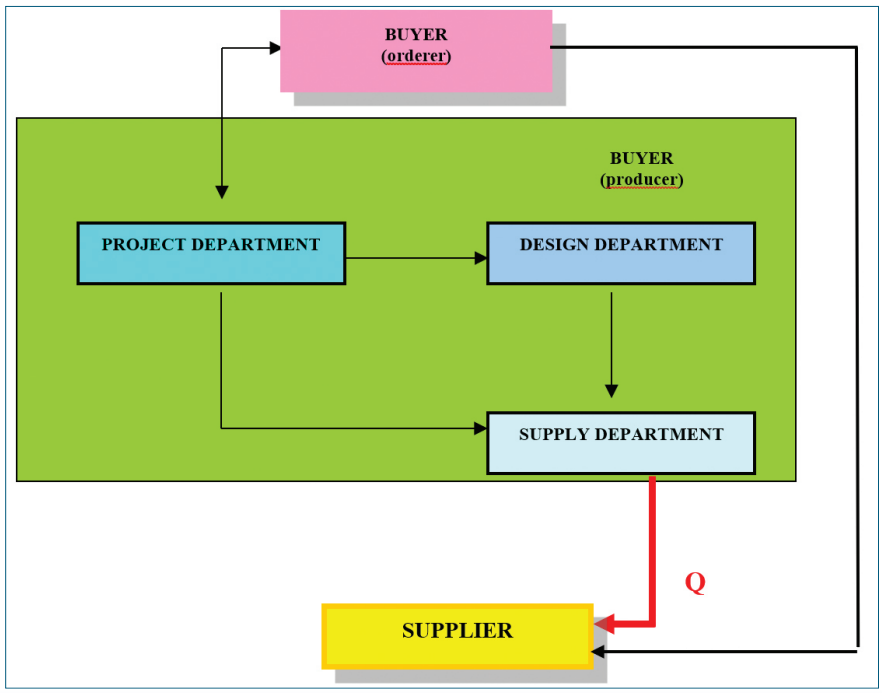

Figure 1.
Customer-supplier relationship in the shipbuilding production proces (Source: Authors).

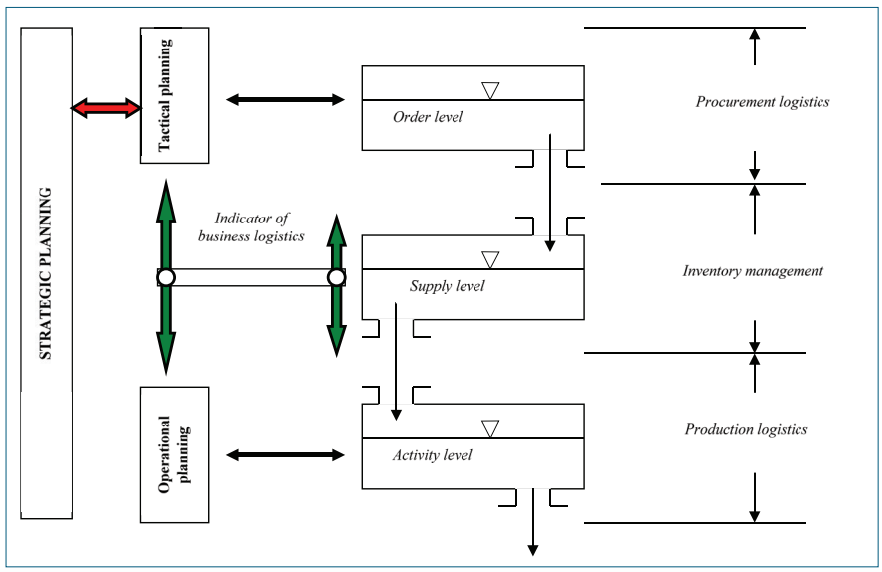

Figure 2.
Connection of flexibility of planning levels with the efficiency of business logistics (Source: Authors).

3. SIMULATION OF THE IMPACT OF THE SUPPLY PROCESS ON THE PRODUCTION SYSTEM IN THE SHIPBUILDING INDUSTRY

In the shipbuilding industry, the functionality of the logistics chain is key to achieving good business results. To make better business decisions and minimize any mistakes potentially detrimental to business, managers use a variety of support tools. The development of information and communication technology has made a major step forward in enterprise management methods (Lee et al., 2014). Various forms of simulations are commonly used by managers from all industries, including the shipbuilding industry. Simulating events is often the only way to predict future mistakes. This paper presents a simulation of the impact of supply on production system costs, on the example of Brodotrogir Shipyard. The model correlates time deviations in the material supply chain (receipt time - XDP, withdrawal - XDI, complaint time - XDR) with cost and product value (PV). The development of the final computer simulation model requires certain steps to be made, which largely determine the accuracy of the values shown. In this context, the systematic – dynamic simulation model should answer the following question: Does the decrease or increase in time deviations in the material purchase chain have an impact on the value of the product itself (Figure 3). The analysis of potential improvement of competitiveness through cost reduction is conducted on the selected segment of the value chain.

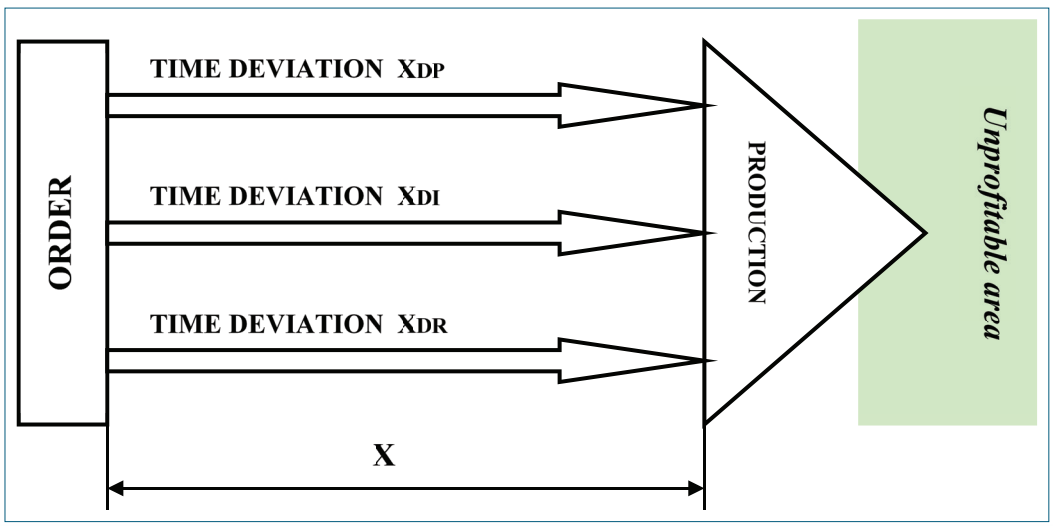

Figure 3.
Impact of time deviations in the material purchase chain on product value (Šundov, 2009).

Purchase is a complex process that can be viewed from different perspectives, i.e. purchase status can be recorded by tracking orders or order segments. Thereby, by gaining an understanding of time deviations (XDP, XDI, XDR), we have attempted to express their impact on the value of the product – ship (ZB) through costs. The model required the issue of the manner of expression of time deviations in terms of costs to be resolved. In addition, the simulation model had to establish a connection between temporal and financial aspects, and present them in an acceptable manner. The focus is on the buyer-supplier relationship. The model is primarily a tool for rapid detection of possible dysfunctionalities in the supply process. The first step after the analysis of the current state of the purchasing process in a shipbuilding system such as Brodotrogir is the development of linear simulation. Statistical data obtained by analyzing eighty orders and tracking time deviations during their realization were used in simulation development. By analyzing and processing the mentioned orders, the basic statistical order distribution indicators according to three-time deviations were calculated (Table 1). The mean receipt time deviation is 65 days, with the mean deviation of 55.46. The mean withdrawal time deviation is 71 days, with the mean deviation of 57.41. The mean complaint time deviation is 17 days, with the mean deviation of 48.33.

Mean deviation of withdrawal time was observed to be the highest and have the highest standard deviation. Yet, the model suggests that the highest receipt time and complaint time deviation is zero (the modal value for receipt time is not representative because 7 out of 80 orders have 0 deviation, whereas in case of complaint time as many as 67 out of 80 orders have 0 time deviation). Positive skewness values indicate that order distribution is skewed to the right for all time deviations. Besides, positive kurtosis values show that peak distributions

Table 1.
Descriptive statistical indicator of eighty orders (Šundov, 2009).

Time deviations	*Xdp*	*Xdi*	*Xdr*
Mean	65.01	70.9375	16.93
Standard Error	6.20	6.419051543	5.40
Median	61	50	0
Mode	0	42	0
Standard Deviation	55.46	57.4137424	48.33
Sample Variance	3075.99	3296.337816	2335.84
Kurtosis	1.62	1.757294151	7.64
Skewness	1.13	1.439355606	2.96
Range	257	257	205
Minimum	0	5	0
Maximum	257	262	205
Sum	5201	5675	1354
Count	80	80	80

(most frequently) are around the modal value. In addition to mean values (arithmetic mean, median and mode), standard deviations, skewness and kurtosis measures, Table 1 also shows the highest and lowest values of variables, as well as the variation range. We have obtained the following values from available data:

Z_N = 63,696,879 (HRK)…… total value of eighty orders
$\overline{X}_{DP}$ = 65 (day)…… mean receipt time deviation per order
$\overline{X}_{DI}$ = 71 (day)....mean withdrawal time deviation per order
$\overline{X}_{DR}$ = 17 (day)……mean complaint time deviation per order

The following values were calculated:

ZU…value of total orders increased by mean time deviations

ZS……value of total orders increased after correcting mean time deviations

Following the analysis of statistical data on eighty orders, we obtained the mean percentage of the linear increase of the basic value. The linear increase is different for individual mean time deviations, and can be expressed as follows:

$\overline{Y}_P = 0.0043 \times \overline{X}_{DP}$…… mean percentage of increase in order value
caused by
mean receipt time deviation

$\overline{Y}_I = 0.0041 \times \overline{X}_{DI}$……. mean percentage of increase in order value
caused by
mean withdrawal time deviation

$\overline{Y}_R = 0.0048 \times \overline{X}_{DR}$…… mean percentage of increase in order value
caused by
mean complaint time deviation

By inserting the known values we obtain:
$\overline{Y}_P = 0.0043 \times 65 = 28$ %
$\overline{Y}_I = 0.0041 \times 71 = 29$ %
$\overline{Y}_R = 0{,}0048 \times 17 = 8$ %

It follows that:
$Z_P = Z_N \times \overline{Y}_P = 63.696879{,}00 \times 0.28 = 17.835126{,}12$ (HRK)
$Z_I = Z_N \times \overline{Y}_I = 63.696879{,}00 \times 0.29 = 18.472094{,}91$ (HRK)
$Z_R = Z_N \times \overline{Y}_R = 63.696879{,}00 \times 0.08 = 5.095750{,}32$ (HRK)

Therefore, the basic value of order N62 was increased by the following amount:
$Z_{PIR} = Z_P + Z_I + Z_R = 17.835126{,}12 + 18.472094{,}91 + 5.095750{,}32 = 41.402971{,}35$ (HRK)

Total order value is:
$Z_U = Z_N + Z_{PIR} = 63.696879{,}00 + 41.402971{,}35 = 105.099850{,}35$ (HRK)

The above indicates that the total mean value of all orders increased by 60 %. Simulation of order value fluctuations through the correction of average time deviations in just two days gives the following results:
$\overline{Y}_P = 0.0043 \times 63 = 27$ %
$\overline{Y}_I = 0.0041 \times 69 = 28$ %
$\overline{Y}_R = 0.0048 \times 15 = 7$ %

Furthermore, when previous values are inserted into the known equations we obtain:

$Z_P = Z_N \times \overline{Y}_P = 63.696879{,}00 \times 0.27 = 17.198157{,}33$ (HRK)
$Z_I = Z_N \times \overline{Y}_I = 63.696879{,}00 \times 0.28 = 17.835126{,}12$ (HRK)
$Z_R = Z_N \times \overline{Y}_R = 63.696879{,}00 \times 0.07 = 4.458781{,}53$ (HRK)

Therefore, the total mean order value increased by the following amount due to mean time deviation corrections:

$Z_{PIR} = Z_P + Z_I + Z_R = 17.198157{,}33 + 17.835126{,}12 + 4.458781{,}5 = 39.492064{,}8$ (HRK)

If the adjustment of average time deviations causes the reduction of value of total orders, the results are as follows:

$Z_S = Z_N + Z_{PIR} = 63.696879{,}00 + 39.492064{,}98$
$= 103.188943{,}98$ (HRK)

The results indicate that significant cost reduction can be achieved and the total value of orders increased by correction of mean time deviations. Total savings for the eighty orders analyzed, with the time correction of two days, are:

ZU – ZS = 105.099850,35 – 103.188943,98 = 1.910906,37 (HRK)

The results obtained by statistical analysis of eighty orders of materials, accounting for 26.88 % of product value, must be analyzed in detail. Owing to such a high share in product value, this sample is relevant for the confirmation or negation of the paper's hypothesis. Table 1 presents variables necessary for purchase process analysis in a manufacturing system such as Brodotrogir. The analysis is based on the well known fact that delays in the delivery of materials create certain costs in the purchase chain, with respect to certified values. However, by defining three time deviations (receipt time XDP, withdrawal time XDI and complaint time XDR), we attempted to examine the efficiency of the purchasing process in a simple manner, by looking into the relationship with the supplier. Cost expressions of three time deviations and connecting them with certain characteristics of the buyer – supplier relationship, may give us a picture of the condition in which the purchasing processes of manufacturing systems such as shipbuilding take place. Figure 4 shows linear dependence of the percentage of total order costs on the number of receipt days. The correlation of positive direction and strong intensity is obvious. Linear dependence between the observed variables is analytically described by a single regression model so as to quantify the average percentage of effect of one-day delay in receipt time on total order cost. The estimated linear regression model with a constant can be expressed as:

$$\hat{y}_i = 26{,}1 + 0{,}2x_i \qquad (1)$$

Parameter and variable x show that one-day delay in receipt time can be expected to increase order costs by 0.2 %. The constant shows that a 26.1 % increase in order costs can be expected if there is no delay in receipt time (x = 0), i.e. some order costs must logically be expected even when there is no delay in receipt time, owing to potential delays in withdrawal or complaint time. Figure 4 shows that these orders lie exactly on the ordinate axis. Still, in order to neutralize the impact of withdrawal and complaint time, linear regression without a constant is estimated (regression line going through the origin).

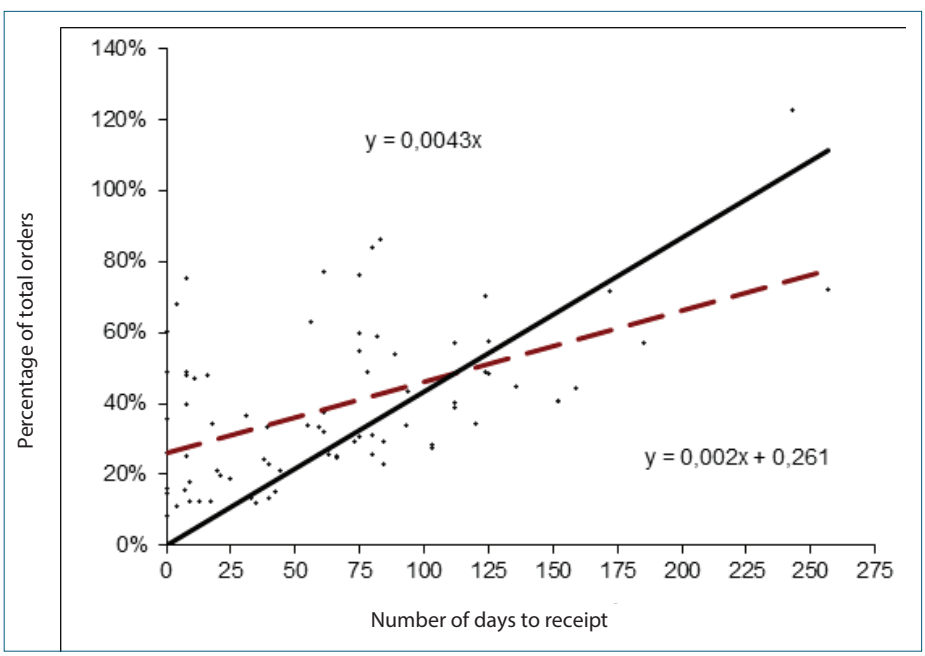

Figure 4.
Scatter plot between the percentage of total order costs and the number of days to receipt (Šundov, 2009).

The regression model without a constant was also estimated using SPSS (Statistical Package for Social Sciences) program support. This model was used to conduct additional tests and regression diagnostics in the defined model. The results of estimation of the defined model using SPSS are given in Table 2. In the first part of Table 2, regression model can be seen to explain 68.7 % of total deviations in the observed dependent variable (R-square – determination coefficient). The correlation coefficient of 0.829 (R) confirms positive dependence of strong intensity. The standard error of 25.094 shows that the mean deviation of observed values from the regression line is relatively medium-sized (64 %). The ANOVA (analysis of variance) table indicates high value of empirical F-ratio, implying that the statistical significance of the regression model at the theoretical level is 5 % and 1 %. In addition to the F-test (group test), a t-test (individual test) was also conducted, which shows that parameter B (unstandardized coefficient) is also statistically significant since the empirical level of significance is fairly close to zero. A small standard error of 0.033 is indicative of the high value of the test size of 13.169. Finally, parameter B and variable Dp show that a 0.434 % increase can be expected for each one-day delay in receipt time, taken together with the neutralized impact of other time deviations.

Table 2.
Regression model estimation and diagnostic tests for time deviations caused by receipt time (Šundov, 2009).

Model Summary

Model	R	R Square[a]	Adjusted R Square	Std. Error of the Estimate
1	,829[b]	,687	,683	25,094817

a. For regression throygh the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression.
This CANNOT be compared to R Square for models which include an intercept.
b. Predictors: Dp

ANOVA [c, d]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	109209,214	1	109209,214	173,417	,000[a]
	Residual	49750,238	79	629,750		
	Total	158959,452[b]	80			

a. Predictors: Dp
b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.
c. Dependent Variable: Post
d. Linear Regression through the Origin

Coefficients[a, b]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	Dp	,434	,033	,829	13,169	,000

a. Dependent Variable: Post
b. Linear Regression through the Origin

Figure 5 shows the linear dependence of the percentage of total order costs on the number of withdrawal time days. The correlation between positive direction and strong intensity is obvious. Linear dependence between the observed variables is analytically described using a single regression model so as to quantify the average percentage of contribution of one-day delay in receipt time to total order costs. The estimated linear regression model with a constant is as follows:

$$\hat{y}_i = 26{,}07 + 0{,}18x_i \quad (2)$$

Parameter and variable x show that one-day delay in withdrawal time can be expected to increase order costs by 0,18 %. The constant shows that a 26.07 % increase in order costs can be expected if there is no delay in withdrawal time (x = 0), i.e. some order costs must be expected even when there is no delay in withdrawal time, owing to potential delays in receipt or complaint time. Figure 5 shows that these orders lie exactly on the ordinate axis.

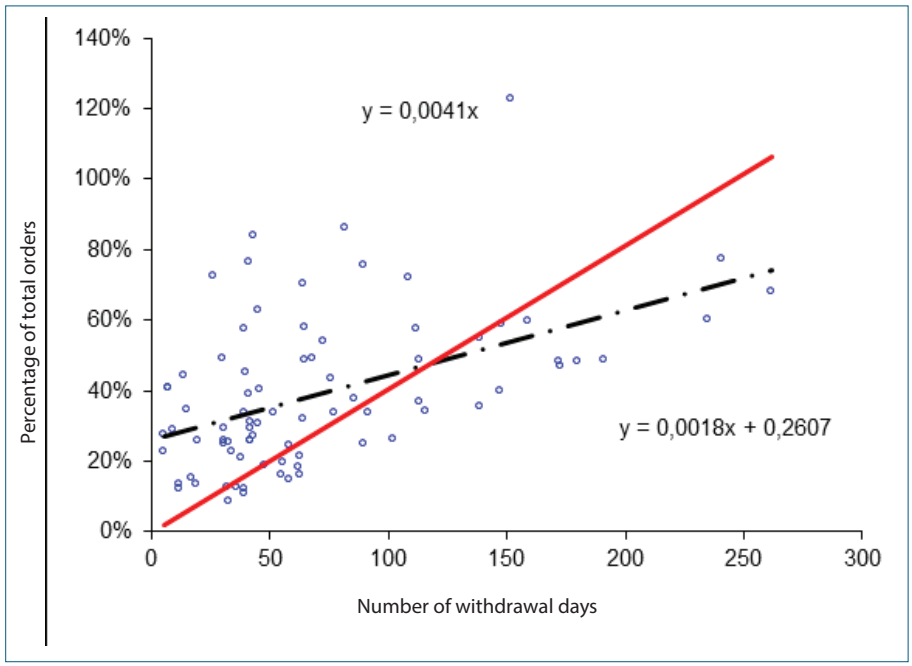

Figure 5.
Scatter plot between the percentage of total order costs and the number of days to withdrawal (Šundov, 2009).

Still, in order to neutralize the impact of receipt and complaint time, linear regression without a constant is estimated (regression line going through the origin). The regression model without a constant was also estimated using SPSS (Statistical Package for Social Sciences) program support. The results of estimation of the defined model using SPSS are given in Table 3. In the first part of Table 2, regression model can be seen to explain 69 % of total deviations in the observed dependent variable (R-square – determination coefficient). The correlation coefficient of 0.831 (R) confirms positive dependence of strong intensity. The standard error of 24.967 shows that the mean deviation of observed values from the regression line is relatively medium-sized (63 %). The ANOVA (analysis of variance) table indicates high value of empirical F-ratio, implying that the statistical significance of the regression model at the theoretical level is 5 % and 1 %. In addition to the F-test (group test), a t-test (individual test) was also conducted, which shows that parameter B (unstandardized coefficient) is also statistically significant since the empirical level of significance is fairly close to zero. A small standard error of 0.031 is indicative of the high value of the test size of 13.266. Finally, parameter B and variable Di show that a 0.407 % increase can be expected for each one-day delay in receipt time, taken together with the neutralized impact of other time deviations.

Table 3.
Regression model estimation and diagnostic tests for time deviations caused by withdrawal time (Šundov, 2009).

Model Summary

Model	R	R Square[a]	Adjusted R Square	Std. Error of the Estimate
1	,831[b]	,690	,686	24,967894

a. For regression throygh the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression.
This CANNOT be compared to R Square for models which include an intercept.
b. Predictors: Dp

ANOVA [c, d]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	109711,190	1	109711,190	175,990	,000[a]
	Residual	49248,242	79	623,396		
	Total	158959,452[b]	80			

a. Predictors: Dp
b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.
c. Dependent Variable: Post
d. Linear Regression through the Origin

Coefficients[a, b]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	Di	,407	,031	,831	13,266	,000

a. Dependent Variable: Post
b. Linear Regression through the Origin

Figure 6 shows the linear dependence of the percentage of total order costs on the number of complaint time days. The correlation between positive direction and strong intensity is obvious. Linear dependence between the observed variables is analytically described using a single regression model so as to quantify the average percentage of contribution of one-day delay in complaint time to total order costs. The estimated linear regression model with a constant is as follows:

$$\hat{y}_i = 34{,}79+0{,}25x_i \quad (3)$$

Parameter and variable x show that one-day delay in complaint time can be expected to increase order costs by 0,25 %. The constant shows that a 34.79 % increase in order costs can be expected if there is no delay in complaint time (x = 0), i.e. some order costs must logically be expected even when there is no delay in complaint time, owing to potential delays in withdrawal or receipt time. Figure 6 shows that these orders lie exactly on the ordinate axis.

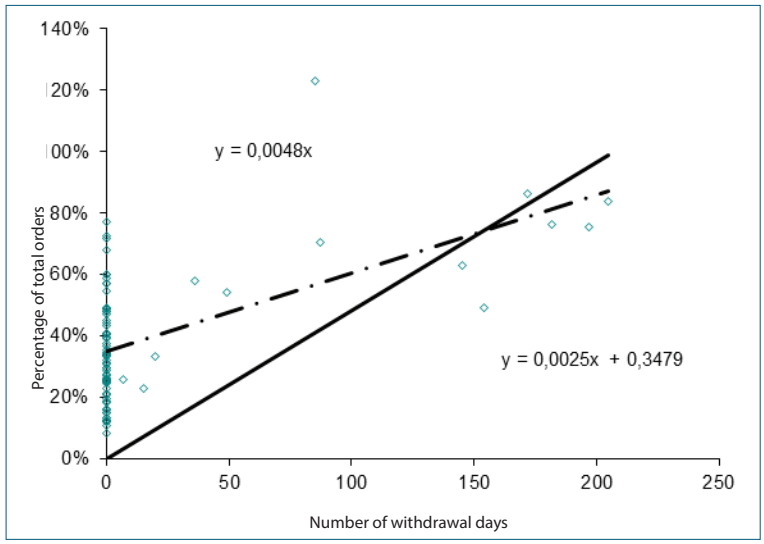

Figure 6.
Scatter plot between the percentage of total order costs and the number of complaint time days (Šundov, 2009).

Table 4.
Regression model estimation and diagnostic tests for time deviations caused by the complaint time (Šundov, 2009).

Model Summary

Model	R	R Square[a]	Adjusted R Square	Std. Error of the Estimate
1	,550[b]	,303	,294	37,457086

a. For regression throygh the origin (the no-intercept model), R Square measures the proportion of the variability in the dependent variable about the origin explained by regression.
This CANNOT be compared to R Square for models which include an intercept.
b. Predictors: Dp

ANOVA [c, d]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	48119,821	1	48119,821	34,297	,000[a]
	Residual	110839,631	79	1403,033		
	Total	158959,452[b]	80			

a. Predictors: Dp
b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.
c. Dependent Variable: Post
d. Linear Regression through the Origin

Coefficients[a, b]

		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	Dr	,482	,082	,550	5,856	,000

a. Dependent Variable: Post
b. Linear Regression through the Origin

Still, in order to neutralize the impact of receipt and withdrawal time, linear regression without a constant is estimated (regression line going through the origin). The regression model without a constant was also estimated using SPSS (Statistical Package for Social Sciences) program support.

In the first part of Table 4, regression model can be seen to explain 30. 3 % of total deviations in the observed dependent variable (R-square – determination coefficient). The correlation coefficient of 0.55 (R) confirms positive dependence of strong intensity. The standard error of 37.457 shows that the mean deviation of observed values from the regression line is relatively medium-sized (71 %). The ANOVA (analysis of variance) table indicates high value of empirical F-ratio, implying that the statistical significance of the regression model at the theoretical level is 5 % and 1 %. In addition to the F-test (group test), a t-test (individual test) was also conducted, which shows that parameter B (unstandardized coefficient) is also statistically significant since the empirical level of significance is fairly close to zero. A small standard error of 0.082 is indicative of the high value of the test size of 5.856. Finally, parameter B and variable Dr show that a 0.482 % increase can be expected for each one-day delay in receipt time, taken together with the neutralized impact of other time deviations.

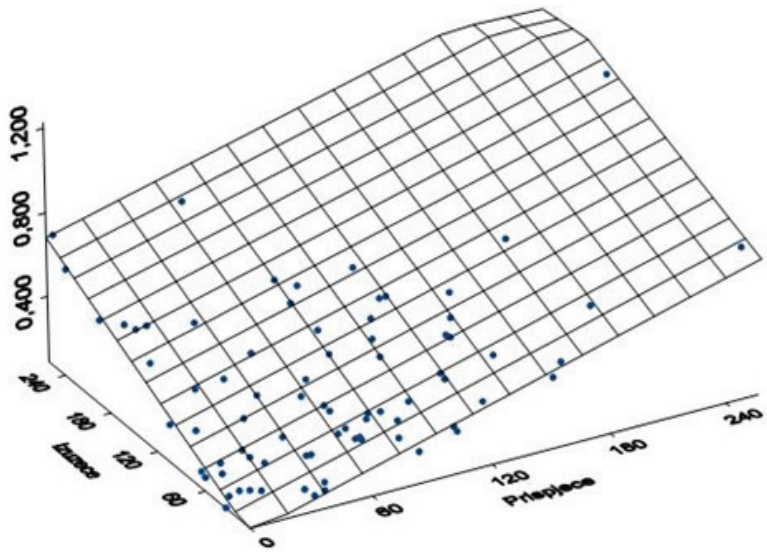

Figure 7.
Three-dimensional representation of order costs depending on receipt and withdrawal time deviations (Šundov, 2009).

The three-dimensional representation (Figure 7) illustrates that order costs are expected to increase when the number of days of order delay increase on account of receipt time simultaneously with the confirmation of withdrawal by the bias of the hyperplane estimated on the basis of original data.

4. CONCLUSION

Simulation is a useful tool in the shipbuilding industry whereby modern management seeks to improve the quality of decision-making. The simulation of eighty statistically processed orders of Brodotrogir worth almost HRK 64 million or 26.88 % of total product value, indicates that deviations have great influence (arrivals, withdrawals and complaints). The influence of three mean time deviations is as follows: receipt time of 65 days and 28 %, withdrawal time of 71 days and 29 % and complaint time of 17 days and 8 %, the total value was increased by 60 %. A decrease in time deviations by two days would instantaneously result in savings. The strong impact of receipt and withdrawal time deviations is also evident, whereas the impact of complaint time deviation is significantly smaller. Therefore, activities aimed at improving the factors that have an impact on these two deviations should be strengthened. In the example presented, considerable deviations in arrival (XDP), withdrawal (XDI) and complaint (XDR) times were observed, which significantly affect the profitability and efficiency of the manufacturing process in the shipbuilding industry. Although the reasons for these deviations are different, subjective and objective, there is sufficient room for purchase chain improvement activities. Nevertheless, any competitive organization in the shipbuilding industry must make active supply chain management a priority. One of the activities that transform the purchasing process from

traditional into strategic is supplier-oriented backward vertical integration. In this way, better cooperation with the supplier has a direct impact on the cost of material inputs, ultimately making the product cheaper. For an immediate buyer – manufacturer knowledge of the value supply chain and its active improvement are the bases for quality positioning on the market. In addition, if the end customer's value chain is known, all the prerequisites for so called category management have been met. By joining these two value chains, immediate manufacturers can ensure timely performance in their production process which will ultimately allow them to remain competitive in the increasingly complex global market such as shipbuilding.

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Port of Rijeka as Cruise Destination

Alen Jugović[a], Gorana Mudronja[a], Krista Elza Putnina[b]

Cruise industry in Europe significantly contributes to the European tourism since many cruise ships visit various European destinations. Europe is the second most visited cruise destination, and the most significant part is the Mediterranean with its most popular ports – Dubrovnik and Venice. Even though the numbers of passengers in Dubrovnik and Venice decreased last year, they are still very attractive destinations for cruise tourists and have some advantages to which the port of Rijeka can look up. The aim of this paper is to analyse the importance of the port of Rijeka as cruise destination as well as to determine its condition and the necessary improvements. The results of the research show that the number of passengers in the port of Rijeka has been increasing over the past few years, which indicates that Rijeka is developing as a cruising destination. To determine the cruise passengers' satisfaction with Rijeka as cruise destination, a survey was conducted among the passengers on cruise ships that visited Rijeka in 2018. The results of the survey show that the passengers were mostly satisfied with Rijeka as cruise destination although there are some aspects that need to be improved such as the offer of souvenirs and shopping in general. Cruise tourists in Rijeka mostly spent money on clothes and accessories, food and beverages, and organised sightseeing. The port of Rijeka has the potential of becoming an attractive cruise destination, but in order to improve, it constantly has to try to satisfy the cruise tourists' demands.

KEY WORDS
~ Cruise tourism
~ Adriatic region
~ Port of Rijeka
~ Cruise passengers

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doi: 10.7225/toms.v09.n01.005

1. INTRODUCTION

Cruise industry is becoming increasingly important in passenger transportation every year. Therefore, ever more tourists tend to choose cruising for their holidays. Europe is the second most popular cruise destination chosen by tourists from all over the world, and its offer is quite diverse. European sub-regions differ in terms of the main sights of ports of call, landscapes, average weather temperatures, and cruising seasons. The Mediterranean region is the most popular cruising region in Europe and the Adriatic Sea is the second biggest sub-region of the Mediterranean. The Adriatic has many cruise ports, most of them small ports serving as ports of call.

The port of Rijeka, mainly a cargo port and the third biggest city in Croatia, located in the northern part of the country, has started to develop as cruise port as well. Rijeka is visited by a few cruise ships each season; however, the number is slowly growing every year. Rijeka fulfils many conditions required for becoming a port of call or home port although it has to improve in the certain segments as well. This paper will compare the port of Rijeka with two biggest ports in the Adriatic region – Dubrovnik and Venice, to understand whether it has the potential of becoming an important cruise port. The survey on cruise tourist visiting Rijeka was conducted during 2018 to find out the information about the tourist preferences and consumption at the destination. The rest of the paper is organised as follows: Section 2 gives the literature review, Section 3 describes the cruise industry in Europe, Section 4 analyses the port of Rijeka and the conducted survey, and Section 5 gives the concluding remarks.

2. LITERATURE REVIEW

Researches dealing with the satisfaction of cruise tourists with the destination and their intention to return to the same destination are numerous. Various authors used different ports as samples and applied different approaches. Andriotis and Agiomirgianakis (2010) researched the motivation and satisfaction of cruise tourists in the port of Heraklion and their willingness to return to the same destination. Research findings have shown that the main motive for cruise tourists arriving at the port of Heraklion is the exploration of culture. Generally, in the Mediterranean destinations, tourists are primarily motivated to explore cultural sights opposed to the Carribbean, where they mostly like to enjoy the sunshine and the sea. The second part of their research was focused on tourists' satisfaction with the destination. The research results showed that tourists were mostly satisfied with the port of Heraklion, while the aspect of the tourists' stay in the port could be improved. Thus, the tourists expressed the desire for a longer stay at the destination in order to see the places of interest. The high level of tourist satisfaction with the destination has a positive effect on their desire to return. In their work, Qu and Ping (1999) researched the cruise tourists' motivation and satisfaction at the destination Hong Kong. The most common motivating factor for visiting this destination was "escape from normal life" followed by "social gathering" and "beautiful environment and scenery". Most cruise tourists were between 18 and 45 years old, which is considered very young cruise tourism population. Furthermore, most respondents were willing to participate in cruising again. Similar research was conducted by Brida, Garrido, and Devesa (2012). The authors researched the satisfaction of cruise tourists in the port of call Cartegna de Indias. The results show that tourists are mostly satisfied with the destination; however, there is room for improvement, primarily in the infrastructure and shopping experience. Most tourists would return to the same destination and recommend the destination to their friends. Teye and Leclerc (1998) researched the cruise tourists' satisfaction with services in the North American area. The results show the cruise tourists' satisfaction with the services provided. Furthermore, the results enable viewing the satisfaction in different segments of the cruise services and help to explain the growth phenomenon that occurred in the cruise market. Cruise tourists were satisfied most with cabin service, while the shore tours received the lowest rating. Ozturk and Gogtas (2016) researched how different attributes of a destination affect tourists' satisfaction with the destination and their willingness to return or recommend the destination to their acquaintances. The destination explored was Honolulu, Island of Oahu, Hawaii. The research findings confirm that there is a relationship of tourist satisfaction with the intention to return to the location or to recommend the destination to acquaintances. The most important attributes that meet the needs of tourists were the high level of services at the port, safe and smooth means of navigating the island, shopping, and a wide range of food and restaurants. The results also showed that the prices of the goods and services contribute to the satisfaction of tourists.

Sanz Blas and Carvajal-Trujillo (2014) researched how a port-of-call's image influences the cruise tourists' satisfaction with the destination and what impact it has on cruise tourists' loyalty. The sample used were cruise tourists in the port of Valencia. The results show that the image has a positive effect on destination satisfaction, which again has a positive effect on behavioural intentions as well. It was researched whether the tourists who have a positive image of a destination return to the destination or recommend it to others. The authors also provided insights to destination managers to improve their destination offer. Chang, Liu, and Roh's (2016) research path went toward developing a measurement scale for evaluating cruise travellers' expectations and for examining cruise tourists' satisfaction before and after visiting Incheon. The tourists were mostly satisfied with the culture and exploration of the destination. Furthermore, they were less likely to revisit the destination Incheon, but were willing to recommend the destination to acquaintances. In their work Testa, Skaruppa, and Pietrzak (1998) researched the relationship between employee satisfaction and customer satisfaction. The findings show that there is a relationship between the two parties, and that travel agencies could benefit from improving employee satisfaction with the company they work for, with their supervisor, and with the work environment. The relationship between tourists and the local community on one hand, and tourists and service personnel on the other was investigated in many papers. However, the authors Huang and Hsu (2010) find that the relationship between the tourists themselves has not been sufficiently investigated and are trying to provide new insights into the topic. They investigated the extent to which the quality and quantity of interactions among tourists had an impact on their cruise experience. The results show that customer relationship quality is a more important factor than quantity. It also points to the strong impact of customer-to-customer interaction on customer experience in cruising tourism overall and is thought to be one of the marketing strategies for the business. The authors believe that the interaction among tourists does not have to be accidental, but can be partially controlled by businesses that can encourage communication among tourists and, thus, create a better service. Various researches provide a quality insight into the topic and can give good guidelines for further research.

3. CRUISE INDUSTRY IN EUROPE

The cruise industry significantly contributes to the European economy. According to the figures released by Cruise Lines International Association, the cruise industry in 2017

contributed to the European economy with 46.86 billion EUR. This represents an increase of 16.9% in comparison with the previous number released in 2015. Europe is the world's second most popular cruise destination, just after the Caribbean, and 6.5 million passengers embarked on cruises from European ports in 2017, which is by 6.1% more than in 2015 (Clia Cruise Lines, 2018). The Mediterranean accounted for more than a half of Europe's deployment capacity market share in 2017 (The Florida-Caribbean Cruise Association, 2018). The Mediterranean region, in general, can be divided into four sub-regions (Žlak et al., 2016):

- The western Mediterranean
- The eastern Mediterranean
- The Adriatic Sea
- The Black Sea

The Adriatic is the second biggest Mediterranean region in terms of cruise activity, hosting 17.2% of the total passenger movements and 21.4% of the total cruise calls in the Mediterranean and its adjoining seas (MedCruise, 2017).

3.1. The Adriatic Cruise Region

The Adriatic Sea is located in the northernmost part of the Mediterranean Sea and is surrounded by Italy, Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, and Albania. It is the second biggest cruise region in the Mediterranean, hosting 2,596 cruise calls in the year 2017, as can be seen from the following Table 1.

Table 1.
The total cruise traffic in the Mediterranean region in 2017.
Source: Cruise activities in MedCruise Ports (MedCruise, 2017)

Region	Total Cruise Pax.	Total Cruise Calls	Home In/Out Pax.	Transit Pax.
Western Mediterranean	19,721,802	8,383	5,468,259	14,253,515
Adriatic	4,447,033	2,596	1,564,711	2,882,322
Eastern Mediterranean	1,740,289	1,141	480,901	1,259,388
Black Sea	6,449	19	460	5,989

The most important ports of the Adriatic region are located in Italy and Croatia, which are followed by Greece, Montenegro and Slovenia (Risposte Turismo, 2017). The areas have both large ports with special facilities for cruises, and small ports without the facilities. However, most of the ports are small ports, mainly for yachts and very small vessels, with no special berths for cruise ships or passenger terminals. The exceptions are Venice, Koper, Rijeka, Zadar and Dubrovnik, which have berths dedicated to cruisers and passenger/cruise terminals. The size and number of ports are determined primarily by the shape of the coastline and the depth of water (Gdynia Maritime University). However, recently many of the smaller ports have become very attractive and their presence in the itineraries calling at the Adriatic ports is increasing on yearly basis which can be a motive for improvement of the ports and tourist sites as well (Risposte Turismo, 2017). The following picture shows passenger ports located in the Adriatic which have the potential to become (or have already become) a significant cruise port.

Cruise ports should examine whether they should be orientated towards serving as a port of call or home port in the cruise market. A home port is the place where the embarkation

Figure 1.
Adriatic cruise ports, Source: Adriatic Sea Tourism Report (Risposte Turismo, 2017).

and/or disembarkation takes place at the start and/or end of the cruise. It is also called a base port, head port or main port. Furthermore, a port of call (also called a secondary or destination port) is the place where passengers disembark and then re-embark to continue with the cruise (Vojvodić, 2003). There are also hybrid ports, which are considered homeports and ports of call at the same time. These ports usually have perfect conditions for embarking and disembarking including great hinterland connections by road, rail, and particularly by air (Žlak et al., 2016). A cruise port is generally interested in becoming a home port for one or more cruise companies. This is due to the high economic impact of this development on the port and the port-related city. In fact, cruise passengers are estimated to spend six to seven times more money in home ports that at ports of call (Zanne and Beškovnik, 2018).

Even though many Adriatic ports are attractive for many cruise passengers, a relatively small number of ports fulfil all the conditions needed for a home port, such as: location, conception, services. Starting ports location in a cruising system is one of the most important factors of service quality. The port should be near an international airport, as the majority of tourists who reach the starting port use charter flights, an interesting town that can offer some attractive places to visit, and a city centre where tourists can have at their disposal the sightseeing of the town while waiting for cruise to begin (Mrnjavac and Črnjar, 2004).

The concept of passenger terminal has to follow the principle of different kind of traffic: dislocation, passenger traffic arriving and leaving the port, bus traffic, car traffic, taxi car traffic etc. The quality of services largely depends on the organisation of customs and other formalities to be based on the same principle as that of airports. Tourists arriving by airplane from very distant places expect their holidays to start at the moment of their arrival at the port. Therefore, starting ports have to offer accommodation services, catering services, shops and entertainment services. As all these facilities favour commerce, ports should have a strong interest to have them well organized in their area because they contribute to the port's enterprises profits.

Ports of call are not required to fulfil so many requests. The most important is to provide adequate berths and other technical elements, parking area for buses and taxis, and road connections. The role of a port of call can only be taken by a port with tourist attractions – cultural and historical monuments, places of natural beauty, entertainment services, etc. in the town or nearby, which are worth calling at the port. As the cruise ship size is constantly growing and many ports have difficulties to follow their dimensions, cruise ships often anchor in the port basin and tourists are taken on shore by smaller ships (Mrnjavac and Črnjar, 2004). The mentioned elements, particularly regarding home port, are not present in many ports in the Adriatic Sea region. Many of the Adriatic ports do not have suitable handling facilities for a large number of cruise passengers (Vojvodić, 2003).

3.2. The Adriatic Major Cruise Ports

According to MedCruise statistics, the port of Dubrovnik is the major port of the Adriatic region in terms of total cruise calls in 2017; however, the port of Venice, Italy, has the highest number of cruise passenger movements in the region (MedCruise, 2017). This means that, although Dubrovnik is visited by more cruise ships, they tend to be smaller and with a lower number of passengers than those who stop at the port of Venice. The other reason could be the restriction that the port of Dubrovnik imposed, concerning the number of tourists that can visit the city, because of its concern about the sustainable development. The following table shows the total number of passengers and cruise calls in the major ports of the Adriatic region.

The third biggest Adriatic cruise port in terms of the total number of passengers is the port of Corfu, Greece, but in terms

Table 2.
Major ports in the Adriatic region by number of passengers and cruise calls.
Source: Cruise activities in MedCruise Ports (MedCruise, 2017)

Rank	Port	2016	2017	Change 2017/2016
		Cruise Passenger Movements		
1	Venice	1,605,660	1,427,812	-11.08%
2	Dubrovnik	831,730	748,918	-9.96%
3	Corfu	748,914	679,681	-9.24%
		Cruise Calls		
1	Dubrovnik	639	539	-15.65%
2	Venice	529	466	-11.91%
3	Kotor	487	430	-11.70%

of the total cruise calls, the port of Kotor, Montenegro, ranks third. Venice had a total of 1,427,812 passengers in 2017, while Dubrovnik had 748,918 passengers. These numbers show that Venice can be considered as home port, while Dubrovnik should be considered as a port of call. Even though Venice and Dubrovnik are different kinds of ports, they both serve a huge number of passengers in the Adriatic region and are the the two biggest cruise ports in the region. Both these cities are world-renowned destinations, UNESCO world heritage sites and, thus, major tourist attractions (Žlak et al., 2016). Both cruise passenger movements and cruise calls have decreased in 2017 in comparison with 2016 (Table 2), which can be an indicator of growing attractiveness of different other ports in other regions.

The port of Venice is the leading home port in the Adriatic and benefits as a popular cruise start and ending point because of availability of an international airport, air connections and reliability of air transport (Venice Port Authority). It has two international airports in the vicinity and two more airports at less than an hour drive (Žlak et al., 2016). Venice is well connected also by rail transport with other important international airports. For example, Venice is 2.5-hour train ride from Milan, and 3.5-hour train ride from Rome (Interrail). This easily accessible location combined with world-renowned tourist attractions are the most important aspects for qualifying as a home port. However, Venice is a highly visited city in general; the city now receives around 30 million tourists per year, disgorged into the narrow streets and small squares. Therefore, it is mostly overcrowded, especially in the summer months, but not only because of cruise passengers (Zanne and Beškovnik, 2018).

The port of Dubrovnik is the second most visited port in the Adriatic region, and its status could develop from a port of call to a hybrid port in the future. It offers a great historical tourist destination as well as the opportunity for embarking and disembarking passengers. Dubrovnik is considered one of the most prominent tourist destinations in the Mediterranean, mostly because of its sublime location and as one of the world's most magnificent walled cities. The main attractions are the charming pedestrian-only old town with aristocratic palazzi and Baroque churches, contained within medieval fortifications and the rocky coast of the Adriatic Sea.

Compared with Venice, Dubrovnik has only one international airport 23 kilometres away from the city. The nearest international airports are Tivat, which is at a 2-hour drive, and Split, which is at a 3-hour drive from Dubrovnik. Compared to the airports in the vicinity of Venice, the airports near Dubrovnik are very small, operating only few flights a day. Regarding inland transportation, there are no trains connecting Dubrovnik with the hinterland; therefore, the only option is a bus or driving by car. These aspects combined make the port of Dubrovnik to qualify as a port of call.

4. PORT OF RIJEKA

Rijeka is the third biggest city in Croatia and has always been a transit centre for tourists. Its location is near the peninsula of Istria, town of Opatija, islands of Krk, Cres and Lošinj, towns of Crikvenica and Novi Vinodolski, which all serve as important tourist centres. The port of Rijeka is the largest port in Croatia, with a cargo throughput of 13,404,784 tonnes, mostly oil, general and bulk cargo, and 260,375 TEUs in 2018 (Port of Rijeka Authority, 2018). The port of Rijeka also has passenger and high-speed lines to the nearby islands. Even though Rijeka is mainly a cargo port,

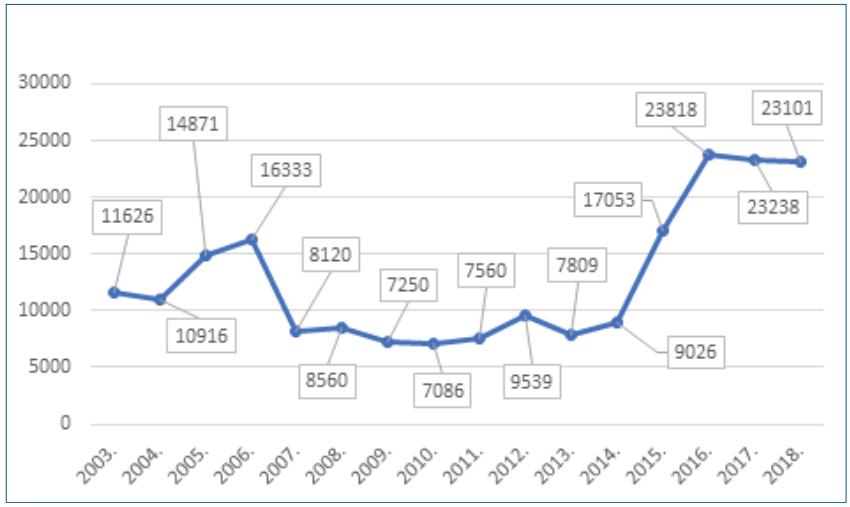

Figure 2.
Number of passengers in the port of Rijeka, Source: Traffic statistics (Port of Rijeka Authority, 2018).

it is starting to develop as a port of call for cruise ships. Rijeka served as a port of call for 15 cruise vessels in 2017 for the 12,656 cruise passengers visiting Rijeka as part of their cruise itinerary (MedCruise, 2017). The following figure shows the total number of passengers in the port of Rijeka on cruisers and sailboats.

The total number of passengers during the observed years was increasing, which shows that Rijeka has been improving as a passenger destination. If Rijeka wants to improve its status and become a home port or a popular cruise port of call, it has to fulfil certain conditions. These conditions include:

- International transport connectivity
- Disposal with adequate berths and technical elements
- Easy public transportation access from the port to the city and main places of interest
- Tourist attractions, such as cultural or historical monuments, natural beauty or other type of entertainment.

Port of Rijeka Authority has plans for further port infrastructure development in terms of cruise shipping; however, it is also necessary to analyse if the city of Rijeka fulfils the requirements for a popular tourist destination. Rijeka has its own international airport, located approximately 30 kilometres from the city. There are other international airports near Rijeka, such as Zagreb at less than a 2-hour drive, Zadar at a 3-hour drive, and the small airport of Pula at just a 1.5-hour drive from Rijeka. These airports are more of charter airports than main transport hubs, and that is the reason why flights landing at Rijeka airport tend to be much higher in prices than those departing and arriving to and from Italy. If compared with Venice, this aspect makes Rijeka less desirable as an embarking and disembarking port.

Although the port is right next to the city centre with pedestrian-only promenade, historical buildings and churches, waterfront with many cafés and a medieval fortress on top of the city, Rijeka is a more industrial city than a tourist destination. On the other hand, Rijeka is well located for day-trips to many popular attractions in Croatia, such as the Plitvice Lakes, Opatija Riviera, the world's smallest town of Hum, beautiful Mediterranean coastal cities of Rovinj and Pula, and the neighbouring island of Krk.

Croatian cruising tourism is an increasingly important component of the economy; however, a large amount of work is still required on its development and attracting new and the current guests (Jugović et al., 2017). In order to analyse and gather information about the cruise tourists' satisfaction and their money spent at the destination Rijeka, the Faculty of Maritime Studies of the University of Rijeka conducted a survey concerning the consumption and activities of passengers on cruise ships that visited Rijeka during 2018. The survey consisted of questions about the general characteristics of passengers (age, nationality, familiarity with destination), about satisfaction at the destination with different categories, and about time and money spent in Rijeka. The survey included 226 respondents, and its main purpose was to obtain the information about passengers' satisfaction and their consumption in Rijeka. Moreover, the purpose was also to determine the strengths and weaknesses of Rijeka as a tourist destination. Many authors (Teye and Leclerc, 1998; Qu and Ping, 1999; Andriotis and Agiomirgianakis, 2010; Brida et al., 2012; Sanz Blas and Carvajal-Trujillo, 2014; Chang et al., 2016; Ozturk and Gogtas, 2016) researched the topic of

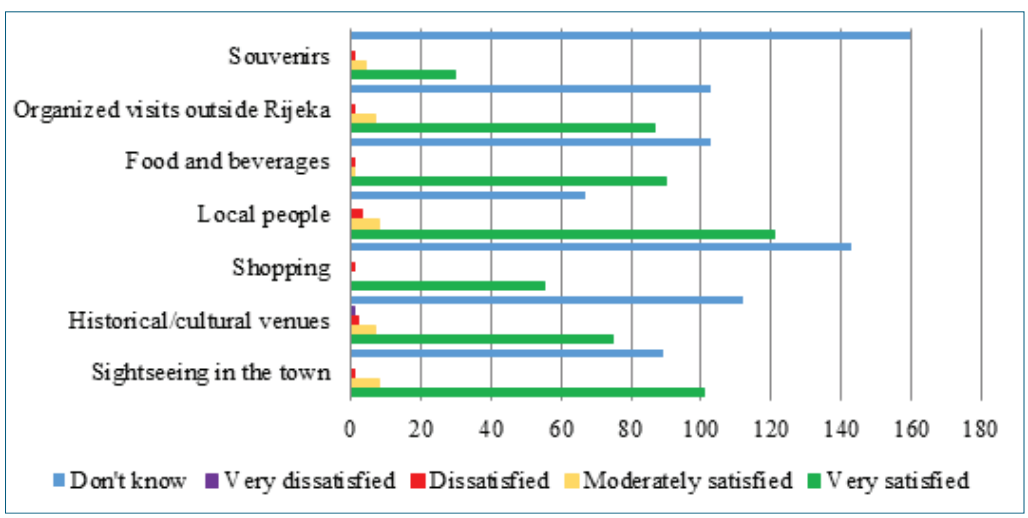

Figure 3.
Satisfaction with destinations across categories, Source: Processed by the authors, based on the survey conducted by the Faculty of Maritime Studies, University of Rijeka.

cruise passengers' satisfaction with various destinations, while this study also introduces information about the money spent at the destination, which provides a new insight for the destination managers and third parties indirectly involved in cruise tourism (restaurants, souvenir shops etc.).

The profile of cruise passengers who volunteered to participate in the study is as follows: the majority of respondents were in the age group of 60+ years (30%), 20% of respondents in the age group of 41-50 years, 18% in the age group of 51-60 years, 17% in the age group of 31-40 years, and 16% in the age group of 18-30 years. Regarding their nationalities, a majority of the passengers were from the USA (31%), England (14%), Germany (9%), Canada and Australia (each 7%). When asked about their first visit to Rijeka, 92% of passengers responded that was their first visit to Rijeka, while 8% had already visited the destination in past. The survey included the question about the time spent at the destination Rijeka, and a majority of respondents (61%) spent 1-6 hours at the destination, while only 3% of the respondents spent 7-9 hours at the destination. The negative feedback was that 36% respondents spent zero hours at the destination, which provides guidelines to the destination managers to work on attracting more passengers to disembark. From the passengers who went sightseeing, 46% participated in organized excursions while the rest were exploring the city of Rijeka on their own. The following figure shows the passengers' satisfaction with the destination across different categories.

The overall satisfaction of the tourists was quite high and the results may be considered satisfactory, especially when it comes to the satisfaction with local people, sightseeing in the town, and food and beverages. However, the results indicate that Rijeka should improve its offer of souvenirs and shopping in general. The same kind of study was conducted in the port of Rovinj in 2014 by the Faculty of Maritime Studies, University of Rijeka, and the results were quite similar. The overall satisfaction was high; however, the lowest satisfaction was with shopping and souvenirs (Jugović et al., 2018). Therefore, there is room for development in certain segments and these results should help the port of Rijeka as a destination in the efforts to meet the tourists' needs and expectations. As mentioned above, this study also included questions about the amount of money spent by passengers in Rijeka, and the results are presented in the following figure.

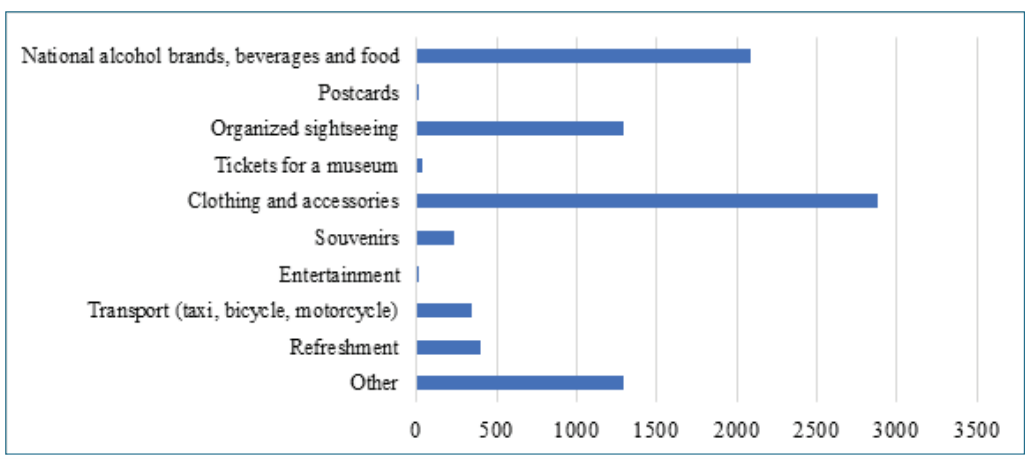

Figure 4.
Cruise tourists' spending by category (in EUR), Source: Processed by authors, based on the survey conducted by the Faculty of Maritime Studies, University of Rijeka.

Cruise tourists were asked to identify how much they spent on different products and services in Rijeka. As it can be seen from the previous figure, the largest amount was spent on clothing and accessories (2,884 EUR), followed by the national alcohol brand beverages and food (2,091 EUR), while organized sightseeing placed third with 1,295 EUR. The smallest amount of money was spent on museum tickets (37 EUR), postcards (14 EUR) and entertainment (10 EUR). The results concerning the money spent per category can give new insights about the tourists' interest and the city of Rijeka's offer. Furthermore, the average spending of cruise tourists in Rijeka amounts to 42.20 EUR per person. The following figure shows the average consumption of cruise tourists by different nationalities.

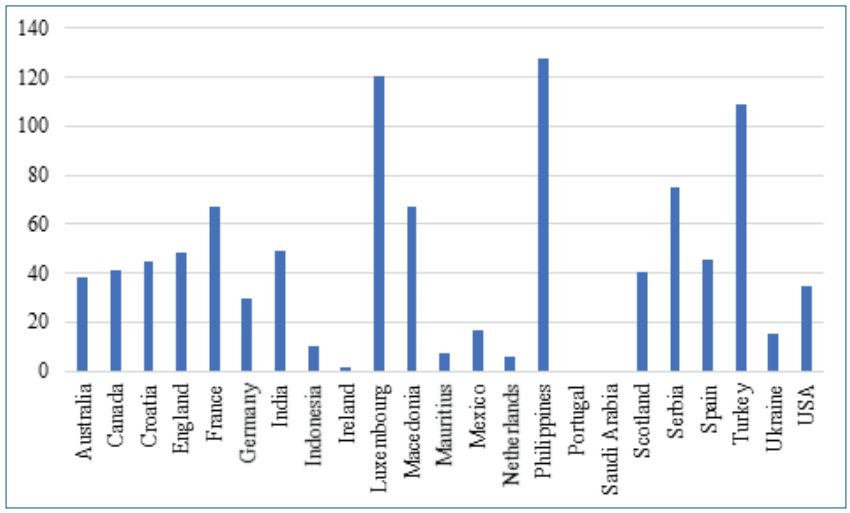

Figure 5.
Average consumption by nationality (in EUR), Source: Processed by authors, based on the survey conducted by the Faculty of Maritime Studies, University of Rijeka.

The highest spending comes from the Filipino nationality (120 EUR), followed by Luxembourg (120 EUR). Since the majority of passengers came from the USA, England, and Germany, they were observed in detail. The passengers from the USA spent on average 34.92 EUR, passengers from England 48.46 EUR, and passengers from Germany 29.41 EUR. The tourists' spending can have effects on the total GDP of Croatia. Although the consumption in Rijeka is still relatively small, there is room for expansion in the future. Multiplicative effects from cruising industry can occur as well, primarily the direct effects on employment and creation of new value as well as indirect effects on employment and creation of new value of the third parties involved such as restaurants, shops etc. The results of this survey provide new insights into the cruise passengers' preferences and satisfaction with the different segments of the destination Rijeka as well as their willingness to spend money, which can help in further decision-making concerning the creation of tourist offer.

5. CONCLUSION

The Adriatic region has a varied offer, and it is an attractive destination for cruise tourists; however, its cruise tourism is still heavily dependent on Venice and Dubrovnik. Both these ports struggle with city congestion, but this does not prevent cruise passengers from visiting these destinations. Venice and Dubrovnik fulfil all the important factors for being home ports or ports of call, and are becoming increasingly popular as cruise destinations each year. Although there are many cruise ports in the Adriatic region, there is none that could compare with Venice and Dubrovnik at the moment.

The port of Rijeka serves mainly as cargo port; however, recently it has started to make its place in the cruising industry. The number of cruise vessels mooring at Rijeka as in-cruise port of call is growing every year. The city of Rijeka fulfils many of the conditions for becoming a cruise port of call; therefore, this research aimed to answer the question to what extent cruise tourists were satisfied with the destination. The research results show that cruise tourists are mainly satisfied with the location and its offer, although there are aspects to be improved such as the offer of souvenirs and shopping in general. Furthermore, cruise tourists mostly spend money on clothing and accessories, food and beverages, and organised sightseeing. The research findings can give valuable insights to the destination managers and third parties in designing their offer. The port of Rijeka has the potential of becoming more attractive to cruise tourists, but it constantly has to try to adapt to the new trends and tourist demands.

However, this study has several limitations. The sample size is sufficient for making general conclusions and giving guidelines, but the representation of findings is limited, and they should be observed as tentative until future studies and results confirm them. The period observed in this study is only one year, which represents a research gap that needs further attention. Therefore, the guidelines for further research can apply to surveys in the future years, gathering more data to make conclusions more accurate.

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Market Analysis and Affirmation Factors of the Northern Sea Route

Tanja Poletan Jugović[a], Dražen Žgaljić[a], Katarina Balić[b]

Maritime transport routes, or corridors, imply specific courses of movement for people and goods (freight) on maritime routes and bring multiple benefits to the area through which they pass. The action and influence frame of a single route in the international transport flow is defined by an increasingly pronounced international competition at the regional and/or global transport market. Considering that the competitiveness of a transport route represents the fundamental factor of its valorization in the transport services market, the question of what defines and conditions the competitiveness mentioned above should be considered. This paper analyzes the competitiveness of the Northern Sea Route as a shorter maritime route between Asia and Europe. Under the new climate conditions in which, over the past few years in September, the Northern Sea Route course is completely ice-free, the indicated route represents a sort of competition to the alternative route through the Suez Canal. Taking into account that the competitiveness of a transport route is conditioned by market determination as well as by the quantity of freight flow through the transport route, the main research aim of this paper is to analyze the current and potential transport supply and demand as well as the Northern Sea Route's competitive environment in order to assess, in this regard its valorization and affirmation possibilities.

KEY WORDS
~ Northern Sea Route
~ Transport supply
~ Demand
~ Competitive environment

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doi: 10.7225/toms.v09n01.006

1. INTRODUCTION

Maritime transport is the main transport mode in the structure of world cargo transport and initiator of commercial exchange in the world. It takes place in maritime transport routes, which connect large industrial, transport, and commercial hubs and their ports in which maritime freight flows are formed. Nowadays, the intensity and quantity of maritime freight flows have become a benchmark for transport effectiveness and usefulness, for inclusion in the international labor division as well as a standard for the level of economic development of a country. Accordingly, along with the existing transport routes, new transport courses affirm themselves in this competitive transport market and with their geo-traffic position they compete with the existing transport routes. As a result, this paper analyses the potential and the affirmation opportunities of the Northern Sea Route.

Under the influence of climate change the amount of sea ice in the Arctic has drastically decreased, thus opening opportunities for international maritime navigation in this area, primarily through the Northern Sea Route as the shorter maritime route between Asia and Europe in comparison to alternative routes through the Suez Canal. The fact that in the past few years in September the Northern Sea Route has been completely ice-free and that this condition allows seasonal navigation for commercial ships opens the potential and opportunity for affirmation of the indicated route as well as the opportunity for affirmation of new commercial shipping lines through the route.

In addition to the new global climate changes which already exist in the Arctic area, the valorization of the Northern Sea Route in the transport services market is conditioned on multiple geo-transport, political, ecological, and socio-economic determinants, which require an in-depth analysis and discussion.

While respecting all the influence of the above mentioned factors, this paper will focus on the market definition analysis of the Northern Sea Route, which is primarily conditioned by three market components: supply-demand and environment. In fact, based on the current estimates, navigation through the Northern Sea Route would largely facilitate international commerce. Among other things, limitations in fuel quantity which are entering into force in the entire world will lead to "transport giants" trying to reduce costs and use shorter and more efficient maritime routes. In line with this, the Northern Sea Route could potentially represent a new alternative to the route through the Suez Canal.

With the aim to determine the above mentioned potentials and affirmation factors of the Northern Sea Route, this paper analyzes the transport supply, the transport demand and the competitive transport environment as well as the new transport routes and reference ports along the Northern Sea Route, which will largely shape the position of the indicated maritime route in a competitive maritime market.

2. NORTHERN SEA ROUTE TRANSPORT SUPPLY AND DEMAND

Generally speaking, the transport route offer may include different transport branches, traffic hubs, port terminals, land terminals as well as other elements and participants to the production of transport services on the transport route (Poletan Jugović T., 2014).

Transport supply is relevant on maritime routes in order for a maritime route to survive. This is reflected in the intensity, structure and quality of commercial shipping lines offered by ship owners as well as in the capacity of the infra- and superstructure and in the quality of services in ports as significant transshipment and logistic-distribution centers, within maritime routes.

In the Northern Sea Route area, ports are being constructed together with the accompanying facilities such as a rescue service, a maintenance center, an airport, and a railway. The above mentioned represents an investment for the future as it reduces risks and increases the attractiveness of commercial transport operators.

In their intention to diversify transport courses towards Europe even the great powers such as China and Japan seek to connect the Chinese project "One Belt, One Road" with the Northern Sea Route. Based on a new national program for the socio-economic development of the Arctic area, even the powerful Russia is interested and plans to invest in the infrastructure of the Northern Sea Route for about half a billion euros. According to certain forecasts, it is expected that by 2029 the freight transport through the Northern Sea Route will increase 11 times. Furthermore, it is expected that by 2035 Russia, with its largest icebreaker fleet in the world will allow eight more icebreakers to navigate through the Northern Sea Route (Express.hr, 2019).

According to the data on transit traffic through the Northern Sea Route, an increasing number of countries is showing a potential interest for affirmation and investments. The Danish Company Maersk, for instance, had already tested the possibility of using the Northern Sea Route course as an alternative route to the course from Asia to Europe through the Suez Canal.

Maritime transport via the Northern Sea Route is the only delivery route for natural resources originating in the remote Arctic regions where there are no pipelines, roadways, or railway infrastructure. Cargoes for export from the Arctic will remain the driving force for the development of shipping on the Northern Sea Route. In the future, oil, gas (LNG), coal, various ores and minerals, fish and timber products will continue to be the main cargoes to be transported from the Russian Arctic to markets in Northeastern Europe and Northeastern Asia. (Centre for High North Logistic, 2019).

As far as the main freights on the indicated route are concerned, a particular emphasis should be put on energy resources such as LNG, oil, coal, but even metal. With regard to this, launching of the complex "Jamal LNG" in December 2017 in the Northern route when five LNG consignments departed from the Russian port of Sabetta was of great significance for the traffic growth. Today China cooperates actively with South Korea, which builds ice tankers and is ready for the construction of icebreakers, while Russia is building a huge shipyard called "Star" in a littoral zone in the Pacific, where classic vessels for navigation in the Northern Sea Route will be constructed (Babić N., 2018).

In the context of analysis of the existing supply and demand, Table 1 and Figure 1 display the structure of voyages through the Northern Sea Route, according to the type of vessels which navigated through the above mentioned route in 2017.

From Table 1 and Figure 1 it may be noticed that in the structure of voyages through the Northern Sea Route the most significant presence of voyages is realized by vessels for the transportation of general freight and vessel for the transportation of oil, i.e. tank ships. Specifically, in the total structure of vessels traveling through the above-mentioned route in 2017, general cargo carriers (29%) and tankers (18%) dominate. In the total structure of voyages through the Northern Sea Route, from a total of 1,908 voyages within freight shipping lines, the largest number of voyages is realized by general cargo carriers (30%), followed by tankers (34%), and tug and icebreaker (5%).

Table 1.
Structure of voyages through the Northern Sea Route according to the type of vessel (Centre for High North Logistic, 2018).

Type of vessels	Vessels	Voyages
Barge	0	0
Boat	1	2
Bulk	9	48
Container	6	103
Crane	1	7
Dive	1	2
Dredger	4	10
Drilling	1	2
Fishing	11	38
General cargo	83	570
Heavy load	19	46
Icebreaker	16	105
LNG tanker	4	13
Pipe burying	0	0
Pallet	2	6
Passenger	3	17
Pilot	1	4
Reefer	4	9
Research	20	87
SAR	6	22
Supply	10	57
Tanker	51	648
Tug	28	105
Yacht	2	7
Auxiliary vessel	0	0
Hopper	0	0
Total number	283	1,908

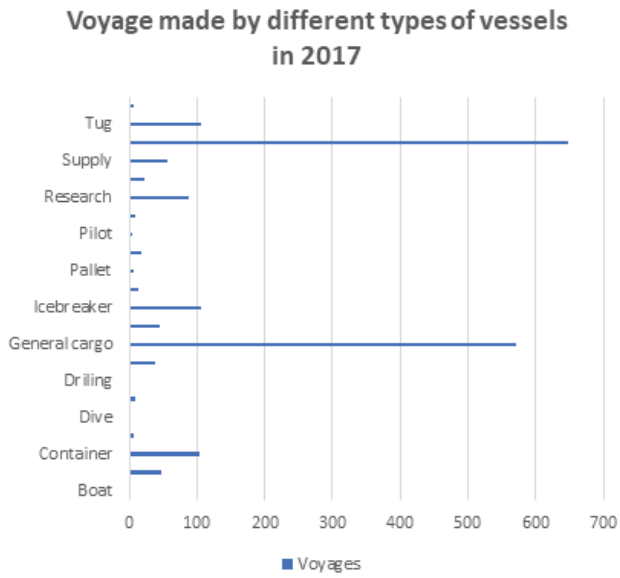

Figure 1.
Structure of voyages through the Northern Sea Route according to the type of vessel (Centre for High North Logistic, 2018).

Transport demand is based on the demands of service users, i.e. market demands. The condition of transport service demand can be analyzed, evaluated, and expressed by the intensity of cargo flows with respect to the orientation, i.e., the main directions of cargo flows (Poletan Jugović T., 2014). There are three different relationships between the supply of transport capacity that provides services and transport demands: a shortage in supply of transport capacity in relation to the transport demand, excess of supply relative to demand, and coordinated relationship between supply and demand. The task of the port traffic forecasting is to determine the quantity, type and structure of the cargo that will be moved through the port in the following period (Jugović A. et al., 2010.). Accordingly, transport flows of general and oil cargoes are currently the dominant cargo types in the Northern Sea Route. It should be noted that Russia uses the Northern Sea Route the most, valorizing the Arctic region for its military and economic purposes and as a source of natural resources.

An evaluation has been developed that about 13% of the world's undiscovered conventional oil reserves are situated in the Arctic and 30 % of undiscovered gas sources, which justified the fact that the Arctic region as a source of natural resources will continue to be interesting (Babić N., 2018). With this in mind and in relation to this route, even in the future we can expect the presence and the potential intensification of this type of freight flows.

As a testimonial of the current and, thus, even potentially predictable interest, there are data regarding the structure of vessels (according to the flag state), which navigated through the Northern Sea Route in 2018.

Based on the data displayed in Figure 2, it may be noticed that in the winter period (from January to June) 2018 even 75% of vessels which navigated through the Northern Sea Route were vessels under the Russian flag.

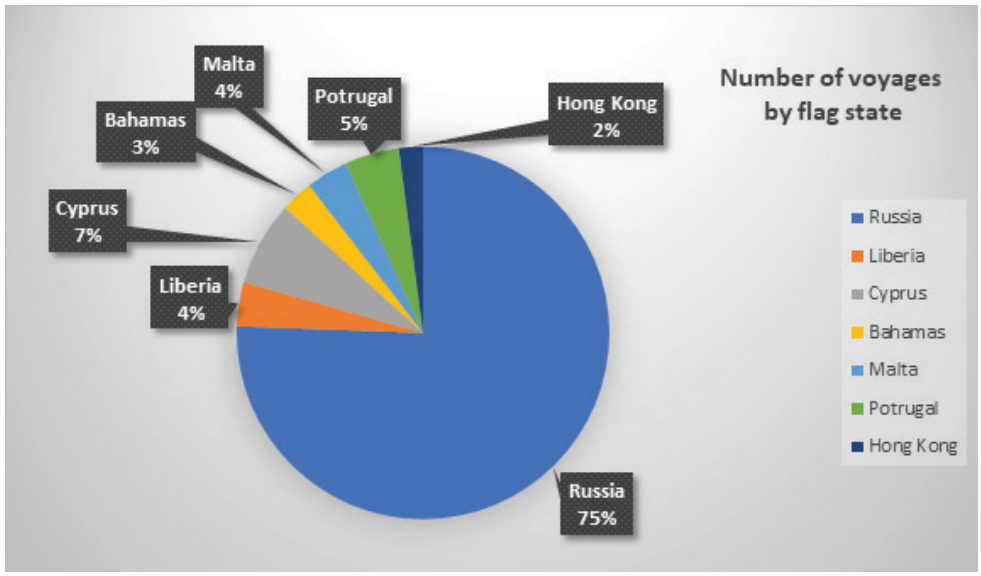

Figure 2.
Vessel structure in the Northern Sea Route according to the flag state, in the period from January to June 2018 (Centre for High North Logistic, 2018).

3. THE NORTHERN SEA ROUTE'S COMPETITIVE TRANSPORT ENVIRONMENT

Maritime transport is essential to the world's economy as over 90% of the world's trade is carried by sea (IMO, 2019), and the quantities that currently pass through the Northern maritime route cannot be compared with the quantities passing through the Suez Canal. However, according to some assessments, it is considered that the Northern maritime route will compete with the Suez Canal route from the Far East to the Pacific, through the Suez Canal towards Europe and the American continent.

Based on the available transport data, freight for the amount of 194 thousand tons has been evidenced through the Northern Sea Route in 2017. At the same time, more than a billion tons of freight, which is 5,000 times more, have passed through the Suez Canal. Taking this into account, it should be emphasized that the Russian goal is to increase the flow of freight passing through the Northern Sea Route to 80 million tons ("Pomorac", 2018).

In the following table, a comparative analysis of space and time components of the voyage through the Suez Canal and the Northern Sea Route is displayed. Data in the table are related to the starting points of Murmansk and to a speed of 14 knots, which is a constant.

Table 2.
Analysis of the spatial and time components of the voyage through the Suez Canal and the Northern Sea Route (Arctic Bulk, 2013).

	Voyage through the Suez Canal			**Voyage through the Northern Sea route**			**Difference between the voyages in days**
Starting point/ Destination	Distance	Speed in knots	No. of days	Distance	Speed in knots	No. of days	
Murmansk-Shanghai/ China	12,050	14	37	6,500	14	19	18
Murmansk-Busan/ Korea	12,400	14	38	6,050	14	18	20
Murmansk-Yokohama/ Japan	12,730	14	39	5,750	14	17	22

The above mentioned shows that travelling through the Northern Sea Route can significantly shorten the traditional route to Europe through the Suez Canal by almost 20 days and that the Northern Sea Route is half shorter in comparison to a voyage through the Suez Canal, which implies a definite advantage of the Northern Sea Route in the context of the voyage time and cost component, which consequently suggests even the economic effects of the voyage. According to some evaluations, foreign ship owners can speed up the consignment through the Northern Route, thus insuring an economic effect of even 500 thousand dollars with each consignment ("Pomorac", 2018). This demonstrates the sustainability of the Northern Sea Route in comparison to an alternative maritime route through the Suez Canal, presuming adequate climate conditions and the reduction of the quantity of ice, not only during the summer, but during the entire year, as it may be seen in the following figure.

The analysis of the realized voyages through the Northern Sea Route in 2016 and 2017 suggests that 69%, i.e. the biggest share of the voyages, was realized in the winter months (from December to May 2017), while only 31% of the voyages took place during the summer months (from June to November 2017). Based on the data for 2016 and 2017, the Northern Sea Route is mostly trafficked in September (Centre for High North Logistic, 2018). The reason for this lies in the fact that precisely in that period the smallest quantity of ice is present on the above mentioned route, which alludes to the influence of ice as a crucial climate factor in time distribution when travelling on this route.

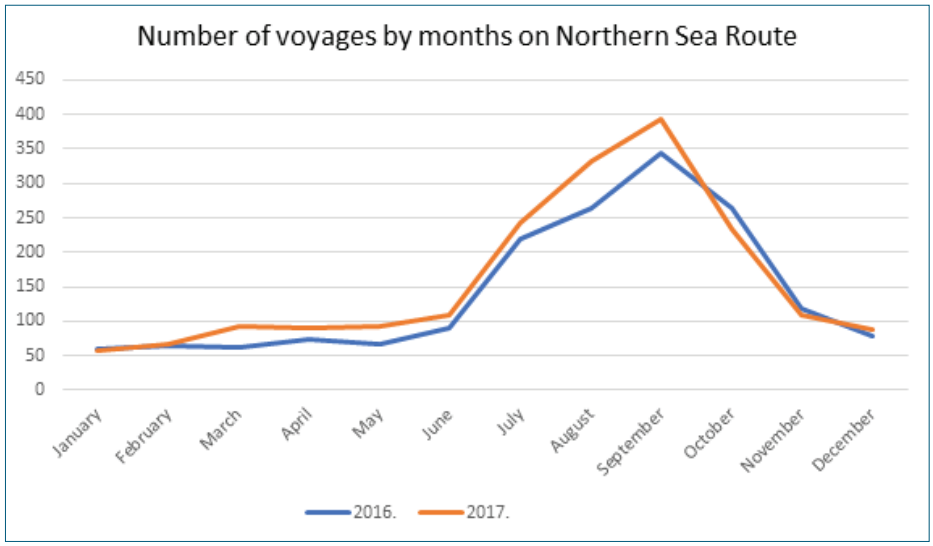

Figure 3.
Time difference in Northern Sea Route voyages for 2016 and 2017 by months (Centre for High North Logistic, 2018).

Currently, the Northern Sea Route is navigable only for four months a year; however, climate change or, more precisely, the reduction in the quantity of ice will contribute to the development and navigability of this route. Until then, it will be necessary to build expensive icebreakers, which requires additional costs. In terms of cost, the route today is still less favorable due to the need for ice-classed ships and ice-breaker assistance, non-regularity of the liner services, slower sailing speeds, navigation difficulties and Russian transit fees (Rodrique J.P., 2017).

The traffic environment within which the Northern Sea Route exists shows traffic routes, or starting-up destination areas which use the indicated route in the function of international maritime commerce and services, with the above mentioned dominant types of goods (freight).

According to the maritime freight directions and number of voyages though the Northern Sea Route during 2017 (a total of 1,908 voyages), the following traffic directions can be structured: (Centre for High North Logistic, 2018).

- traffic directions from European ports, including part of the routes towards European ports through the Suez Canal (54 voyages)
- traffic directions within the areas of Western (European) Russia (537 voyages)
- traffic directions from/to ports of Northern Russia towards Eastern (European) ports and Western (Russian and Asian) ports (657 voyages)
- traffic directions from/to (between) Northern Russian ports (591 voyages)
- traffic directions through the Northern Sea Route (for Europe, Asia) (27 voyages)
- traffic directions from Eastern Russia (30 voyages)
- traffic directions from Asian ports (12 voyages).

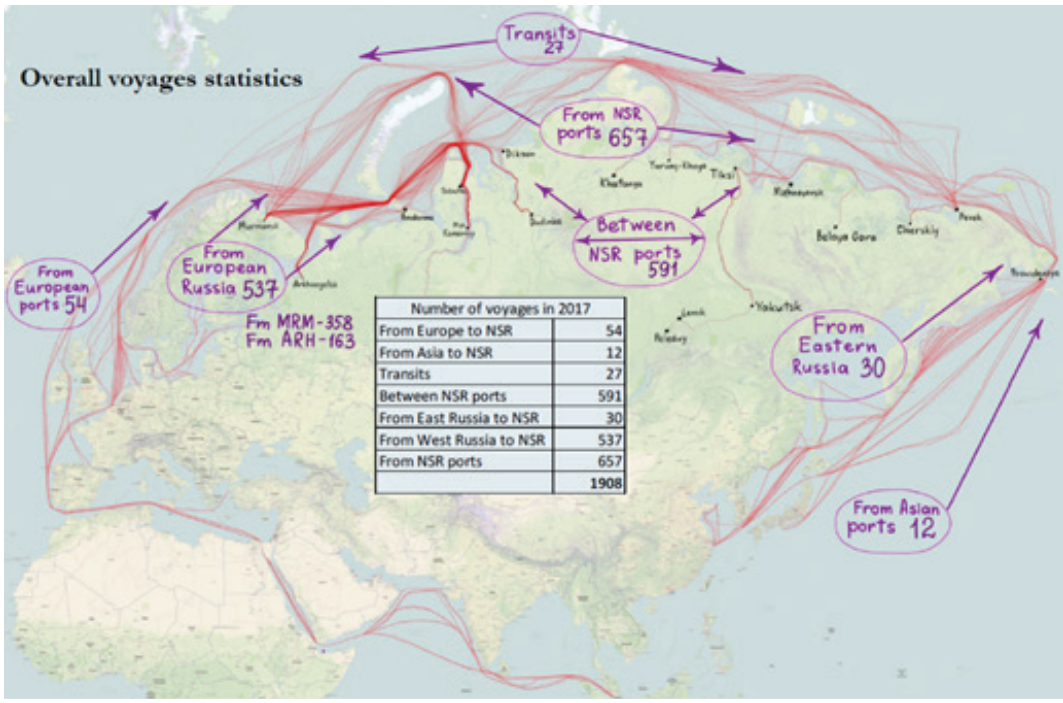

Figure 4.
Traffic directions of freight flows (voyages) through the Northern Sea Route in 2017 (Centre for High North Logistic, 2018).

According to their initial destination areas and ports, the indicated routes differentiate based on the traffic intensity, i.e. the number of voyages, as previously mentioned. It can, therefore, be concluded that the most intensive traffic route is the one from/to the Northern Russian ports towards the Eastern (European) ports and Western (Russian and Asian) ports. With regard to the total number of voyages in 2017, this route has registered 34% of the voyages.

Immediately after this route, and based on intensity, i.e. on the number of voyages, we can find the routes between Russian ports with a 30% share, and the routes within the area of Western (European) Russia with a 28% share in all voyages.

Routes from the European ports, including part of the routes towards the European ports through the Suez Canal, have also been actualized, which suggests that a certain amount of freight circulating through the Northern Sea Route travels from the Suez Canal, a route with which the Northern Sea Route can potentially compete. Part of the traffic routes that pass through the Northern Sea Route represent a transit in the need of Asian and European ports. The Northern Sea Route can therefore be defined as a competitive market of crucial interest as the most intense traffic route in the global maritime transport as far as the relation Asia-Suez Canal-Europe is concerned.

4. INFLUENCE OF THE AFFIRMATION OF THE NORTHERN SEA ROUTE ON THE WORLD'S MARITIME ROUTE

Along with the intensification of the energy and mineral resources in the Northern region, an efficient alternative transport solution, between Europe and the Far East, will become of utmost importance. This will result in the formation and consolidation of potentially new freight flows that will significantly affect the intensity of the traffic and the development of hub ports on the analyzed route, as well as the general frame of the world's maritime transport. Considering the above mentioned and along the lines of the main aim of this research, what follows is a statistical analysis of the effects of the Northern Sea Route's affirmation in the context of consolidation of the new transport routes and freight flows, as well as in the context of affirmation of the sea ports, that will be in function and of service to the latter.

4.1. Affirmation of the New Transport Routes and Freight Flows

At the beginning of 2018, China became Russia's main partner in the common use of the Northern Sea Route. China intends to support and work on the affirmation of the Northern

Sea Route, i.e. the so-called Polar Silk Road in the Arctic. It participates in the study of navigation modes, i.e. of hydrographic work, but also in the scientific research in the Arctic. The Russian efforts as well as their adoption of special laws in the Northern Sea Route have inspired China to also add among its strategic projects the Polar Silk Road (Babić N., 2018).

The initiative "Belt & Road" is a Chinese proposal, whose goal is to promote a peaceful cooperation and a common development of the world. The cooperation "Belt & Road" is a framework in which all countries, smaller or larger, richer or poorer, can participate on equal basis. This cooperation is public, transparent, open, and it brings positive energy, peace and development to the world (Koboević Ž. et al, 2018). The initiative Belt & Road is very significant because infrastructure has historically tended to be something that's domestically focused, done through government spending. Now there are many countries collaborating in their infrastructure development. It's certainly multi modal and covers transportation, energy, communications, and many other areas. It's not just publicly financed either – yes, Chinese public funding has provided a jolt of support to Belt & Road initiative – but it is multilateral as it is beginning to include the world's biggest financiers who are seeking to tap into this initiative. This includes both private financiers and other multilateral development banks (Khanna P., 2019).

The initiatives Silk Road (One Belt) and Maritime Silk Road (One Road) strive for the same win-win situation, achievable by building together, with the respect of common principles and the connection of three continents. The route is thought of as an economic tool which would stimulate growth and modernize ports as well as the infrastructure of the participating countries. The initiative has no political or military aims; on the contrary, which is always emphasized is the implementation of a peaceful plan, addressed towards China's wealth and the progress of the world.

The program is based on a win-win approach, on the five principles of a peaceful coexistence contained in the UN Charter: mutual respect, equality, fulfillment of the promise, mutual benefit, and a win-win approach.

"Belt and Road" is made of two parts (showed in Figure 5):

- the land "belt" that connects China to Central Asia, Russia, South Asia and Europe, and
- the maritime "belt" that connects Chinese ports to the ones in Southeast Asia, South Asia, Africa, the Middle East, and Europe.

The goal of the initiative "Belt and Road" is to connect Asia, Europe, and Africa through five transport routes.

The land belt focuses on: (1) connecting China with Europe through Central Asia and Russia; (2) connecting China with the Near East through Central Asia; (3) connecting China and Southeast Asia, South Asia and the Indian Ocean. The maritime "road" focuses on using Chinese coastal ports: (4) connecting China with Europe through the South China Sea and the Indian Ocean; and (5) connecting China with the South Pacific Ocean through the South China Sea. (Wong B., 2016).

By targeting the above indicated five routes, the 21st century Silk Road ("Belt and Road"), will use the advantages of international transport routes as well as the key cities and ports to additionally strengthen cooperation and build six international economic cooperation corridors.

The initiative "Belt and Road" has been identified as the

Figure 5.
The Chinese route for the initiative "Belt and Road" (China Daily, 2015).

New Land Bridge in Eurasia, China-Mongolia-Russia, China-Central Asia-Western Asia, the peninsula of China-Indochina, China-Pakistan and Bangladesh-China-India-Myanmar (Wong B., 2016).

The transit route from Yokohama to Hamburg through the Northern Sea Route is 6,600 nautical miles distant, while the one through the Suez Canal counts 11,400 nautical miles. From this, it can be concluded that through the Northern Sea Route the voyage from Japan to Europe would be reduced by 40 percent. Following the above mentioned, it may be suggested that the Northern Sea Route will provide China with a faster freight consignment in Europe and reduce the transit time by 20 to 30%, which will save a significant amount of fuel and human resources. Considering that 90% of the Chinese goods are delivered by sea, the development of the Polar Silk Road could potentially ensure for China a major economic growth, but also an increase in the profit (Babić N., 2018).

4.2. Affirmation of Reference Ports

Ports represent the origin of the worldwide navigation, i.e. significant hubs in the circulation of maritime freight flows. They connect individual maritime routes and, together with them, create a network of formed routes. Taking into account the very the fact that ports are reference points in which it is possible to measure the intensity, i.e. the volume of freight flows, port traffic (ports of departure-destination) is an indicator of the quantity of maritime traffic in individual maritime routes (Poletan Jugović T., 2014.).

Reference transport hubs, i.e. ports on the Northern Sea Route are: Murmansk, Arhangelsk, Nordvik, Ambarčik, Igarka, Dudinka, Dikson, Tiksi, Pevek, Providenije, whose traffic (the number of vessel arrivals/departures) in 2017 is shown in the following figure.

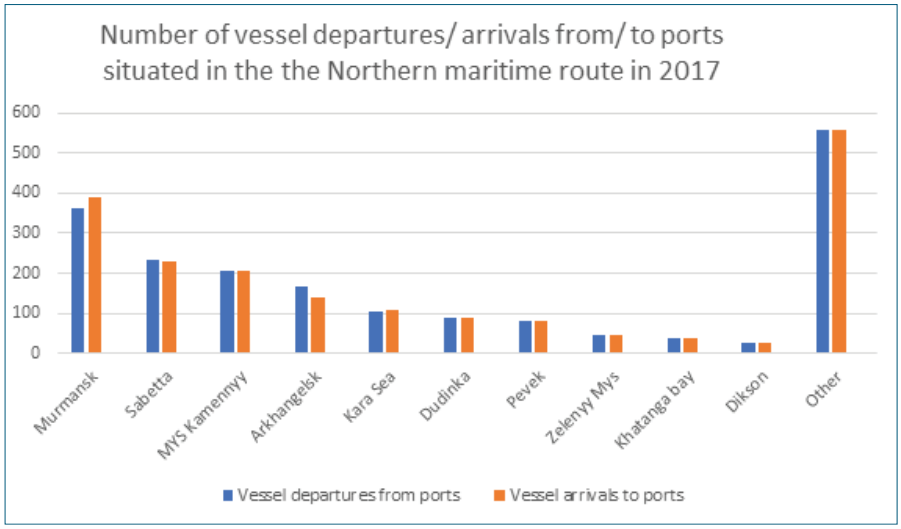

Figure 6.
Number of vessel departures/ arrivals from/to ports situated in the Northern Sea Route in 2017 (Centre for High North Logistic, 2018).

Based on the elaborated data from the port of Murmansk, with 363 departures from the port and 390 arrivals to the port in 2017, this is the most frequent Russian port in 2017, and with the affirmation of the Northern Sea Route, the above mentioned port traffic is likely to increase, especially because of its location on the most significant courses of the Northern Sea Route, as shown in Figure 5. An increase in the number of arrivals and departures from/to the Northern route ports indicates the need to invest in the ports mentioned.

For the Northern Sea Route to realize its full potential also as a transit route, a number of changes need to take place in the coming years and decades to improve the route's overall safety, reliability, services, and attractiveness for shipowners and cargo owners. A further development of essential transportation and logistics infrastructure is needed, including more icebreakers to assist vessels, a fleet of specialized high ice-class Arctic shuttles, improved search and rescue capacity, oil spill preparedness and response, environmental protection measures, communication systems, hydrographic surveying and navigational aids, and better forecasting of sea-ice conditions. These measures together with the modernization of Russian Arctic ports will take time and will require large investments (Centre for High North Logistic, 2019).

With the document "Strategic goals and recommendations for the EU's maritime transport policy until 2018", the European Commission has confirmed to the European Parliament that

with the increase and expansion of the maritime routes capacity, part of the traffic will inevitably be attracted to the Northern Sea Route, which has "special requests". The European Commission estimates that it is in Europe's interest to research and improve the conditions that would gradually lead to joint navigation in the Arctic. The EU (as well as the USA) considers that it is important to emphasize that all the member states should support the principle according to which the right of undisturbed passage and the freedom of navigation would be allowed on the newly opened routes and passages.

The Ilulissat Declaration from May 2008, which was issued by the Arctic coastal states (Canada, Denmark-Greenland, Norway, Russia and the USA), has touched upon a sensitive topic related to sovereignty and jurisdiction of the Arctic coastal states in the greater area of the Arctic. In their opinion, it is not necessary to adopt any new legal regime in that area. In this way, the declaration has left the impression that it excludes not only non-Arctic states, but also Finland, Sweden and Iceland, which are also members of the Arctic Circle Assembly. The European Commission has demonstrated its interest for a greater role in the Arctic region and it encourages challenges in the Arctic to become an international issue. However, the Arctic Circle Assembly still keeps on hold the EU's application to join the Assembly in the role of observer, while China has entered this selected circle in 2013, together with India, Italy, Japan, South Korea and Singapore (Blunden M., 2012).

Before the above mentioned countries, the role of the observer has also been approved to France, Germany, the Netherlands, Poland, Spain, and the United Kingdom. The refusal to grant the observer status to EU is to be found in the disagreement with the European seal hunt ban. Germany sees the Ilulissat declaration as an attempt to isolate Arctic regions from the influence of other interested parties, and it considers that the five above mentioned Arctic states emphasize their supremacy over that area, which is the reason why it will not be possible to influence issues related to the Arctic from the outside. Germany is aware that the Northern Sea Route can bring a considerable profit which is estimated, for large vessels, to half a million euros per voyage. Consultants in Germany consider that the Arctic resources should be declared world heritage sites, with the aim to look at everyone's well-being, which Russia opposes (Blunden M., 2012).

The signature of Italy's Accession Memorandum to the new Silk Road, will positively affect the development of the North Adriatic ports: Trieste, Koper, Rijeka, Venice and Ravenna. In case all the announced Chinese investments in Trieste and its transport route should be realized, which is still uncertain, the port of Trieste would not become a new Hong Kong or Singapore, especially not overnight. In other words, even with major investments, the port of Trieste is not sufficiently large to compete with the biggest and most important ports of Northern Europe in the matter of port infrastructure as well as in relation to the traffic connection and possibility to transport freights to the final destinations in due time (Glavan M., 2019).

For instance, as far as the container transport is concerned, which carries the greatest portion of goods between the Far East and the European market, all three ports, i.e. Trieste, Koper, and Rijeka, recorded top results last year. With 988,000 TEU, Koper approached its maximum current capacity; Trieste registered 625,000 TEU, and Rijeka 227,000. Altogether, the three ports did not have more than 2 million containers, which is less than 1/5 of last year's container transport only in the port of Antwerp, where more than 10.5 million TEU have been transshipped. If we add the traffic of the port of Rotterdam (11 million TEU), of the port of Hamburg (10 million TEU) and others to the port of Antwerp, it is completely clear that the ports of Trieste, Koper and Rijeka altogether, even with major investments, could not compete with any of the above mentioned individual Northern European ports. Individually, they could not satisfy even roughly the needs of the Silk Road (Glavan M., 2019).

Finally, it can be concluded that the affirmation of the Northern Sea Route on the world stage will significantly influence the restructuring of freight flows at the world and European levels, but the influence on the North Adriatic ports cannot be certainly predicted, regardless of the signature of Italy's Accession Memorandum to the Silk Road.

5. CONCLUSION

New climate conditions are opening the possibility for international maritime navigation in the Arctic area, in particular through the Northern maritime route, as an incomparably shorter route between Asia and Europe than the one passing through the Suez Canal. Apart from natural limitations, the challenges of navigation on the Northern Sea Route are also represented by various other factors such as investments in the transport infrastructure and other requirements for a quality and safe service, as well as the consolidation of political-economic interests.

The Russian government promotes navigation through that route, but wants to keep its exclusive right of jurisdiction in the area. Although major tensions have not occured so far in relation to this matter, some countries disagree with this, considering that the route should be treated as a common world good and interest. The economic-political groups that, together with Russia, could affect the realization and the affirmation of this transport route are China and Japan, who are also interested to invest in the indicated route. In particular, China and Japan wish to invest in transport routes towards Europe, i.e. there is a potential opportunity to connect the Chinese project "One Belt, One Road"

to the Northern Sea Route. It can be concluded that through the Northern Sea Route, the voyage from Japan to Europe would be reduced by 40 %. Following the above mentioned, it can be suggested that the Northern Sea Route will provide China with a faster freight consignment in Europe and reduction in the transit time by 20%-30%, which will save a significant amount of fuel and human resources. Considering that 90% of the Chinese goods are delivered by sea, the development of the Polar Silk Road could potentially ensure not only a major economic growth for China, but also an increase in the profit.

Based on the main problem and object of research in this paper related to market analysis and affirmation factors of the Northern Sea Route, the research has made the following contribution:

- The most intensive traffic route is the one from/to the Northern Russian ports towards the Eastern (European) ports and Western (Russian and Asian) ports. With regard to the total number of voyages in 2017, this route has registered 34% of all voyages.
- Immediately after this route, and based on intensity, i.e. the number of voyages, we can find the routes between Russian ports, with a 30% involvement, and the routes within the area of Western (European) Russia, with a 28% involvement.
- The routes from European ports, including part of the routes towards European ports through the Suez Canal, have also been actualized, which suggests that a certain amount of freight circulating through the Northern Sea Route travels from the Suez Canal, a route with which the Northern Sea Route can potentially compete. Part of the traffic routes that pass through the Northern Sea Route represent a transit for the needs of Asian and European ports. The Northern Sea Route can, therefore, be defined as a competitive market of crucial interest, as the most intense traffic route in the global maritime transport.

Taking into account the above mentioned political-economic interests as a relative-variable factor in planning the valorization of the transport route, the basic aim and purpose of the research is to analyze the existing situation in the indicated route and the affirmation factors of the transport route in the maritime market, with the aim to define further perspectives of the Northern Sea Route.

Following all the above mentioned, the contribution of research in this paper is reflected in the determination of the principal market categories that predispose the transport route's competitiveness, i.e. transport supply, demand, and environment in which the transport route exists. The Northern Sea Route has been analyzed based on the traffic structure according to the type of freight and vessels, the traffic direction and intensity in single route directions, the traffic intensity in ports, as port reference hubs. Based on the performed analysis, conclusions were drawn about the basic market definitions of the Northern Sea Route. Finally, relevant affirmation factors of the transport route on the dynamic maritime market, which always shapes new requests, expectations, and opportunities, were emphasized.

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Port-City Development: The Spanish Case

Beatriz López-Bermúdez, Maria Jesus Freire-Seoane, Carlos Pais-Montes, Emilio Lesta-Casal

The objective of this paper is to try to evaluate the port-city relationship from its onset, taking into account the challenges of port 4.0. Indicators such as the percentage of employees participating in training programs, the percentage of female employees in Galician ports, the percentage of merchandise moved by private operators and the percentage of companies with quality certification in Galician ports are evaluated. The fourth revolution is based on the transition from current fossil fuel-based energy models to alternative energy sources, changes in the logistics and transport parameters and finally, on the elimination of intermediation. The key component of the third pillar of new Economy 4.0 is complete digitalization. The optimum port-city solution must address the need of both the urban planner and the port manager to evaluate potential measures that would alleviate the pressure of dedicated port facilities on the city and vice versa to the greatest extent possible.

KEY WORDS
~ Port-city
~ Port 4.0
~ Automatization
~ Sustainability

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doi: 10.7225/toms.v09.n01.007

1. INTRODUCTION

Maritime activities have historically been a direct driver of urban growth and the city used to grow hand in hand with its port. Recent advances in transport technology have caused a transition from port-to-port market to door-to-door economy. This observation is described by Norcliffe, et al. (1996), who held the view that until World War II, ports created cities and large ports created large cities. However, the containers, dry ports, railway access and, in short, the development of logistics in the second half of the 20th century have made city size less dependent on port size. The correlation between port dimensions and the size of the city has since grown less direct since the port is now at the service of a much larger region: its hinterland.

In addition, although the economic contribution of the ports has decreased, their social and environmental costs have increased. Problems range from traffic congestion and environmental impact of highly polluting port activities to great competition between the port and the city over land use. (Liao et al., 2010; Salazar and García-Menéndez, 2012). Taken together, these factors gave rise to the "key question" of whether ports and their host cities should be developed together, as integrated economic-functional spaces. Despite the perceived negative externalities in the urban development, ports in large cities have still experienced phenomenal growth. In fact, in recent decades, most of the world's most important ports have been situated in populous cities (Hall and Jacobs, 2012). Research studies often analyze port system structure and the urban-city system separately, with only a few having made an attempt to integrate the two, although this is necessary for a better understanding of the sustainable development of port cities in the face of regulatory and policy changes.

The optimum port-city solution must address the need of both the urban planner and the port manager to evaluate potential measures that would alleviate the pressure of dedicated port facilities on the city and vice versa to the greatest extent possible. Therefore, urban development projects and private sector investments should strive to open spaces of little or marginal use to the port to the public. The idea is to create an interface between the port and the city, that would allow coexistence between the commercial operations of the port and the recreational vision of the port as the seafront.

The fourth revolution is based on the logical and undoubtedly unstoppable transition from current fossil fuel-based energy models to alternative energy sources, changes in the logistics and transport parameters and the elimination of intermediation. The key component of the third pillar of new Economy 4.0 is complete digitalization. The ports of the future must meet their needs by means of the fourth revolution, always striving for maximum efficiency and effectiveness. The objective is to achieve the balance between the port and the city in terms of sustained development, without compromising the production of future generations, as well as to take advantage of the development of digitalization, embodied in automation and the use of highly sophisticated software in ports.

The objective of this paper is to identify the challenges of port 4.0 from a holistic perspective and evaluate a series of indicators of the Spanish port system, and particularly of the ports of Galicia. The paper is structured as follows: section 1 introduction; section 2 summarizes the port-city relations; section 3 develops the concept of port 4.0; section 4 presents the benchmarking methodology; section 5 presents the results obtained; and finally, the last two sections contain the conclusions and bibliography.

2. PORT-CITY

Port-city relations have been characterized by the fact that maritime transportation of goods has undergone a transition from port-to-port to door-to-door concept, resulting in the expansion of the port hinterland into the interior and the consequent urgent need to ensure maximally efficient and effective land transport, entailing the need for an intermodal transport chain that necessarily requires industrial parks or logistic activity zones (hereinafter: "LAZ") where these infrastructures can be located. The port thus acts as a link between the city and its regional development. Apart from facilitating trade and industry, ports also encourage economic progress through the multiplying effect of port cluster activities (Suykens, 1989; Zhang and Lam, 2013). Nevertheless, there is generally (no clear) definition of the concept of port-city "due to the complex interactions of several networks and territories in one place" (Wang and Ducruet, 2012). Port cities are economic entities closely related to maritime activities. In addition, these cities are the link between local and global environments, acting as exchange centers and meeting points of different cultures and environments. Currently, ports are considered to be nodes within the international trade logistics network (Tan, 2007).

The researchers have pointed out that relations between ports and cities greatly vary from region to region. Ducruet (2006) analyzed the interdependence of ports and cities by examining the correlation between the population of the city and port performance. The results have shown European port cities to have a relatively weak but stable interdependence index, while Asian port cities have a stronger, but steadily declining, interdependence. Predominant in Europe, in Asia, controlled markets are concentrated in coastal areas. The conflicts between a port and its city pertain to the congestion of urban traffic and the redevelopment of the seafront (Hayuth, 2007, Wang and Ducruet, 2012). A typical example is the shortage of adequate land and sea space for port expansion (Yap and Lam, 2013). Many port terminals, initially located in the vicinity of the city center in the 1960s and 1980s, now face "increasing competition from high-end real estate, commercial and residential developments due to the gradual expansion of the city center" (Grossmann, 2008; Rondinelli, 2001).

In recent years, with the development of the economies of scale, ports have evolved towards fourth generation ports which, though physically separated, can still be linked by common operators or common administration. Apart from specialization, post-industrial ports are also characterized by the need to optimize their land (truck and rail freight) and maritime access (by dredging to increase drafts and constructing dikes to facilitate shelter). All this highlights the importance of a port's location for the development and maintenance of its terrestrial (hinterland) and maritime (foreland) areas of influence. Another feature, no less important for modern ports, is the new environmental and social sensitivity of the post-industrial city. Thus, the modern port, as the fundamental component of the merchandise distribution system and the point of convergence of various transport systems, can be the subject of environmental and social conflicts that endanger port development itself. All these external factors now have greater importance than in the industrial stage.

The conflicts between the city and the port have affected and resulted in the formation of a negative relationship between the port and the city, ruling out any positive aspects (Xiao and Siu, 2017). However, the port system cannot be separated from the city it serves. Therefore, Hall and Jacobs (2012) attempted to gain a dynamic understanding of the city-port relationship. Their research is one of the few attempts to identify dynamic advantages that urban agglomerations can offer to ports. An in-depth and systematic analysis of the positive and negative aspects of the port-city interaction is required. Studies have to date focused on analyzing the port system separately (Dinwoodie

et al., 2012, Cetin and Cerit, 2010 and Bekebrede and Mayer, 2006) from the urban one (Baynes, 2009).

3. PORT 4.0

The appearance of containers in the 1950s and their proliferation in the 1960s when they became the main axis of maritime transport, resulted in the standardization of cargo handling in TEUs and the development of superstructures (cranes) specialized for their management (Rodrigue, 2017). As for productive processes, following the construction of the first automated containerized goods terminal in Europe in the port of Rotterdam in 1993, semi-automation or automation have been introduced worldwide, but gradually and singularly, since the generalization of this innovative technology / infrastructure has not been achieved.

The new era is characterized by two opposing poles. The negative pole would be container growth rates coming to rival gross domestic product (hereinafter GDP) growth rates, due to the stagnation of China; the positive pole are the new opportunities opened by digitalization, the use of databases, detailed analyses and automation.

The digital age imposes new challenges on an industry traditionally focused on physical assets, altering trade models and creating new value systems. Customer expectations with respect to container traffic are being radically transformed by electronic commerce and innovations in "last-time" logistics, the demands in the container transport industry will only increase, as end consumers expect delivery in the shortest period possible.

As pointed out by McKinsey & Company (2018), maritime transport is characterized by five aspects to which it must rapidly adapt to be competitive:

- physical characteristics of the industry: container competitiveness depends on loading / unloading, i.e. on crane characteristics and dock operations that connect intermodally;
- world trade flows tend to balance through different routes, as income converges between East Asia and developed economies;
- automation is increasingly present in the logistics supply chain - in ports, terminals, railways and trucks;
- the digital age of data and analysis will fundamentally change the sources of value creation. Customers no longer seek only transport capacities between two locations (containers, terminals and suppliers) and "out of sight, out of mind" orchestration (of freight forwarders);
- industry leaders will greatly change. Some will be the larger versions of the current leaders, emerging from even greater consolidation realized either by focusing on a part or by integration throughout the value chain.

Since the modernization of industrial production processes commenced with the industrial revolution and has been gradually evolving ever since, many authors refer to the current situation as the fourth transport revolution (Schwab, 2017) or the third wave of globalization (McKinsey & Company, 2018). The so called third wave of globalization in the maritime transport sector is characterized by (McKinsey & Company, 2018): greater economies of scale, flexibility, reliability and predictability of the supply chain, consolidation and integration, automation and productivity, and environmental performance. However, even though the evolution of maritime transport, as a reference sector of industrial services, has generally been positive, it seems to lag behind when certain relevant factors are analyzed.

A study conducted by McKinsey & Company (2018) shows that automation has become a trend. The study has shown that 80 % of respondents expect that at least "half of all new port projects will become semi or fully automated" in the next five years, 35 % believe that the share of automated ports will increase by more than 70 %. The realization of return on port automation investment was shown to require the effort on the part of port operators, as well as on the part of investors and initial capital outlays are high. It is estimated that the operating expenses of a newly constructed automated terminal would have to be 25 % lower than those of a conventional terminal or productivity 30 % higher and operating expenses 10 % lower to justify these investments. Environmental awareness and the demand for higher quality of life in the cities have become a growing trend. These circumstances will result in the separation of the port from the city. City dwellers see the port as an entity that though attached to the city, is not integrated with, but is rather separate from the city proper, and have a negative attitude to port-generated pollution and the environmental costs of port activities to the city.

The 1st World Conference on Sustainable Transport was held in 2016, where alternatives to road, rail, air, ferry and maritime transport were discussed, as well as, among other issues, climate change, energy, financing and road safety. In his speech, Ban Ki-moon highlighted the importance of action in the transport sector to ensure the implementation of the Paris Agreement on climate change and limit the increase of global temperature. The Conference reflects the dilemma between growth and sustainability. In addition to supporting the achievement of the 2030 Agenda Objectives, it is essential to adopt an approach that would take into account three types of results: economic performance, social dimension and respect for the environment, that will foster interrelation and establish a balance between them. (UNCTAD, 2018). There are many definitions of sustainable transport, each placing emphasis on a different dimension - economic (efficient and competitive transport), social (inclusive transport) or environmental (ecological transport). The UNCTAD

came to the conclusion that the sustainability of maritime transport required balance between the three dimensions. In particular, among other criteria, it requires infrastructures, services and maritime transport operations to be effective, safe, socially acceptable, universally accessible, reliable, affordable, efficient in the use of fuels, environmentally friendly, with low carbon emissions and resilient to climate change.

There is no doubt that increasing the sustainability of the maritime transport sector is essential to realizing the Sustainable Development Goals, as well as the Paris Agreement. Maritime transport is one of the key elements when it comes to environmental protection, since 80 % of traded goods are transported by sea and approximately a quarter of greenhouse gas emissions (UNCTAD, 2018) are estimated to be attributable to this form of transport. However, the application of sustainable maritime transport solutions entails costs and requires additional resources. It is therefore important to increase investment, particularly into new energy sources and mechanisms, and promote greater participation of the private sector, for example, through public-private partnerships that would likewise be subject to sustainability and resilience criteria (European Commission, 2018). The maritime sector is at the crossroads of new developments, in particular, innovations and new digital technologies (UNCTAD, 2018).

At the international level, the International Maritime Organization (IMO, a United Nations agency) has adopted a Strategic Plan for 2018-2023 (Resolution A.1110 (30)). The Strategic Plan identifies the strategic directions on which IMO will focus in 2018-2023, guarantees that the opinions of all stakeholders participating in its decision-making processes will be taken into account and envisages paying special attention to the needs of developing countries, developing island states and the least developed countries (Resolution A.1110 (30)). The strategic directions are as follows:

- Improve implementation.
- Integrate new and advanced technologies into the regulatory framework.
- Respond to climate change.
- Participate in the governance of the ocean.
- Engaging in global facilitation and international trade security.
- Ensure regulatory effectiveness.
- Ensure organizational effectiveness.

Transport activities have a variety of negative external effects, which are often not taken into account in the strategies. These include infrastructural stress, congestion, accidents, pollution (for example, air, noise, the generation of debris) and increasing pressure (Acciaro et al., 2014) of the governments, customers, environmentalists and other interested parties on the transport sector (Sys et al., 2012). This is also true of the port sector, where e.g. external costs are internalized in an attempt to raise ecological awareness, increase the efficiency of resource use and ensure fair competition between transport chains.

4. BENCHMARKING

Most practical and theoretical approaches to the assessment of port performances fall into one of the three broad categories (Bichou, 2006): metrics and individual indices, economic impact studies, and efficiency approaches (UNCTAD, 2016).

Benchmarking is a process whereby the strengths and weaknesses of an organization and its advantages over its main competitors are established, best practices identified through the development of a strategic plan aimed at achieving a dominant position over its competitors and subsequently evaluated (Rodrigue et al., 2017; Tovar and Rodríguez-Déniz, 2015; Hokey and Jong, 2006; Cuadrado et al., 2004). Information on port management and operations are required for analysis of port performance (Doer and Sánchez, 2006).

Port performance indicators are relatively simple to obtain and understand from financial information or operational conditions. Given the difficulty of gaining access to financial information in ports, we chose indicators that can be derived from the sustainability memories of the Spanish port system. In their Sustainability Reports, Puertos del Estado and port authorities make manifest their commitment to transparent management by providing an overview of achievements made and challenges faced in fields such as competitiveness, quality of service provision, efficient use of resources, environmental, economic and social impact (Puertos del Estado, 2019).

The port-city research field is new and hugely important (Schipper at al., 2017; Ducruet et al., 2018; Monios et al., 2018; Van der Berghe and Daamen, 2020). At present, there have been no further developments in indicator evaluation, but the quality of companies that operate in the port, the reduction of the gender gap in the labor market, continuous training and public-private partnerships will certainly contribute to the better integration of port-city aspects. Consequently, indicators analyzed in this research are the percentage of companies with quality certification, the percentage of female port employees, the percentage of employees participating in training programs and the percentage of merchandise moved by private operators. Evaluation is based on the comparison of these same indicators with those of companies operating in the cities adjacent to the ports, as well as on the presence / importance of private operators, i.e. private companies in the port and the situation of port employees residing in the cities. All these elements taken together give us an image of the port-city, although further investigation is desirable where more data are available.

Available information suggest that the percentage of companies operating in the port that have quality certificates or recognize quality standards is indicative of port-city

integration, since quality standards include social, economic and environmental standards. In addition, data on the percentage of merchandise moved by private operators is analyzed, since the majority of Spanish terminals use the landlord system, i.e. land is granted to private operators for exploitation, which indirectly affects both the creation of private companies and jobs. Secondly, the percentage of female employees and employees participating in training programs are two characteristics of the labor market and ports were initially recognized as drivers of the labor markets in their host cities.

5. RESULTS

The analysis was conducted by means of evaluation of the selected indicators for the Spanish port system for 2013-2016. A total of 46 ports of general interest have been taken into account. In particular, the situation in Galician ports (A Coruña, Ferrol-San Cibrao, Marín, Vigo and Vilagarcía) was evaluated, also taking into account the Spanish port with the highest values and the Spanish average obtained from 28 port authorities.

Figure 1 shows the percentage of companies that have quality certificates or recognize quality standards in the total number of companies operating in the port. The greatest percentage of companies with these characteristics in Spain was recorded in the Mediterranean port of Valencia. The indicator analyzed oscillates between 8.61 % in 2013 and 6.92 % in 2016. The Galician port of Ferrol continuously has values above the national average, between 2.27 % in 2013 and 2.67 % in 2016. As of 2015, Vilagarcía has likewise been exceeding the average value, reaching 4.35 % in 2016. However, the port of Vigo is below 1 % and there are no available data on the port of A Coruña.

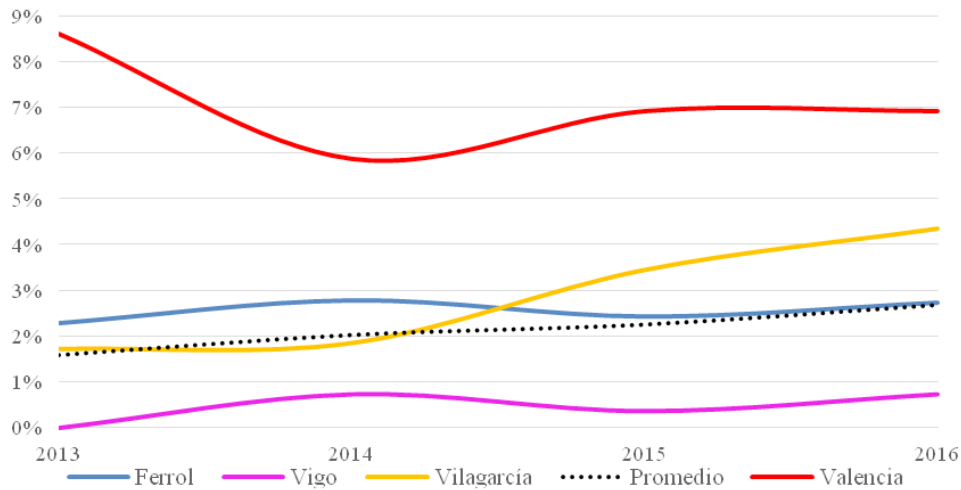

Figure 1.
Percentage of companies with quality certification in Galician ports and the national average,
Source: own elaboration.

Companies with quality certification are evaluated by external agencies and take sustainable management into account in all their areas of activity. Increased presence of this type of company in the city is beneficial for both economic growth and sustainable development of the port and its entire hinterland.

Figure 2 illustrates the percentage of merchandise moved by private operators in the ports. The port with the highest percentage of merchandise moved by private operators is the port of Valencia, where it accounts for nearly 100 % of merchandise moved. In the period analyzed, all Galician ports except Ferrol have been below the state average of approximately 60 % in the last two years. The port with the lowest percentage (under 50 %) of private operators is Vilagarcía, while A Coruña and Vigo approach 60 %. It is important to note that Ferrol experienced significant growth, reaching 91 % in 2016.

The presence of private operators at the terminals boosts both maritime trade and the labor market. Although the values recorded are below the state average, they are very close to 50 % and the trend seems to be stabilization or even growth as in the case of Ferrol.

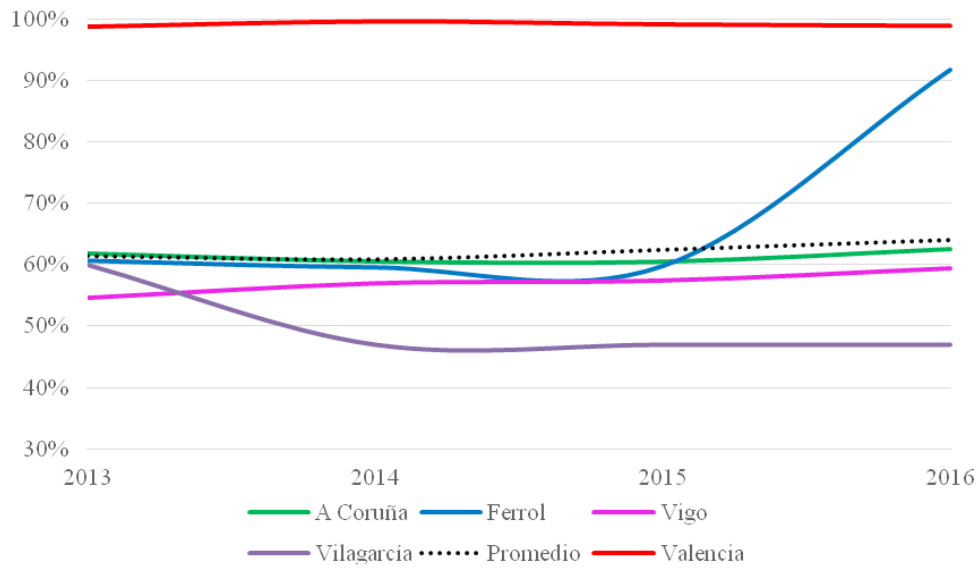

Figure 2.
Percentage of merchandise moved by private operators in Galician ports and the national average.
Source: own elaboration

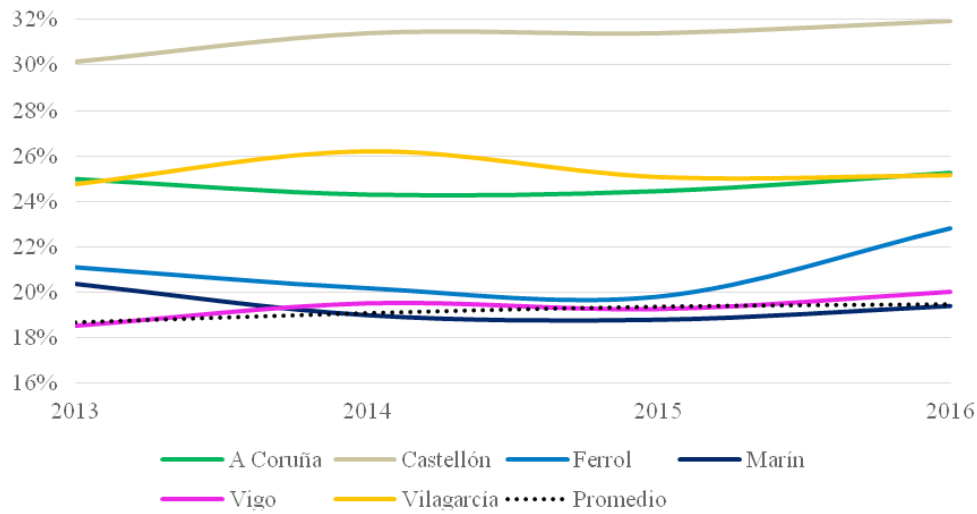

Figure 3.
Percentage of female employees in Galician ports and the national average.
Source: own elaboration

Figures 3 and 4 show data relevant for the labor market: first, the percentage of women working in ports, and then the percentage of employees participating in training programs. Labor market evaluation was reduced to these two indicators due to the limited availability of data. The evolution of the number of women in this traditionally male sector is very significant given the changes in the market and the necessary start-up of industry 4.0.

The port with the highest percentage of female employees in the entire Spanish port system is the Mediterranean port of

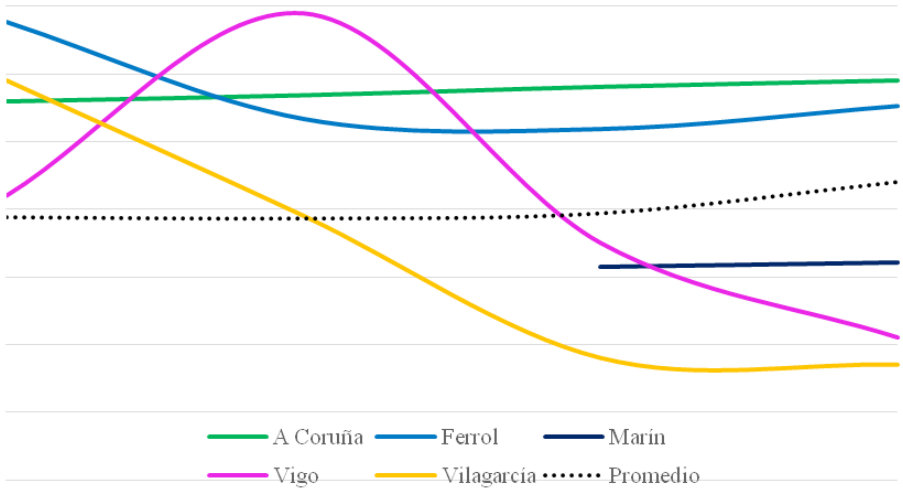

Figure 4.
Percentage of employees participating in training programs in Galician ports.
Source: own elaboration

Castellón, with values above 30 %. In absolute terms, the port of Castellón had 38 female employees in the period analyzed, which coincides with the average number of women in 28 port authorities. The percentage of female employees is lower in Galician ports, though still above the national average, with the exception of the port of Marín. The port of Vilagarcía has the highest percentage of female employees, followed by A Coruña, both having values above 24 %. Ferrol was around 20 % before exceeding 22 % in 2016. Vigo comes close to the state average of just under 20 %. In absolute terms, A Coruña has 43, Ferrol 25, Vigo 46 and Vilagarcía 18 female employees.

Figure 4 illustrates the percentage of employees participating in training programs. Available information has shown the state average to be approx. 70 % of employees participating in training programs. These values are higher than the state average in the ports of A Coruña and Ferrol, in which they included almost 90 % of the workforce in 2016. However, the trend in Vilagarcía and Vigo was that of decrease, falling below the national average in 2015, and dropping to only 50 % of the workforce in 2016. Data for the port of Marín were not available until 2015, and the values have since been around 60 %.

6. CONCLUSIONS

Port-city integration can be considered an intrinsic characteristic of all coastal localities that have achieved economic hegemony or rather realized growth through maritime trade, as a factor that eliminates geographical barriers. The port-city relationship has its advantages and disadvantages, but the development of port 4.0 with a 'blue' perspective is expected to contribute to a sustained and sustainable growth of global economy.

In the first place, the evolution of the term port-city needs to be controlled, i.e. we need to control unifying elements such as companies operating in ports, the labor market and environmental protection measures. If the advantages of this relationship are to be separated from its disadvantages, the evaluation of more complex indicators is required.

Second, in order to take advantage of new technologies, lower their costs and expand their competitive advantage, both the city and the port must prepare for the 4.0 revolution.

Third, since automation must be linked to other aspects, e.g. generate benefits for the city, a number of indicators of the quality of companies operating in the ports have been analyzed.

Fourth, companies with quality certification are evaluated by external agencies and take sustainable management into account in all their areas of activity. Increased presence of this type of company in the city is beneficial for both economic growth and sustainable development of the port and its entire hinterland.

Finally, the analysis of certain indicators of the port labor market, such as the percentage of female employees, has shown that this industry continues to be dominated by men. Employee training, including generic training and training in process updates, and especially in new technologies is considered to be important.

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Matching Interaction Design Principles and Integrated Navigation Systems in an Electronic Classroom

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This article deals with cross-cultural and cross-disciplinary virtual engagement aimed to match human-computer interaction design principles and contemporary integrated navigation information systems. As interaction design principles ten general principles - heuristics are used, and as examples of contemporary navigation information systems, chart Radio Detection (or Direction) and Ranging (RADAR) device and Electronic Chart Display and Information System (ECDIS) are used. This cross-disciplinary research has been achieved through a Collaborative Online International Learning (COIL) project by Durban University of Technology (DUT) in South Africa and University of Colima (UoC) in Mexico. Namely, the students from both sides guided by their lecturers have been engaged in analyzing today's most frequently used marine navigational aids from the perspective of their reliability and user centeredness. The complexity of the systems and the lack of standards are observed as main problems when it comes to marine information systems effectiveness and their user centeredness.

KEY WORDS
~ Collaborative Online International Learning (COIL)
~ Software usability
~ Interaction design principles
~ Chart radar
~ ECDIS

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doi: 10.7225/toms.v09.n01.008

1. INTRODUCTION

Internet has considerably changed people's lifestyle and working conditions worldwide. In parallel, modes of generating and transferring knowledge have been changing. Thanks to the technological advancements, it becomes possible to learn and lecture through a variety of channels that combine face-to-face and virtual engagements. One of those channels is the Collaborative Online International Learning (COIL). In 2014, the Durban University of Technology (DUT) became the first African institution involved in the global network of partners established at the State University of New York (SUNY) COIL system. This has contributed to the development of the curriculum, education in general and graduate attributes, provided systemic benefits for the staff and students, developed innovative cost-effective strategies (Pillay and Samuels, 2016), etc. At present, DUT has several ongoing COIL projects merging several different disciplines: medicine and journalism, chemistry and information technologies, navigational information systems and software testing methods, etc., as a result of collaboration with several overseas universities. The last mentioned couple of modules, i.e. navigational information systems (Maritime Studies Department, DUT) and software testing methods (Engineering Department, UoC) within the COIL are in the focus of our research study. In

this regard, the rest of the paper is organized as follows: Chapter 2 gives a short literature review in the field; Chapter 3 gives an overview of contemporary navigation information systems with an emphasis on chart radar and ECDIS; Chapter 4 contains basic description of human-computer interaction design principles; Chapter 5 gives applied methodology overview; the sixth part presents the outcomes achieved through applying interaction design principles upon selected navigation information systems along with the following discussion; the last chapter contains some conclusion remarks.

2. LITERATURE REVIEW

Several studies on the Collaborative Online International Learning (COIL) projects have been done. Here are presented some of the most comprehensive ones available to the authors. The first one deals with the social media as advanced electronic tools used to support learning among nursing and midwifery students (O'Connor et al., 2018). The key findings of this study are that social media can aid acquiring knowledge and skills among nursery and midwifery students, enhancing confidence, and facilitating professional and personal networks. It has also been concluded that the social media (Facebook, Twitter, and YouTube) as dynamic, interactive online environments can affect the learning processes in several ways. After the detailed and in-depth study, the conclusion has been reached that more robust studies are required to objectively measure whether and how social media improve learning. The second comprehensive study taken into consideration was performed at the University of Arizona, USA (Brooks and Pitts, 2016). It deals with the issue of how students consider and display their own identities through cross-cultural virtual engagement. This study has been focused on the USA college students who have participated in an array of online conversations with students from Singapore, and their conceptions on themselves relative to others in cross-cultural conversations. The study leads to a conclusion that the globally-connected classroom will become a natural extension for many universities. Therefore, more critical discussions and reflections about practices and behaviors of students in their Internet-based cross-cultural exchanges are to be conducted around the globe. Within the context, it is also worth to mention the study which considers transforming teaching, learning, and research through practicing mindfulness and action research study (Brendel and Cornett-Murtada, 2019). The study fosters more mindful university culture through including mindful grading and assessment, awareness of students in the classroom, and cultivating self-awareness in teaching. The COIL projects can support the innovative approach to teaching, learning, and conducting research based on mindfulness mediation and transformative pedagogy. This kind of virtual engagement aims at internationalization of students' learning experience and their preparation for a competitive international labor market and workplace (Anderson et al., 2010; Brooks, 2011, 2012). Collaboration in multi-cultural environments across disciplines requires a higher level of mindfulness in teaching, team work, research, and providing the accompanying services. Concerning the COIL environment, learning processes and outcomes, it is also important to mention the Substitution Augmentation Modification Redefinition (SAMR) model developed by Puentedura (2006). This model has two roles in technology-supported education: enhancement and transportation. Enhancement includes substitution, where technology acts as a direct tool substitute with no functional change, and augmentation, where technology acts as a direct tool substitute with functional improvement. The examples might be a word processor used as a typewriter (substitution), and word processing with spell check (augmentation). On the other hand, transformation includes modification, where technology allows significant task redesign and redefinition, previously inconceivable. For instance, technology enables lesson redesign by using graphs, images, spreadsheets, etc., (i.e. modification), and creation of new tasks, previously inconceivable, e.g. Skype with experts, comparing and combining results via wikis and blogs, publishing worldwide online, coming up to the new conclusions by using different simulation software tools, etc., (i.e. redefinition). Hamilton et al. (2016) gave a critical review and suggestions for the use of SAMR model through three different perspectives: lack of context, rigid hierarchical structure, and putting product over process. Among others, this review concludes that it is an imperative for lecturers to understand how to use technology to promote student learning and achievement in today's interconnected world and ubiquity of technology. Lecturers should explore possibilities of how to operate effectively and efficiently in tandem with technology, in order to promote students' growth and achievement (Koehler et al., 2014). Bower et al. (2012) gave a framework for Web 2.0 learning design in the context of Technological Pedagogical and Content Knowledge (TPACK) model. In this study, the authors considered possibilities of using social bookmarking, wikis, shared documents, blogs, microblogging, presentation tools, podcasting, screen recording, mind-mapping, digital storytelling, etc., in creating a more engaging educational content. Bauk and Radlinger (2013) compared features of Windows Movie Maker, Camtasia Studia, Adobe Premiere, and other advanced dedicated software in reviving instructional materials and making them more alluring for the students. Furthermore, Bauk (2019) proposed a non-monetary return of investment model for assessing success of two recently accomplished COIL projects at DUT, through which she confirmed the hypothesis of high level of lecturers' and students' satisfaction with the virtual engagement, achieved learning outcomes and opportunities for extending further collaboration despite the impediments inherent to the virtual engagement. Recently, Jahnke (2020) has argued that

lecture-based learning should be replaced by action-based learning and gives the following example: a group of students in the history class developed an app that virtually teaches the users about history surrounding the Berlin Wall. Therefore, professors should rethink how they design the courses. They should make a shift from purely lecture-based learning towards technology-based learning where students collaborate and come up with creative and novel solutions in a team setting.

3. CHART RADAR AND ECDIS

A segment of the analyzed COIL project was the DUT students' attempt to explain to their colleagues at the UoC the basic features of the modern chart radar and ECDIS. Accordingly, the following sub-sections give an overview of these two advanced navigation systems.

Radar is the most important electronic aid for observation and evaluations of the risk of collision. (Satellite-) Automatic Identification System (S-)(AIS) and ECDIS must not be used as aids alone, without comparison with the radar display. Most modern radars can show chart data together with ordinary radar data. This is the so-called chart radar. Chart data on chart radar must be updated in the same way as on ECDIS. Also, it is possible to show radar data on ECDIS. This is called radar overlay, while radar video is transferred directly from the video output port on the electronic chart. Radar is the safest aid to coastal navigation. It is almost unthinkable to leave port without having the radar in order. Seafarers should be capable to interpret the radar display in a fast and safe way. They have to be critical about having too much information on the radar screen since the important small echoes can be easily overlooked. All the synthetic data at frequent intervals are to be removed in order to keep a good radar observation.

The primary function of radar, including chart radar, is collision avoidance. On the other hand, ECDIS' primary function is avoiding grounding. ECDIS is a system that displays hydrographic information, which are combined with information provided by electronic position-fixing systems like Global Positioning System (GPS), radar, Automatic Radar Plotting Aid (ARPA), etc., to assist in the safe navigation of a vessel. It consists of Electronic Navigation Chart (ENC) as a data file, and Electronic Chart Display Equipment (ECDE) hardware (Norris, 2013). In addition, ECDIS is a system which can also store and use information from the list of lights, sailing directions, tide tables, etc., together with the chart. An Electronic Chart System (ECS) is a generic term for equipment which displays electronic charts, but which does not satisfy all Safety of Life at Sea (SOLAS) Convention requirements (SeaGull AS, 2001). ECDIS has made a revolutionary change in the traditional way of navigation during the last decade of the 1990s, and there is a tendency for its full implementation at the global level. The main related problems are numerous non-SOLAS ships (Bauk et al., 2017). Both, (chart) radar and ECDIS should be a perfect tandem for supporting seafarers' decision-making in avoiding collision and grounding respectively.

4. USABILITY HEURISTICS AND USER INTERFACE DESIGN

As part of the considered COIL projects, the students at the UoC had the task to explain to the DUT students what is meant by user interface design as part of the analyzed project and how these principles can be applied in the case of integrated navigation systems.

In order to develop applications that are effective, efficient, and easy to use, the developers need to put the user at the center of the development process (Fajardo et al., 2017). Placing users or human elements into the forefront in maritime is a part of IMO resolution A.850(20) (IMO, 2003).

The ten heuristics for user interface design by Jakob Nielsen are the most common principles for designing an effective, interactive and attractive software or hardware interface according to the human factors of users (here seafarers). These heuristics are: visibility of the system status, match between the system and the real world, user control and freedom, consistency and standards, error prevention, recognition rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, helping users recognize, diagnose, and recover from errors, and help and documentation (Nielsen, 2014). The related heuristics can be used to evaluate any user interface in order to detect problems and suggest improvements. The heuristics are applied here to assess users' centeredness in the realm of modern chart radar and ECDIS.

5. APPLIED METHODOLOGY

The project was carried out during eight weeks in March-May, 2019. In the project, twenty-two students from DUT and thirteen students from UoC were involved. Their ages were about twenty and their nationalities were mostly Zulu and Xhosa at DUT, and Mexican at UoC. They were guided by two lecturers: one at DUT, and the other at UoC. Since the South African students were in the field of navigational information systems and the Mexican students were in the domain of software testing methods, they had different tasks. Namely, the South African students' task was to explain to the Mexican students the basis of chart radar and ECDIS, while the Mexican students' task was to apply the ten heuristic principles to assessing user centeredness and friendliness across the mentioned advanced navigational devices' interfaces.

The students were divided into twelve groups, and the teachers provided the lists with the students' names, e-mails, and cell-phone numbers of some students for both the parties

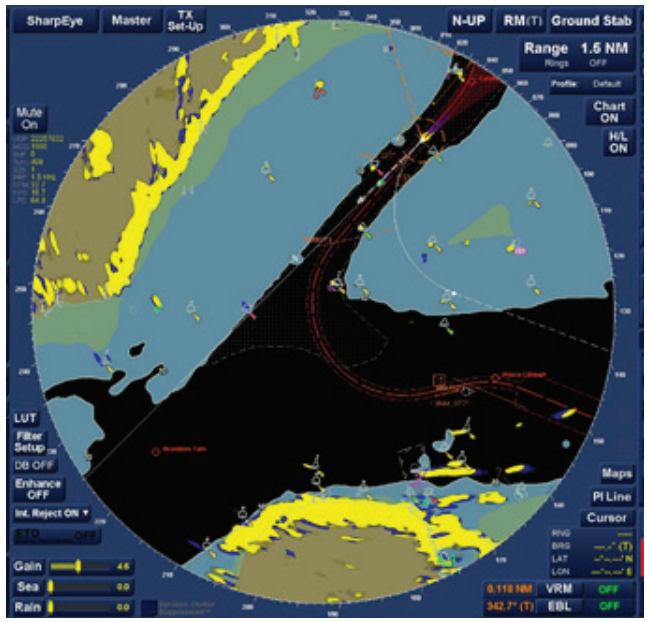

Figure 1.
Chart radar - Kelvin Hughes (Source: Kjerstad (2016), p. 2-77).

involved. Also, the teachers proposed the group leaders at both sides for an initial one-to-one chat. During the ice-breaking Skype session the lecturers explained to the students the project tasks, their roles, and the project goal. They also introduced the students with radar and ECDIS main purposes, functions and key design features on one side, and on the other, with the main principles of ten-heuristics-approach in software design and its testing. When it comes to contemporary navigational devices, different groups of students dealt with different types of navigational equipment interfaces depending on their producers: Kelvin Hughes, (Telchart) Furuno, Selesmar, Simrad, JRC, Maris, Navico, Transas (Wärtsilä), etc.

Afterwards, the students started to chat via mail, WhatsApp, and Skype. In a later phase, they started to work on joint PowerPoint presentations in Google Docs. It was an interesting, dynamic, and edifying process of creating a joint learning environment in the Cloud. The South African students were focused on the main components and purposes of the navigational devices, while the Mexican students were focused on evaluating the interface design according to the heuristics and giving suggestions for improvement. The results of the students' joint work were twelve PowerPoint presentations, whose contents are summarized in the following section. It is important to note that the lecturers from both sides were continuously giving support and directions to the students from both sides. In that regard, in addition to the face-to-face classes at DUT and UoC, several group Skype meetings were organized and realized during the project. It is important to mention that the lecturers and students had to deal with the eight-hour-lag between South Africa and Mexico. Therefore, group Skype meetings were organized in the morning at UoC, i.e. in the evening at DUT. The lecturers used to arrange their own preparatory Skype meetings in their free time and/or during the weekends.

6. EVALUATING THE TEN HEURISTICS ON CHART RADAR AND ECDIS

As stated in the previous section, the heuristic evaluation of some contemporary navigational aids' interface design was performed by the UoC Mexican students, once their DUT South African counterparts had explained them the purposes, basic functions and features of radar in general, with a particular emphasize on chart radar and also on ECDIS. The students were divided in groups and made twelve PowerPoint presentations in Google Docs, out of which their lecturers, i.e., the authors of this paper, have chosen the best insights and summarized them in Tables 1 and 2 on the basis of the analyzed navigational devices' interfaces given in Figures 1 and 2.

The students from UoC were working, among others, on the Kelvin Hughes chart radar display since their DUT counterparts had explained to them the main purpose, different presentations, i.e. the screen orientation, functions available on the display, and communication/connection between ECDIS and radar. The DUT students had also explained in detail the meaning of the symbols on the chart display. The UoC students' observations regarding the advantages and disadvantages of this type of display from the aspect of its design are summarized in Table 1.

Table 1.
Chart radar & ten heuristic principles (Source: Own).

Advantages	Disadvantages
User control and freedom. User has freedom to choose different controls. For instance: TX (transmitting) or RX (receiving); Set-Up: N-UP (north-up), H-UP (head-up) or C-UP (course-up) display mode; RM (relative motion) or TM (true motion) presentation; Ground Stab (ground stabilization) or Sea Stab (sea stabilization), etc. However, the information related to connected sensors can only be monitored on chart radar display. If the user has made an error in the radar configuration, s/he can return to the default configuration of each component of the radar and its display.	**Aesthetic and minimal design.** Due to the complexity of chart radar it is very difficult to provide a minimalist design. The information is unevenly distributed all over the screen so that there is a minimal order and no clear point of reference. In presenting additional data on the chart radar, the operator must evaluate the need for this critically. Important chart radar data can easily drown in unnecessary text and/or graphical symbols.
Match between the system and the real world. There is the absolute match in the true motion and relative motion due to the own ship, which is always in the centre of the display in the relative motion. However, the seafarer familiarization with the relevant moving and fixed objects' presentation is of high importance. Additionally, the chart radar deploys graphical symbols that the seafarer can recognize as boats, buoys, lights, light-houses, pillars, separation schemes, etc. The nuance of sea color can help the navigator to quickly get an overview of the sea depth (e.g., dark blue: shallow water; light blue: deep sea).	**Flexibility and efficiency to use.** The efficient use of chart radar depends mostly on the seafarer's skills. In other words, the seafarers have to adapt to the radar. There is no way round. If one is a beginner in the world of chart radars, s/he will probably have problems to understand the information provided.
Visibility of the system status. The system status is always visible, e.g. Variable Range Marker (VRM) and Electronic Bearing Line (EBL) values are given in [m] and [°] respectively; information on chosen maximal Range is visible, as well as information on Gain, Clutter, etc. However, the screen sometimes indicates a lot of information simultaneously, which can confuse the user. Therefore, the users should know on which information to focus in certain occasions.	**Consistency and standards.** Currently, there is a lack of uniformity and consistency with respect to what information is considered critical and how it should be displayed. For instance, the color of radar objects' presentation on the chart varies with the producer. The names of functions and features including their arrangements may vary as well. New, harmonized performance standards are to be widely adopted and provide *intelligent* integration of all relevant information from different sensors.
Help users to recognize, diagnose and recover from errors The only way in which chart radar can help users in this regard is via audio and/or visual alarms. However, the users, i.e. seafarers, have to be well trained and skillful to diagnose and recover from the error(s).	**Error prevention.** There is no error prevention for the user. The user can not do much when it comes to system error. (S)He must closely observe and follow all the available information from different navigation aids as well as react timely and properly in order to avoid an accident. Chart radar is a monitoring and controlling, but not a handling device. In fact, it is not a maneuvering system, but it can make maneuvering easier.
Recognition rather than recall. The user can easily distinguish between the moving and fixed objects.	**Help and documentation.** Chart radar does not give the user any help on the screen if s/he has a problem while doing a certain activity. If something wrong has happened, the chart radar should give the user a good feedback on the error to assist him/her in resolving the problem. There is always an extensive manual onboard with some help instructions, but they are not always user-friendly or practical.

Another set of observations have been made through the analysis of the students' presentations of Telchart Furuno ECDIS. The South African students explained to their COIL partners from Mexico the main components of the display, including the purpose of tab controls, falling windows, and their key functions (Figure 2).

Upon the explanations given by the South African students, the Mexican students evaluated the design using the ten heuristic principles in order to examine the display from the aspect of its user-centeredness, i.e. easiness of use and, consequently, the reliability of the system. The Mexican students' analyzed and summarized observations are presented in Table 2.

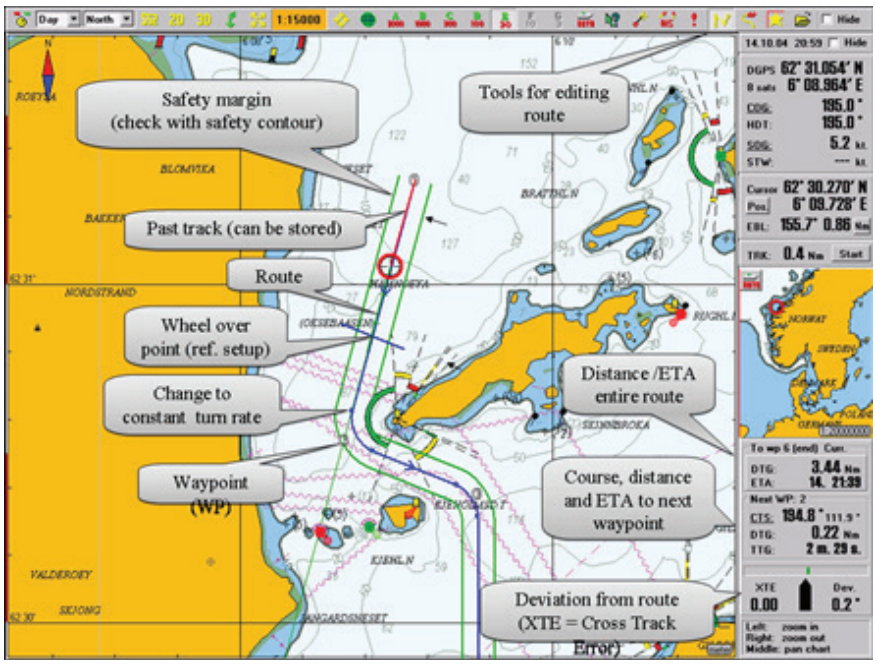

Figure 2.
ECDIS - Telchart Furuno (Source: Kjerstad (2016), p. 2-192).

Table 2.
ECDIS & ten heuristic principles [Source: Own].

Advantages	Disadvantages
User control and freedom. User has freedom to choose different control buttons (upper menu, Figure 4) and different falling control panel windows on the left side of the screen. It has to be pointed out that the arrangement of the controls may vary with the producer. Also, the user can divide the chart area into two parts either horizontally or vertically, getting thus a simultaneous insight both into the closest surroundings of the ship and the wider area. If the user has made an error in adjusting the ECDIS presentation settings, s/he can return to the default presentation mode (standard one) and get quickly an overview of the actual traffic situation.	**Aesthetic and minimal design.** Due to the complexity of ECDIS, it is very difficult to provide a minimalist design. There are a lot of control buttons, control panel windows, and sometimes at the bottom of the screen there are tabs of functional panels for route planning, monitoring, navigational and safety alarms, etc. In presenting additional data on ECDIS, the operator must critically evaluate the actual need. Important ECDIS data can easily drown in unnecessary text and/or graphical symbols.

Match between the system and the real world. There is absolute match with the position of own ship and surrounding objects in real time. This is not the case with paper charts. However, sometimes a mismatching of radar overlay and chart image might happen, and an experienced user should know how to interpret the distortion. Additionally, the ECDIS deploys graphical symbols that seafarer can recognize as boats, buoys, lights, lighthouses, separation schemes, etc. The nuance of the sea color can help the navigator to quickly get an overview of sea depth (e.g. dark blue: shallow water; light blue: deep sea).	**Flexibility and efficiency to use.** The efficient use of ECDIS mostly depends on the seafarers' skills. In other words, seafarers have to adapt to the ECDIS. There is no way round. If one is a beginner in the world of ECDIS, s/he will probably have problems to understand the majority of information provided.
Visibility of the system status. The system status is visible, e.g. ship's longitude and latitude, course and speed over ground, heading, speed through the water, estimated time of arrival, cross track error, etc. Detailed information on each way-point is also available including alteration of course at each waypoint, and alike. Information on wind, current and tide can also be visible. The screen might contain radar and AIS overlay, including all other relevant information for safe and efficient navigation.	**Consistency and standards.** Currently, there is a lack of uniformity and consistency with respect to what information is considered critical and how it should be displayed on ECDIS. For instance, the appearance of the chart display and control panels and/or buttons varies with the producer. The names of functions and features may vary as well. New, harmonized performance standards are to be widely adopted. They provide *intelligent* integration of all the relevant information from different sensors.
Help users to recognize, diagnose and recover from errors The only way in which ECDIS can help its users in this regard is via audio and/or visual alarms. However, the users, i.e. seafarers, have to be well trained and skillful to diagnose and recover from the error(s).	**Error prevention.** There is no error prevention for the user. The user cannot do much when it comes to a system error. The user must sharply observe and follow all available information from different navigation aids to react timely and properly in order to avoid an accident. ECDIS is a monitoring and controlling, but not a ship-handling system although it makes ship handling or maneuvering much easier.
Recognition rather than recall. The user can easily distinguish between moving and fixed objects.	**Help and documentation.** The ECDIS does not give the user any help on the screen if s/he has a problem while doing a certain activity. If something goes wrong, ECDIS should give the user a good feedback of error at the display to assist him/her to resolve the problem. However, there are always the manuals on board with plenty of instructions, but sometimes they are not practical or user friendly.

The following section highlights the observed advantages and disadvantages of the analyzed interfaces of particular types of modern navigational aids, i.e. chart radar and ECDIS, with the intention to give the equipment designers at least an idea about the users', i.e. seafarers' real needs and preferences/expectations when it comes to the display design and available key controls and options.

6.1. Discussion of the Observations

By analyzing the identified advantages and disadvantages of the chart radar and ECDIS displays, due to the ten heuristic principles it can be observed that both analyzed navigational aids satisfy or not the same principles. Namely, in both cases the following have been identified as advantages: presence of user control and freedom; match between the system and the real world; visibility of the system status; ability to recognize, diagnose, and recover from error; feature of recognition rather than recall. On the other hand, the following have been identified as disadvantages: lack of aesthetic and minimal design; flexibility and efficiency of use; consistency and standards; error prevention possibilities; including help and documentation on the screen, which are missing.

Since we would like the designers to concentrate more on the drawbacks of the contemporary navigational devices in the future, we have highlighted some of the key problems noticed that should be overcome. When it comes to both chart radar and ECDIS, the following deserve a further, more rigorous investigation that should lead to systemic improvements in the future:

- (a) Important chart radar and ECDIS data can easily drown in unnecessary text and/or graphical symbols;
- (b) Differences in presentations at different types of chart radar and ECDIS are considerable, depending on their producers. This should be facilitated or the navigators will need specialized training for a particular type of equipment;
- (c) Furthermore, the color of radar (chart) objects and presentations on the chart (radar) vary with the producer. For example, the color used to represent water is not always blue across different radars. Sometimes it is black. The same is with the names of functions and features, including their arrangements on the screen. This should also be harmonized in the future to make the seafarer's job easier and safer;
- (d) There is no error prevention for the user. User cannot actually do anything with the system errors. Sometimes it is difficult to identify them. Therefore, more safety checks and options, including the appropriate alarms, should be conceived of and fitted;
- (e) Neither chart radar nor ECDIS give the user any help on the screen if the seafarer has a problem while doing a certain activity. So, this should also be improved in the future.

Besides these specific recommendations for the designers, in order to improve seafarers' satisfaction and confidence while using these devices, some additional, more general conclusions regarding both collaborative international online learning and navigational equipment interface design are given in the last section.

7. CONCLUSION

This article describes the possibility of matching two disciplines, i.e. navigational information systems (DUT, South Africa) and software testing methods (UoC, Mexico), thanks to the attempts of the involved students and lecturers to attract the attention of the architects of modern navigational aids regarding the need to make these devices more user friendly, more reliable and, consequently, safer. The designers of today's navigational systems should not compete among themselves in terms of which system will be more complex and shiny, but which one would be more user friendly, effective, efficient, and safe.

The chart radar and ECDIS systems must be easy to operate and safe to use. The human machine interface and user friendliness of the earlier systems of this kind is not what the mariners want and are likely to accept today. The technology for improvement is here, but the manufacturers have to invest more effort and money to make the contemporary navigation aids more user-friendly and improve its operational safety. Navigators hope and believe that future chart radars and ECDIS systems will be more user-friendly than they are today. The manufacturers should offer additional options if they are actually useful and can be fitted without confusing the operator. The key to designing interfaces that are effective and easy to use is to focus on the users' context, needs, and motivations.

In addition, the article can be also used as an experimental proof of the below listed usual COIL projects' benefits and impediments. Namely, the common benefits of the COIL projects are: students and staff development, interdisciplinary international and professional collaboration, conversations that lead to other forms of collaboration and engagement, etc. On the other hand, general shortages of the COIL projects are: different time zones, languages, institutional cultures and expectations, academic semester time schedules and requirements, course contents, assessment of learning, quality assurance systems, technological issues, lack of technical and administrative support, and alike. However, both advantages and disadvantages should be taken into consideration and used for paving the way for a further development and achievements within the global electronic classrooms of the future.

ACKNOWLEDGEMENT

We would like to thank the students at the DUT (South Africa) and the UoC (Mexico) for their efforts to accomplish the tasks within the COIL project, and also for their diligence, although they may not agree with all of the interpretations and conclusions of this paper.

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Realism of TRANSAS NTPRO 5000 Radar Simulation in Search and Rescue Training Exercises

Ivan Toman[a], Pero Vidan[b], Mate Barić[a], Luka Grbić[a]

In this study, the results of an evaluation of current navigational simulator Transas NTPRO 5000 ability of realistic training in search operations by radar has been presented. By testing the performance of detecting different targets at various distances from the vessel model and comparing the results to the theoretical models of radar limitations from the literature, we found that the equipment can be used in search and rescue training, but with several important limitations. Some aspects of radar simulation in the current simulator version is considered as acceptably realistic, but we identified several points where the results showed significant deviations from the theoretical models. Those points limit the equipment's ability to perform some aspects of search-by-radar training, and the instructors are advised to carefully set up exercises in a way that those shortcomings are avoided during student training.

KEY WORDS
~ Navigational simulator
~ Search and rescue training
~ Transas NTPRO 5000
~ Radar detection

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doi: 10.7225/toms.v09.n01.09

1. INTRODUCTION AND BACKGROUND

Around 360,000 lives are lost by drowning every year (WMRC, 2019). The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW), adopted by the International Maritime Organization (IMO), requires that all navigational officers must undergo training procedures for search and rescue operations.

In typical SAR operations at sea, both visual and instrumental lookout takes place during area sweeps. However, when visibility is poor, either because of searching for the unlit object during night hours or during the day, in fog or precipitations like rain and especially snow, we cannot rely on visual search methods. In such a situation, different onboard equipment like the vessel's radar, infrared search devices, video cameras, and similar tools might be used to enhance the chances of target detection. Of these, the vessel's radar will be of highest value, given that the target's radar cross-section (RCS) is large enough compared to environmental clutter RCS.

Specialized navigational watch officers' training using navigational simulators is today an industry-wide accepted training method that accelerates gaining experience in handling dangerous situations that can be met in the real world. This method of training is particularly useful when onboard training is either not possible or would be too impractical or expensive. Many papers state that simulator training is an effective means to improve SAR efficiency (Kobylinski, 2011, Feng 2013).

Using simulators in the SAR training has a particular value because of very high costs, potential risks in the real world SAR

exercises, and a limited number of participating personnel (Lubcke, 2016). However, despite having many advantages in navigational officers' training, simulators used in such a way must be very realistic and present reality accurately (Sorensen, 2006). In case of an unrealistic simulation, the training process will be less than optimal and in some cases even impossible, or the experience can be misleading if training is conducted using unrealistic equipment.

The goal of this study is to determine the ability of current nautical simulator equipment commonly found in the Croatian maritime training centers to be used in SAR operations training when the primary way of search is the vessel's radar observation.

As the simulator is a commonly used tool in students' training and a potentially excellent tool for search and rescue exercises, we state our hypothesis that the simulator used must be able to realistically display radar targets regarding the radar sensitivity to target the echo strength and respecting sea horizon limitations.

In this paper, we evaluate the accuracy and limitations of Transas NTPRO 5000 navigational simulator in simulating target detection using radar to test our hypothesis of the product's usability in students' training for search operations by radar. The realism of this particular aspect of the simulator has been tested against the theoretical model of radar detection. The particular tested version of the simulator did not include a special SAR module. The experiments showed mixed results compared to the theoretical models.

2. METHODS

In radar theory, the ability of a radar system to detect a particular object at a certain distance is determined using the basic radar range equation. The basic radar equation is given by (ex. Skolnik, 1981; Gržan, 2012

$$SNR = \frac{P_S}{P_N} = \frac{P_T G_T G_R \lambda^2 \sigma}{(4\pi)^3 R^4 k T_0 B F_n L} \quad (1)$$

where SNR is the signal-to-noise ratio (dB), P_s is the signal power (W), P_N is the noise power (W), P_T is the radar peak transmit power (W), G_T and G_R are the transmitting and receiving gain of the antenna and are usually expressed in (dB), λ is the radar wavelength (m), σ is the target's radar cross-section (m^2), R is the range from the radar to the target (m), k is the Boltzman constant, which equals 1.38×10^{23} W/(Hz K), T0 is the ambient temperature (K), B is the effective noise bandwidth of the radar (Hz), F_n is the radar noise figure (unitless), and L accounts for all the losses in the system (dB).

From Equation 1, by shifting terms the range equation can be derived. It is the maximum range at which the probability of detection of the target is high enough. To quantify the term "high enough", the SNR threshold is regularly used and usually set around 13 dB (Matika, 2013; Budge, 2011). In the literature, this value is also commonly referred to as the detection threshold, and the value around 13 dB is the threshold that represents the probability of 50 % for the target to be detected by the system.

$$R = \frac{P_T G_T G_R \lambda^2 \sigma}{(4\pi)^3 (SNR) k T_0 B F_N L} \quad (2)$$

Apart from radar's ability to detect the echo returned from the target, there is also the limitation of range due to the radar horizon that results from the Earth's surface curvature (Bole, 2005). From ray geometry, the equation for the radar horizon can be derived. In normal atmospheric conditions, with standard refraction, the radar horizon distance equals

$$RHD = 4.12 \cdot \sqrt{H} \quad (3)$$

where the variable H is the height in meters of the radar scanner above the sea level, and the result is expressed in kilometers (ex. Briggs, 1996). When searching for a target floating on the sea surface, the target's height (h) accounts for the increased maximum range for the target to be above the horizon:

$$RHD = 4.12 \cdot (\sqrt{H} + \sqrt{h}) \quad (4)$$

The radar horizon distance expressed in nautical miles should be multiplied with the factor of 2.22 in Equation 4, which yields:

$$RHD = 2.22 \cdot (\sqrt{H} + \sqrt{h}) \quad (5)$$

The radar will be able to detect the target if it is within its radar horizon distance (Equation 5) and within its maximum detection range (Equation 2).

In this paper, using Equations 2 and 5, different case scenarios have been simulated to provide an insight into the maximum range of radar detection. The calculated figures are compared to the observed maximum values using the simulator's radar equipment.

The tested Transas simulator was NTPRO 5000 version 5.35. Apart from the 5 different standalone types of radar simulation (Bridge Master, Bridge Master E, Bridge Master E Tactical, Furuno and Nucleus), the NTPRO 5000 features also a new, Multifunctional Display (MFD) integrated, chart-radar version, which we used in this study. The tested version was MFD 4000 v3.00.340 – MSN-34, build 5225.

Simulation parameters for SAR scenario experiments are given in Table 1. The radar values are copied from simulator settings and the documentation for both X-band and S-band radar models used. The missing values that are not documented are taken from the literature examples (Matika, 2013; Gržan, 2012) assuming the standard maritime radar equipment on large commercial vessels, and those are given in italics inside Table 1.

Table 1.
Simulator radar equipment parameters for X-band and S-band model used. Values for S-band model that are different from X-band are given in parenthesis.
Source: simulator's documentation, Matika, 2013, Gržan, 2012.

Parameter	Value	Unit
Peak transmit power	10,000 (30,000)	W
Antenna gain - transmit	*813*	*W/W*
Antenna gain - receive	*813*	*W/W*
Operating wavelength	0.0315 (0.0983)	m
Ambient temperature	290	K
Effective noise bandwidth	*2x106*	*Hz*
Radar noise factor	*3.98*	*W/W*
All losses	*5.01*	*W/W*
SNR detection threshold	*13*	*dB*

The simulator tested scenarios consisted of setting up target objects at small distance increments away from the stationary vessel model. The maximum distance has been noted for the radar model to be able to detect objects. The radar models were set up in an attempt to get the strongest target echo on the screen, still clearly discernible from the radar noise. The gain setting has been adjusted to 85%, anti-clutter sea and rain settings to 0%, pulse length to long, and echo accumulation filter to off. The radar scale setting was set to 24 nautical miles. The variable range marker tool has been used for distance measurements.

Four different vessel models with significantly different height above the sea surface have been chosen to assess the ability of the simulation to simulate the effects of the radar horizon accurately. The chosen vessel models with their particulars are given in Table 2. The eye height and air draft are taken from the simulator's documentation, whereas the radar antenna height is not documented, so we assumed some additional distance above the eye height (above wheelhouse) depending on the vessel type as the typical radar mast installation, but at a height that is lower than the vessel air draft value.

Both the X-band and S-band models of radar have been used to evaluate their simulated performance. The default simulator radar values have been accepted for X-band and S-band radar models tested, as presented in Table 1.

The radar's ability to detect the total of 5 different target objects (Table 4) has been evaluated. Of those, neither X-band nor S-band radar have been able to detect two objects regardless of the distance from the vessel, vessel model used or number of the same objects grouped together. Those were "Man overboard" and "Lifebuoy". The rest of the objects have been detected by both radar models from all the vessel models, and the obtained figures of maximum distances are presented in the results section.

The simulated environmental conditions were set to calm sea, no wind, and no precipitation, in order to avoid influence

Table 2.
Vessel models used for simulation exercises with particulars concerning estimation of radar antenna height over sea surface.
Source: Simulator documentation and author's estimation.

Abbreviation	Name	Eye height (m)	Air draft (m)	Radar antenna height (m)
BC7	Bulk Carrier 7 Panamax	22	49	35
LNG1	LNG 1	42	67.4	55
RRF6	Ro Ro Ferry 6	6	10.6	8
PBS	Patrol Boat Shkval	2	4.6	4

of the radar clutter on the experiment results, as the theoretical model equations we used do not account for clutter effects..

The radar cross-section (RCS) of a target is the fictional area intercepting the amount of power which, when scattered equally in all directions, produces an echo at the radar equal to that from the target (Skolnik, 1980). Some RCS measurements of real objects floating on the surface of the sea have been documented in literature and examples are shown in Table 3 (Williams, 1978). As the RCS value is highly dependent on the target aspect, there is a range of values for each target, but for this calculation purposes an approximate medium value is selected from the given ranges in the literature.

Table 3.
Typical RCS values for common SAR targets. Sources: (Williams, 1978; Gržan, 2012).

Example target	Typical RCS value (m^2)
Inshore fishing boat / life boat	5
Small open rowing boat	1
Small to medium size metal ship	100
Life raft	0.5
Man overboard	0.1

The RCS values of objects in the simulator are not documented, so we assumed the typical values given in the literature (Williams, 1978; Gržan, 2012) for floating objects similar enough to those used in testing. For the purpose of calculating the maximum theoretical range limited by the radar characteristics and target RCS value ignoring radar horizon limitation, we assumed the RCS value for the target objects as given in Table 4.

It should be noted that non-conductive materials like the ones used for life-buoys have much lower reflection of the radar pulses than conductive materials like metal. So, life-buoy and man overboard object should have small RCS value and, consequently, be much harder to detect on the radar screen. Still, we argue for them having non-zero RCS value that should be at least barely detectable in the environment where no clutter is present and the radar gain setting is maximized. The fact that radar can be used for bird detection has been known for a very long time (Lack and Varley, 1945). Also many radar manufacturers are currently advertising "bird mode" for fishing purposes. So, if radar is able to detect birds at more than several nautical miles away, we claim that it should also be able to detect human head floating above the surface since it is of a size comparable to that of a bird and also because humans and birds share similar tissue properties. Therefore, we hypothesize that the marine radar should be able to detect at least a group of several people floating together around a life buoy if not a single person alone. However, the best method to verify the hypothesis that the marine radar should be able to detect a man overboard or a life-buoy on calm sea would be to perform the actual testing on board vessel (not performed in this study).

Table 4.
Simulator objects used as targets in tests. Target names are from simulator documentation and RCS values are estimated by the authors.

Target object name	Estimated RCS (m^2)	Notes
Life raft	4	Assumed that a medium-size passive radar reflector effect is simulated
Cardinal buoy	2	Assumed that a small-size passive radar reflector effect is simulated
Pella boat	1	
Man overboard	0.1	
Life buoy	0.1	

3. RESULTS

The results of radar ability to detect small targets at a certain distance from the targeted vessels are presented in Table 5. The figures are given as the maximum observed range at which visual detection was still possible for a particular model of the vessel, using X and S-band radar for each type of the target, with the values expressed in nautical miles. In addition, an approximate maximum theoretical distance due to radar horizon in standard atmospheric conditions is given for each combination of radar antenna height and target object height, calculated by using Equation 5, where target height is set to be 1.5 meters above the sea level for all the three detectable target objects, as there is no documented height for those objects in the simulator. Non-detectable objects (man overboard and life-buoy have not been used in the further range calculations). For S band radar, coefficient from Equation 5 is slightly larger than for the X band radar because of increased diffraction of larger wavelength, but the difference is small and insignificant for the results presented. So, we assumed 2.22 coefficient for both radar bands.

Table 5.
Observed maximum radar ranges for targets used for both X-band and S-band radar models. Results are given for all vessel models used. RHD column is radar horizon distance calculated for vessel model antenna height and target object height using the theoretical equation. Two objects that are not detectable at all regardless of distance are left out of the table.
Source: authors' observation.

	Observed max. values (NM)						Theoretical max. values (NM)
Target	Life raft		Cardinal buoy		Pella boat		RHD
	X	S	X	S	X	S	
Vessel model							
BC7	8.5	14	7.5	12	6.7	10.5	15.9
LNG1	8.6	13.5	7.4	11.8	6.2	10.8	19.2
RRF6	8.6	13.4	7.5	11.4	7.1	10.2	9
PBS	8.5	14.1	7.6	12.2	6.5	10.9	7.2

As shown in the table above, there is virtually no observed difference in the maximum range between vessel models for a particular type of radar. However, the simulated detection range significantly surpasses radar horizon distance for the vessel models with low antenna height above sea level. Those findings lead to a conclusion that the radar horizon effect is either not simulated properly or most probably not simulated at all in this particular version of the simulator.

With those figures, documented radar particulars and Equation 2, we calculated the maximum theoretical distance for each combination of radar type and target object. The results are given in Table 6.

In Figure 1, the observed maximum distances of the target objects tested are compared with the theoretical maximum distances depending on target RCS values for both simulated radar models. The theoretical maximum distance lines are calculated using Equation 2 and they ignore the effects of the radar horizon. The observed maximum distances are plotted as scatter plot (dots). The comparison shows an acceptable level of agreement between the theoretical model and the observation on the simulator.

Table 6.
Maximum theoretical range for target objects calculated using radar equation.
Source: authors' calculation.

Life raft		Cardinal buoy		Pella boat		Man overboard / Life buoy	
X	S	X	S	X	S	X	S
7.2	16.8	6.1	14.1	5.1	11.9	2.9	6.7

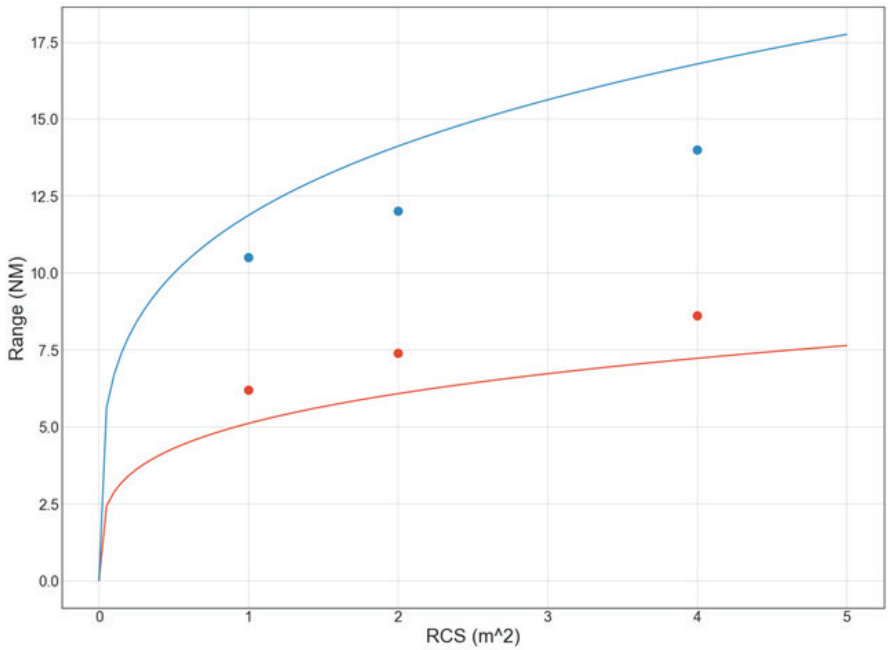

Figure 1.
Comparison of theoretical maximum radar range for a given target RCS value, calculated using radar equation (solid lines, blue for S-band, red for X-band model), with observed maximum distances (dots, blue for S-band, red for X-band model) for three detectable targets at RCS 1 m^2 ("Pella boat"), 2 m^2 ("Cardinal buoy") and 4 m^2 ("Life raft").

4. DISCUSSION, CONCLUSIONS AND FURTHER WORK

The results of the study experiments on the Transas NTPRO 5000 simulator show several shortcomings that can be important for SAR exercise training. In the conducted tests, the simulator was completely unable to detect some target objects like "Man overboard" and "Lifebuoy" regardless of their distance from the vessel. There is a high probability that those objects are not simulated within radar simulation at all and can be used in SAR exercises using visual lookout only. Failure to display those targets on the radar screen makes them unusable for SAR exercises where radar equipment is used, which is practically in all SAR exercises.

Another important problem with realism that we have found out in this study is the radar's inability to simulate the effects of the radar horizon. The results from Table 5 show that no amount of change in radar antenna height above the sea level impacts any results on the maximum detectable distance for low-height objects like small targets used in SAR exercise operations.

On the positive side, the effects of the maximum range depending on the target RCS seem to be simulated with acceptable realism as shown on Figure 1. As target RCS data is not recorded in the simulator documentation, we estimated it and, because of that approximation, it is not possible to comment on the small differences found between the maximum theoretical range and the maximum observed range on the simulator radar screen. However, the general agreement of the results of both X-band and S-band observations vs.(versus???) equation suggests that radar sensitivity and dependency on target RCS are simulated well enough.

Our results show that in simulated SAR exercises on the tested type of simulator the instructor must be aware of its limitations and set up exercises so that the aspects that are not simulated with acceptable realism will not impact the exercise and the training outcomes. In particular, we suggest that objects like "Man overboard" and "Lifebuoy", which cannot be detected on the radar screen at all even in ideal search conditions, are not used in SAR exercises. Also, instructors are advised to pay particular attention to limitations due to the simulator's failure to simulate the radar horizon effect on detectable distances of low-height objects. Special attention has to be put to situations where small vessels are used as SAR units because in such situations targets can appear on the radar screen much farther away than they should as radar horizon limitations have not been simulated. This problem is pronounced with S-band radar simulation because of its ability to detect small RCS targets at much larger distances.

In order to validate some parts of our hypothesis, apart from comparing simulator results to the theoretical models, a comparison with onboard equipment would have been

necessary. This refers particularly to our viewpoint that actual onboard radar should be able to detect life-buoy and man overboard floating on the calm water surface as we are not aware of any study that confirms or rejects this hypothesis. So, that can be a good direction for further research in the area. Also, the real measurement at sea could improve our understanding of radar's maximum detectable range of objects that are detected in simulator tests such as a life-raft and small non-metal boats.

We also suggest that the simulator manufacturer should provide a patch in the future product updates to properly simulate radar horizon effects in the simulation.

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An Overview of Horizon Detection Methods in Maritime Video Surveilance

Miro Petković, Igor Vujović, Ivica Kuzmanić

The interest in video surveillance has been increasing in the fields of maritime industry in the past decade. Maritime transportation system is a vital part of the world's economy and the extent of global ship traffic is increasing. This trend encourages the development of intelligent surveillance systems in the maritime zone. The development of intelligent surveillance systems includes sensor and data fusion, which incorporates multispectral and multisensory data to replace the traditional approach with radars only. Video cameras are widely used since they capture images of greater resolution than most sensor systems. Also, combined with video analytics they provide sensors with high capability, complex pattern recognition analytics, and multiple variables for the decision making process. In this paper, an overview of a small part of the system is presented – horizon detection.

KEY WORDS
~ Video surveillance
~ Horizon detection
~ Projection-based methods
~ Hybrid methods

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doi: 10.7225/toms.v09.n01.010

1. INTRODUCTION

Since radar tracking is sensitive to shape, size and material of the targets, it has to be enriched with other types of sensors for better situational awareness, collision avoidance, and navigation. Video cameras are widely used since they capture images of greater resolution than most sensor systems. Also, combined with video analytics they provide sensors with high capability, complex pattern recognition analytics, and multiple variables for the decision-making process.

Maritime video surveillance is important for a wide range of applications. For example, video surveillance systems are employed to increase the security of ports and ships, to control maritime traffic in ports or a maritime zone, and it is one of the vital systems in autonomous ships. Maritime video surveillance may take place from a small surface-vehicle (manned or unmanned)-mounted camera or buoy in line with the water to static land-based cameras or aerial surveillance from drones. According to (Gladstone et al., 2016; Bloisi et al., 2017; Vujović and Kuzmanić, 2018), maritime surveillance systems have to overcome a set of challenges:

- Wide monitored domain
- Weather issues (rain, snow, fog …)
- Ever-changing nature of the sea (waves, white foam, sun reflections)
- Inconsistent size of tracked objects
- Multiple tracked objects with possible occlusions.

As described in Prasad et al. (2017), basic maritime video surveillance system is composed of five main components: the initial detector, image processor, classifier, tracker, and behaviour analyser if necessary. The basic components of maritime video surveillance are illustrated in Figure 1.

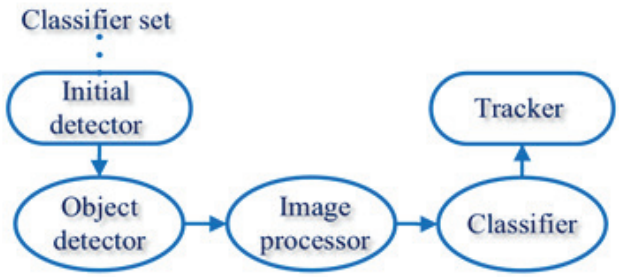

Figure 1.
Basic components of maritime video surveillance.

The initial detector detects pixel motion or an object based on a classifier set. The obtained information is managed by the image processor for noise elimination. Also, relevant regions of interest (RoI) are determined. RoIs in the frame are evaluated by the classifier to determine presence of an object that is object of interest (OOI). The role of the tracker is to locate the OOI in a RoI at each frame and determine its position. The OOI's course and speed are sent to behaviour analyser. These components are not part of every maritime video surveillance system.

This paper presents an overview of horizon detection methods. The second section describes the main topic, using math and examples. It is divided into several subsections dealing with projection-based, region-based, hybrid and ANN (Artificial Neural Networks) methods. Finally, the conclusions are given.

2.HORIZON DETECTION IN MARITIME ZONE VIDEO SURVEILLANCE

Horizon detection is one of the essential tasks in maritime video analysis since its results affect the performance of the surveillance system. This importance can be seen in Figure 2 as it shows a generalized flowchart of data processing in maritime surveillance for object detection.

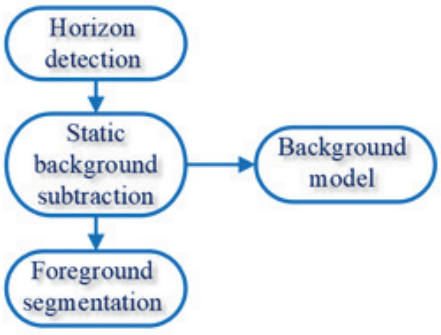

Figure 2.
Generalised flowchart of maritime surveillance data processing for OOI detection (Prasad et al., 2017).

Horizon information is used in some object detection approaches and for the reduction of false positives for a given object detection rate (Jeong et al., 2018a). Also, it is used for distance prediction of another object to the camera (Gladstone et al., 2016) or for maritime target detection and tracking in infrared images (Jian and Wen, 2019). We can distinguish three main approaches for horizon detection: projection-based, region-based and hybrid. We also noted a few methods based on artificial neural networks (ANN).

2.1. Projection-Based Methods

Projection-based methods use edge detectors (Moreira et al., 2014), such as Canny detector (Gershikov et.al., 2013), to compute the edge map of the image. To identify line features more easily, the edge map is projected to another space. For such projections Hugh and Radon transforms are often used.

In the line equation:

$$x \cos(\theta) + y \sin(\theta) = \rho \quad (1)$$

where θ is the angle between x-axis and normal to the line, and ρ is the distance from the origin of the coordinate system to the line. The coordinates (x, y) of an edge pixel are transformed as a curve into the Hough space (θ, ρ) (Ginkel et al., 2004):

$$H(\theta,\rho) = \iint \{1-\delta[I(x,y)]\}\,\delta(x\cos\theta + y\sin\theta - \rho)\,dxdy \quad (2)$$

where δ is the Dirac delta function while I(x, y) represents the edge map. (θ, ρ) cells in the histogram, corresponding to the largest values of H(θ, ρ) represents the line parameters (Prasad et al., 2017).

The Radon transformation is formulated as (Ginkel et al., 2004):

$$R(\theta,\rho) = \iint I(x,y)\,\delta(x\cos\theta + y\sin\theta - \rho)\,dxdy \quad (3)$$

where the cells in (θ,ρ) containing the highest number of entries in R(θ, ρ) define line parameters. The simplicity of projective approaches makes them popular, but they are sensitive to pre-processing (Prasad et al., 2017). Also, when the dominant line is not the horizon line, they frequently fail to detect the correct line (Liang and Liang, 2019).

2.2. Region Based Methods

By estimating the RoI in an image containing the horizon line, Mou et al. (2016) reduced the processing area of the original image, thus reducing the computing expense. Also, the authors used the random sample consensus-based method (RANSAC) hierarchically. This approach proved to be fast, but it also renders errors on scenarios with much noise, e.g. sea-shore scenarios, objects on the horizon, etc. Some region-based methods rely on the fact that in the horizon region, intensity variations are higher than in the sky or sea regions alone. Such intensity variations can be used for horizon detection. Also (Gershikov, 2014) evaluated usage of colour variations in horizon detection. In the paper by Jeong et al. (2018b), the authors investigated the use of RoI method for horizon detection. In the first step, the input image is resized and divided into N horizontal regions with 50 % overlapping, and mean vectors and covariance matrices of the colour distribution are calculated for each region. To calculate the difference between two successive regions, Bhattacharyya distance is used:

$$D(R_1, R_2) = (\mu_1 - \mu_2)^T (\Sigma_1 - \Sigma_2)^{-1} (\mu_1 - \mu_2) \quad (4)$$

where μ and ∑ are the mean vectors and covariance matrices of the colour distribution of the regions.

The region with the highest distance is chosen as the RoI for horizon detection, confirming that average region colour suddenly changes near the horizon. This method detects edges by applying a median filter (with three different scales) as smoothing filter of various sizes. Then, Canny edge detector is applied on the multi scale images independently (Jeong et al., 2018) to obtain the weighted edge map, as follows:

$$W(x,y) = \sum_{s=1}^{N} w_s \cdot E_s(x, y) \quad (5)$$

where:

N represents the number of median filters

w_s is the weight of scale s

E_s is the edge maps of the scale s.

For the horizon line estimation, Hough transform and a least square method are used sequentially. This approach showed reliable performance, but when the horizon edges could not be detected because of blur occurring due to the moving camera problem, its performance degraded. To solve this problem, the authors suggested using sophisticated filtering methods to overcome the motion of vessels.

In Sun and Fu (2018), for unmanned surface vehicle (USV) application, the authors used line segment detection algorithm with fast computational speed (von Gioi et al., 2010). By applying gradient features to extract all line segments for building a pool of candidate lines. Since the pool will probably contain many false detection results, hybrid feature filtering is used to select segments of the horizon line from candidate pool. Morphology features and colour features of the horizon line are used to filter out the false results and, similar to Jeong et al. (2018b), calculate the distance between the regions. Line segments are stitched using RANSAC to obtain the whole horizon line. The average computing time for this method was 94 ms (Sun and Fu, 2018), and it proved to be fast and robust. Also, when the horizon lines are very blurry as shown in Fig. 3 b), its performance degraded.

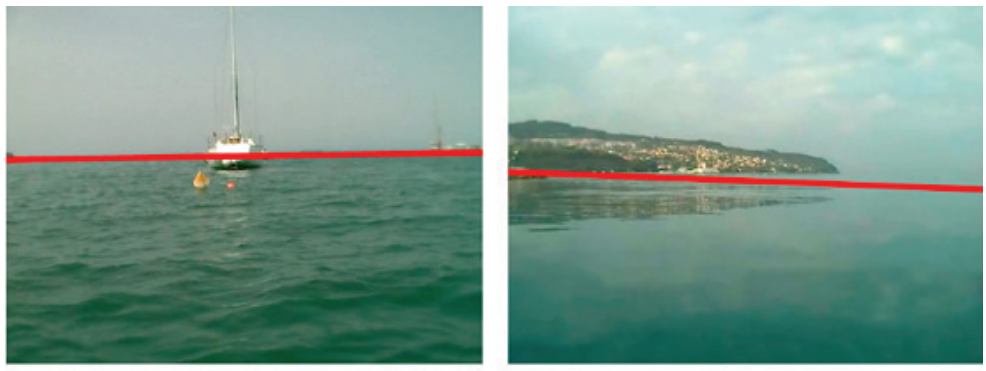

Figure 3.
Results of CFS horizon line detection method (Sun and Fu, 2018, CC BY Licence).

2.3. Hybrid Methods

Fefilatyev et al. (2012) used a hybrid approach to generate the line estimation by projection method and then applied statistical analysis. Regions below and above the estimated line are considered as potential sky and sea regions, then their statistical distributions were computed. Then Bhattacharyya distance between the two distributions was calculated as follows:

$$f(Y, \alpha) = (\lambda_1 - \lambda_2)^T (\Sigma_1 + \Sigma_2)^{-1} (\lambda_1 - \lambda_2) \quad (6)$$

where λ and ∑ represent the mean vector and the covariance matrix of distribution, and the estimated line with the maximum value is chosen as horizon. In Lipschutz et al. (2013) a similar method is proposed, where at the pre-processing stage they used morphological filter, and histograms of sky and sea regions were calculated to produce the colour distribution of each region.

The method proposed by Liang et al. (2015) consists of three parts, as shown in Fig. 4.

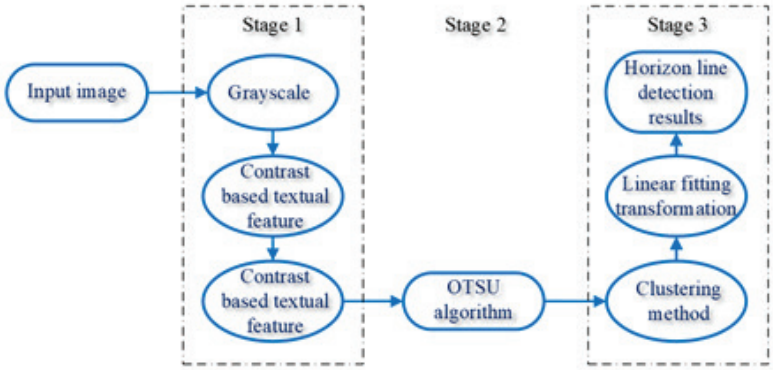

Figure 4.
Flowchart of method proposed by Liang et al. (2015).

The first part locates the horizon region by using grey level concurrence matrix from the texture feature. This feature helps in the reduction of interference caused by waves and light. The second structure consists of OTSU algorithm used for obtaining a set of estimated points of the horizon line. The third structure is the horizon line detection, which eliminates unwanted points caused by ships and waves appearing on the horizon. For this purpose, the authors designed a simple clustering algorithm with a low computation cost. The proposed method proved to be very capable for maritime images under complex background, e.g. clouds, sea waves or too much light. The authors noted that by narrowing the search window this approach can perform faster to achieve a greater processing speed without affecting the accuracy of horizon detection.

In their paper, Prasad et al. (2016a) proposed a multi-scale cross modal linear feature (MSCM-LiFe) method, where multi-scale approach for edge detection is adopted. Multi-scale images I_s are computed with vertical median filter of scale s. For estimation of the horizon line, Hough transform (Eq. 1) is used, and top 10 candidates with the largest values of H(θ,ρ) are selected and their Hough score H_n is stored . Also, mean multi-scale image ($\tilde{I}_s$) is computed, and intensity variation is calculated for each column of pixels defined by pixel x, so the point (x,y'(x)) is determined as follows:

$$y'(x) = \arg\max_y \left| \frac{d\tilde{I}_s(x.y)}{dy} \right| \quad (7)$$

Then, a line is fitted on all points of maximum intensity variation and is used as IVA candidate. For each scale s, the mean value of intensity gradients of all columns is determined to obtain IVA score S_s:

$$S_s = \underset{x}{mean} \left| \frac{d\tilde{I}_s(x.y)}{dy} \right|_{y=y'(x)} \quad (8)$$

Each Hough candidate n and IVA candidate s are used to compute the goodness score of the pair and their geometric proximity. Goodness score is defined as:

$$G(n,s) = H_n S_s \quad (9)$$

while geometric proximity P(n,s) is defined as:

$$P(n,s) = \left(1-\left(\frac{y_n - y_s}{max\,(y)}\right)^2\right) cos^2\,(\alpha_n - \alpha_s) \quad (10)$$

where max(y) is the number of pixels along the y-axis, $(Y_n-Y_s)/max(y)$ is the relative vertical distance between horizon candidates (n, s), the term $(\alpha_n-\alpha_s)$ represents angular difference (Prasad et al., 2016a). By analysing goodness score and geometric proximity of each estimated pair, the final horizon line is obtained by selecting the Hugh candidate with highest affirm score A(n, s):

$$A(n,s) = G(n,s)\,P(n,s) \quad (11)$$

According to Sun and Fu (2018), MSCM-LiFe has high average computation time of 231 ms. Also, this method scored excellent results when horizon line was blurry, as shown in Fig. 5 b), but when horizon line was partially occluded by ships or objects, it failed to detect the line accurately Fig. 5 a).

Figure 5.
Results of MSCM-LiFe horizon line detection method (Sun and Fu, 2018, CC BY Licence).

Also, in the paper by Prasad et al. (2016b) multi-scale consistence of weighted edge Radon transform (MuSCoWERT) method was proposed. First, this method generates multi-scale images by applying edge preserving filter, with different sizes. It helps in smoothing intensity variations not related to the edges, coming from dynamic sea and sky noise. Then, by analysing the length of the edges the authors generated weighted edge map. Radon transform is applied for each weighted edge map to approximate parameter of the estimated line. Then, by observing each estimated line parameter, final horizon line is selected by voting. Despite its excellent performance, this method can fail in certain scenarios where the horizon line is occluded by various objects or ships.

Most hybrid methods require statistical analysis for the horizon detection since the number of estimated horizon lines is large. Hence, they have high computation time.

2.4. ANN-Based Methods

Machine learning approach was proposed by Fefilatyev et al. (2006) where they manually drew the horizon line as a ground truth θ and ρ parameters of line on each image used for classifier training. All pixels that satisfied:

$$x\,cos\,(\theta) + y\,sin\,(\theta) < \rho \quad (12)$$

were labelled as sky-pixel, and all pixels that satisfied:

$$x\,cos\,(\theta) + y\,sin\,(\theta) \geq \rho \quad (13)$$

were labelled as ground-pixel. The authors defined 21 attributes for each pixel, texture measurements for each of the three colour channels (described in Fefilatyev et al., 2006) for a histogram of 10 x 10 region centred on each pixel. The output of the classifier is a black and white image (representing ground and sky) in which they obtained the line that separated the white and black regions declaring it as the horizon line. The results of this approach largely depend on the amount and variety of data used

for classifier training, and have lower accuracy under changing lighting conditions.

In Kristan et al. (2016), the authors used image segmentation with weak priors for obstacle detection on USV. The role of the semantic segmentation is to assign every pixel its appropriate class label. The authors observed that each image can be split into three semantic regions where the bottom region represents the sea, top region represents the sky while middle region can represent the land or horizon region. Their approach estimates per-pixel class probabilities and optimizes segmentation within a single online framework, avoiding the need for a good horizon detection estimation. However, this probabilistic approach is general enough to include horizon detection if needed. Semantic segmentation approach is evaluated by Ahmad et al. (2017) on land-sky images under various weather and illumination conditions. Fully convolutional network performed the best on said images, but further post processing is required to improve the segmentation. Cane and Ferryman (2018) evaluated semantic segmentation networks (SSN) for object detection system in the maritime environment. The authors proposed a simple system which takes RGB images on input. Then, images are processed using SSN to generate the probability distribution of a class for each pixel. A binary map is created for each class by selecting pixels with the maximum probability for that class. Next, by marking the connected components and computing bounding boxes, estimated regions are extracted from the binary maps. For network training, they used subset of the ADE20k dataset because it was the only dataset available at the time which covers the appropriate classes with pixel level ground truth. The authors found that their approach made the horizon line detection easy by extracting it from segmentation map.

A novel approach for horizon detection was proposed by Jeong et al. (2018a). The authors segmented each pixel into semantic categories using a pyramid scene parsing network (PSPnet). To extract sea line, in each column of the segmented image PSPnet searches for the maximal vertical location corresponding to the sea. Unnecessary edges are excluded by using brightness variation analysis. For situations where the horizon is occluded by objects such as ships or buoys, the authors implemented a robust line fitting method to complement the PSPnet. To estimate candidate line, the least squares method is applied to the boundary image. The residual, between the estimated line and the boundary pixels is calculated. The pixels with distances larger than the median residual are ignored. Repeating this process until convergence of the horizon parameters improves the accuracy and robustness of the horizon line detection of this method.

The use of back propagation neural network (NN) was evaluated in the paper by Kumeechai and Jiriwibhakorn (2019) and tested versus Hough transform, least squares and RANSAC. Their focus was on the accuracy rate and efficiency of the horizon detection. Back propagation NN gave the best results in general, but with high computation time. Therefore, it is not suited for embedded applications. Praczyk et al. (2019) applied AutoEncoder NN for horizon line detection in maritime images taken in the open sea. Hough transform was applied for line extraction and was represented by a feature vector containing the average brightness of the image fragment below and above the line. Then, authors trained an AutoEncoder on the representations of only true lines, while neglecting the remaining lines. The aim of this approach is to obtain the network that would be able to accurately reconstruct true lines on the output, while the other lines should be reconstructed with greater error than the true lines. This method proved highly effective for horizon detection, but is highly computation demanding.

3. CONCLUSION

Research in the field of maritime video surveillance is increasing every year, but there are not many papers in the horizon detection niche, as can been observed from this overview. The projection-based, region-based, hybrid and ANN-based methods for horizon detection are discussed in the paper. Simplicity is the main advantage of projection-based methods, but they often fail in the horizon line detection when horizon is not the dominant line in the frame. On the other hand, the region-based methods have proved to be reliable in the horizon line detection with low computation time, which is ideal for static land-based maritime surveillance. However, its performance degraded when used on buoy as system due to blur occurring from the moving camera problem. Hybrid method combines projection and/or region-based methods with statistical analysis with excellent results. The usage of statistical analysis greatly increases the computation time, but this problem can be reduced by narrowing the search window. The researches of ANN methods in the maritime surveillance increased in the past couple of years. They have proved to be very effective in the maritime object segmentation and made the horizon line detection easy, accurate, and robust. ANN methods will improve even more if the number of datasets with pixel-level ground truth for semantic segmentation network training increases.

ACKNOWLEDGMENT

This research has been performed as a part of the scientific project "Establishment of reference database for studying the influence of weather conditions on marine video surveillance" at the Faculty of Maritime Studies, University of Split, and the project "Functional integration of the University of Split, Faculty of Maritime Studies, Faculty of Chemistry and Technology, and Faculty of Science through Development of Scientific and Research Infrastructure in the Building of 3 Faculties,

KK.01.1.1.02.0018", financed by the EU. It is conducted by the research group "New technologies in maritime" at the Faculty of Maritime Studies in Split.

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CONTRIBUTION

News
Pjesme / Poems
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News

Workshops on research integrity and PhD supervision at the Maritime Faculty in Split

In this academic year, the Faculty of Maritime Studies in Split launched a PhD program: Technology in Maritime.

Two workshops have been organized in the framework of the PhD program as part of continuous education of teachers and students:

1. "Research Integrity" held by our fabulous full professor Ana Marušić, and

2. "Supervision of PhD Students – Obligation or Challenge", held by professor emeritus Matko Marušić.

As the program is held in English, it can also be enrolled by foreign students.

Monography of the Faculty of Maritime Studies: 60 years of seafarer education

The Faculty of Maritime Studies (University of Split) marked its 60th anniversary in December 2019 by opening its Planetarium and publishing a bilingual monography titled "Logbook 1959-2019" in Croatian and English. The monography recounts the faculty's history, presents ongoing scientific research and activities, and gives a list of graduates. We extracted several paragraphs on the history of maritime education:

"The 60-year long development of the Faculty of Maritime Studies in Split has been based on the thousand-year long maritime tradition of the region of Dalmatia. The development has experienced a number of formal, organizational, structural, functional and historic changes, resulting primarily from a rapid economic growth on the national and international maritime markets, but also from significant political changes. Croatian maritime tradition started in the Early Middle Ages, in the times of Illyrian, Phoenician and Greek settlements on the eastern Adriatic coast. From the 7th century onwards, many records confirmed the arrival of the Croats on the Adriatic shores, their growing economic and military power, and their maritime ventures.

… The city of Split was founded over 1,700 years ago. Throughout its history, Split has always been one of the major maritime and economic nodes on the Adriatic. This resulted in the need for maritime education. According to the results of the research on the organized maritime schooling in Split, it can be stated that the first relevant institutions were founded 170 years ago. The 105-year long rule of the Austro-Hungarian Empire over the region of Dalmatia and the city of Split (1814 - 1919) saw a rapid growth of shipbuilding, shipping and maritime affairs, and the Empire decided to establish maritime schools in Split, Zadar, Dubrovnik, and Kotor, in addition to the already existing schools in Trieste and Rijeka. The first Maritime School in Split was founded on 24 September 1849 and became fully functional in March 1850.

…Much later, in 1925, the first marine engineering department was founded in Technical High School in Split. Maritime education was interrupted again in 1953, and the local seamen that needed secondary education had to wait until 1959 when the Maritime College in Split was established.

…The development of maritime higher education (1959 -2019) has been vitally dependent on the growth of the secondary education and the progressive development of new technologies in the sea-borne and multimodal transport."

JÔ, DA MI JE

Izvor Oreb

O HOW I WISH I COULD

trans. by Mirna Čudić Žgela

Jo, da mi je opet pasat rivon
Priko Kalih kad se zora javja
I sa svojin dobrin mi tovaron
Poći starin putun po Zanavja.

Što bi voli posli pravog dažja
Navonjat se zemje i morača,
Što bi voli kako nekad davno
Zaspat slatko u hladu rogača.

Jo, da mi je sa gundulun poći
Do Proizda veslajuć pomalo,
Na mrkinti smokrit noge samo
Uz vonj braga kad je osekalo.

Što bi voli kad bi samo moga
U bonaci svrgat nasrid vale,
Gledat Luku i vrh kampanela
U sutonu dok se svitla pale.

O how I wish I could once more pass along the waterfront
Across the Kali, at the break of dawn,
Riding my good old donkey
On the old path to Zanavje.

O how I long, after a shower of rain,
To breathe in the sweet scent of soil and fennel,
O how I would love, as in those days of yore,
To sink into a sweet slumber in the shade of a carob tree.

O how I wish I could, in my little boat,
Go to Proizd, rowing leisurely,
Just dip my feet from a rock
Inhaling the smell of sea-weed at low tide.

How I would love, if only I could,
In a dead calm, to moor my boat mid-bay,
Gaze at Luka and the top of the church-tower
In sunset twilight as lights are coming on!

RJEČNIK

pasat	proći
tovar	magarac
pu	put, prema
dažja	kiše
morač	aromatična biljka momorač, anis
gundula	vrsta male barke
mrkinta	stijena, grota
brag	morska travanj
svrgat	usidriti se
kampanel	zvonik

ART

LANTERNA NA ŠKOJU

Izvor Oreb

O, lanterno na pustemu škoju,
Iz larga se tvoja svitlost vidi,
Daješ nadu, sigurnost i voju,
Ko te vidi, ti te uvik slidi.

Pokazuješ kojin putun poći,
Kad nevere grube nas zatvoru
U samoći dugih, škurih noći,
Kako plovit i dočekat zoru.

Kripiš viron bidne odbačene
I klonule prid svojin vratima
Od strpjenja jadno izmučene.

Pa u tebi smirenje nahodu,
Crikvo naša otvorena svima,
O, lanterno, put si svomu rodu!

LIGHTHOUSE ON AN ISLAND

trans. by Mirna Čudić Žgela

O lighthouse on a desert island,
Your light is seen from afar,
You give hope, safety, an a will to live,
He who sees you, will follow you incessantly!

You show which way to go
When we are flogged by ferocious storms
In the loneliness of long, dark nights,
Which way to sail and how to see dawn.

With faith you strengthen the poor outcasts
And those exhausted and despondent at their own threshold,
Worn out by long suffering.

In you they find tranquillity and peace,
You, church open to all,
O you beacon, you are the path to all our kinsfolk!

RJEČNIK

lanternas	vjetionik
škoj	otok
iz larga	iz daleka
škuro	crno, mračno
bidne	jadne
jadno	jako
nahodit	nalaziti

About ToMS: Ethics, Conflict of Interest, License and Guides for Authors

The Journal is published in English as an open access journal, and as a classic paper journal (limited edition).

ToMS aims at presenting the best maritime research primarily, but not exclusively, from Southeast Europe, particularly the Mediterranean area. Papers will be double-blind reviewed by 3 reviewers. With the intention of providing an international perspective at least one of the reviewers will be from abroad. ToMS also promotes scientific collaboration with students and has a section entitled Students'ToMS. These articles also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, books and workshops in the fields of maritime science.

Our interest lies in general fields of maritime science (transport, engineering, maritime law, maritime economy) and the psychosocial and legal aspects of long-term work aboard.

1. PUBLICATION ETHICS

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Plagiarism is arguably the most complicated ethical issue. Our policies define plagiarism as "taking material from another's work and submitting it as one's own." ToMS *holds authors — not the Publisher or its editors and reviewers — responsible* for ensuring that all the ideas and findings included in a manuscript are attributed to the proper source. We also refer to our role as steward of what constitutes ethical conduct. Ethical misconduct is the reason for our commitment to continue to strive to educate all the parties in the publishing process how to handle this matter. As a member of Crossref, ToMS has a powerful weapon – iThenticate system, which is not perfect.

"Even if there were reliable and sensitive plagiarism detection software, many issues would remain to be addressed.

For example, how much copying is legitimate? Clearly, the reuse of large amounts of others' text constitutes plagiarism. But what should one think about copying short passages from the author's own earlier work, such as commonly occurs in the Methods section? In the Nature article it is suggested that some journals set a quantitative limit whereby the amount of text that can be reused is limited to about 30 percent. This may be utilitarian, but it seems curious and arbitrary that 25 percent of copied text might be deemed acceptable whereas 30 percent might not. Indeed, two authors who copied the same number of words could find themselves on opposite sides of that border if one author simply was more verbose and thus diluted their plagiarized content below the threshold! No, this is not a simple issue at all." [cited from: http://newsletter.aspb.org/ethics.cfm]

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The Journal is published in English as an open access journal, and as a classic paper journal (limited edition).

ToMS aims at presenting the best maritime research primarily, but not exclusively, from Southeast Europe, particularly the Mediterranean area. Papers will be double-blind reviewed by 3 reviewers. With the intention of providing an international perspective at least one of the reviewers will be from abroad. ToMS also promotes scientific collaboration with students and has a section entitled Students'ToMS. These articles also undergo strict peer reviews. Furthermore, the Journal publishes short reviews on significant papers, books and workshops in the fields of maritime science.

Our interest lies in general fields of maritime science (transport, engineering, maritime law, maritime economy) and the psychosocial and legal aspects of long-term work aboard.

6.1. Before you Begin

6.1.1. Ethics in publishing

For information on Ethics in publishing and Ethical guidelines for journal publication see Publication Ethics

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All authors are requested to disclose any actual or potential conflict of interest including any financial, personal or other relationships with other people or organizations within three years of beginning the submitted work that could inappropriately influence, or be perceived to influence, their work.

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6.2. Guidelines for Authors: Manuscript Preparation and Submission

6.2.1. Organization of the manuscript

First (title) page

The first page should carry:

a. the paper title;

b. full names (first name, middle – name initials, if applicable), and last names of all authors;

c. names of the department(s) and institution(s) to which the work should be attributed. If authors belong to several different institutions, superscript digits should be used to relate the authors' names to respective institutions. Identical number(s) in superscripts should follow the authors names and precede the institution names;

d. the name, mailing address and e-mail of the corresponding authors;

e. source(s) of research support in the form of financial support, grants, equipment or all of these.

Last page

The last page should carry:

a. ethical approval, if required;

b. authors' declarations on their contributions to the work described in the manuscript, their potential competing interests, and any other disclosures. Authors should disclose any commercial affiliations as well as consultancies, stock or equity interests, which could be considered a conflict of interest. The details of such disclosures will be kept confidential but ToMS urges the authors to make general statements in the Acknowledgement section of the manuscript.

c. a list of abbreviations used in the paper (if necessary);

Other pages

Each manuscript should follow this sequence:

- title page;
- abstract;
- text (Introduction, Methods, Results, Conclusions/ Discussion);
- acknowledgments;
- references;
- tables (each table complete with title and footnotes on a separate page);
- figures and figure legends, and the last page.

6.2.2. Text organization and style

6.2.2.1. Abstract

The second page should contain the Abstract. ToMS requires that the authors prepare a structured abstract of not more than 250 words. The abstract should include (at least) four sections: Aims, Methods, Results, and Conclusion, not necessarily separated.

Aim. State explicitly and specifically the purpose of the study.

Methods. Concisely and systematically list the basic procedures, selection of study participants or laboratory/ experimental/simulation setup, methods of observation (if applicable) and analysis.

Results. List your primary results without any introduction. Only essential statistical significances should be added in brackets. Draw no conclusions as yet: they belong in to the next section.

Conclusion. List your conclusions in a short, clear and simple manner. State only those conclusions that stem directly from the results shown in the paper. Rather than summarizing the data, conclude from them.

6.2.2.2. Main text

Do not use any styles or automatic formatting. All superscripts or subscripts, symbols and math relations should be written in MathType or Equation editor.

Introduction

The author should briefly introduce the problem, particularly emphasizing the level of knowledge about the problem at the beginning of the investigation. Continue logically, and end with a short description of the aim of the study, the hypothesis and specific protocol objectives. Finish the section stating in one sentence the main result of the study.

Results

Key rules for writing the Results section are:

a. the text should be understandable without referring to the respective tables and figures, and vice versa;

b. however, the text should not simply repeat the data contained in the tables and figures; and

c. the text and data in tables and figures should be related to the statements in the text by means of reference marks.

Thus, it is best to describe the main findings in the text, and refer the reader to the tables and figures, implying that details are shown there. The formulations such as "It is shown in Table 1 that the outcome of Group A was better than that of Group B" should be replaced by "The outcome of Group A was better than that of Group B (Table 1)."

The need for brevity should not clash with the requirement that all results should be clearly presented.

Discussion/Conclusions

The discussion section should include interpretation of study findings in the context of other studies reported in the literature. This section has three main functions:

a. assessment of the results for their validity with respect to the hypothesis, relevance of methods, and significance of differences observed;

b. comparison with the other findings presented in the relevant literature; and

c. assessment of the outcome's significance for further research.

Do not recapitulate your results, discuss them!

6.2.2.3. Tables

Information on significance and other statistical data should preferably be given in the tables and figures. Tables should not contain only statistical test results. Statistical significances should be shown along with the data in the text, as well as in tables and figures.

Tables should bear Arabic numerals. Each table should be put on a separate page. Each table should be self-explanatory, with an adequate title (clearly suggesting the contents), and logical presentation of data. The title should preferably include

the main results shown in the table. Use tables in order to present the exact values of the data that cannot be summarized in a few sentences in the text.

Avoid repetitive words in the columns: these should be abbreviated, and their explanations given in the footnotes. Present data either in a table or a figure.

Each column heading for numerical data given should include the unit of measurement applied to all the data under the heading. Choose suitable SI units.

Place explanatory matter in footnotes, not in the heading.

Explain in footnotes all nonstandard abbreviations that are used in each table.

6.2.2.4. Figures

Figures should be numbered in sequence with Arabic numerals. Legends to figures should be listed on a separate page, in consecutive order. Minimum resolution for all types of graphics is 300 dpi and 600 dpi is recommended. The legend of a figure should contain the following information:

a. the word "Figure", followed by its respective number;

b. figure title containing major finding (e.g. Manuscripts which follow Guidelines for Authors had higher acceptance rate, and not Relationship with manuscripts style and their acceptance rate).

Use simple symbols, like closed and open circles, triangles and squares. Different types of connecting lines can be used. The meanings of symbols and lines should be defined in the legend.

Each axis should be labeled with a description of the variable it represents.

Only the first letter of the first word should be capitalized. The labeling should be parallel with the respective axis. All units should be expressed in SI units and parenthesized. Make liberal use of scale markings.

Graphs, charts, titles, and legends in accepted manuscripts will be edited according to ToMS style and standards prior to publication.

Preferred format for graphs or charts is xls. Graphs and charts saved as image (raster) files such as JPG, TIF, or GIF and imported or copied/pasted into Word or Power Point are not acceptable.

The resolution for photographic images should be at least 300 dpi, and minimum image width should be 6 cm. Please submit files in RGB format. For published manuscripts, image files will be posted online in their original RGB format, maintaining the full color of your original files. Note that we will still need to convert all RGB files to CMYK for printing on paper and color shifts may occur in conversion. You will not receive a CMYK proof. You can view an approximation of print results by converting to CMYK in Adobe® Photoshop® or Adobe® Illustrator®.

6.2.2.5. Authorship statement

All contributing authors must fill out and sign these statements and submit them to the Editorial Office. Accepted manuscripts will not be published until signed statements from all authors have been received.

6.2.2.6. Acknowledgments

Technical help, critical reviews of the manuscript and financial or other sponsorship may be acknowledged. Do not acknowledge paid services, e.g. professional translations into English.

6.2.2.7. References

References cited in the manuscript are listed in a separate section immediately following the text. The authors should verify all references. Usage of DOIs is mandatory.

Examples of citation in text:

It is well known fact (Strang and Nquyen, 1997; Antoniou, 2006) that FT is not an appropriate tool for analyzing nonstationary signals since it loses information about time domain.

First group of authors (Vetterli and Gall, 1989) proposed Multiresolution Signal Analysis (MRA) technique or pyramidal algorithm. Second group (Crochiere et al., 1975; Crochiere and Sambur, 1977) proposed subband coding algorithm. Legal acts are cited as in example: The Constitution of the Republic of Croatia (Constitution of the Republic of Croatia, 2010) is the main legal source for this subject matter, as well as any other subject matter relating to the Croatian legal system. References from the Web are cited in the text as (Author(s) last name, year of origin if known (year of accessed in other cases). If the author is unknown, such as in case of company web page, instead of author's name, title of the web page is used.

Examples for reference section:

Journals

Petrinović, R., Wolff, V. S., Mandić, N. and Plančić, B., (2013), International Convention on the Removal of Wrecks, 2007. – a New Contribution to the Safety of Navigation and Marine Environment Protection, Transaction on Maritime Science, 2(1), pp. 49-55., https://doi.org/10.7225/toms.v02.n01.007

Pennec, E. and Mallat, S., (2005), Sparse Geometric Image Representations with Bandelets, IEEE Transactions on Image Processing, 14(4), pp. 423 – 438., https://doi.org/10.1109/TIP.2005.843753

Web links

Donoho, D., Duncan, M. R., Huo, X. and Levi, O., (1999), Wavelab, available at: http://www.stat.stanford.edu /_wavelab/, [accessed 12 August 2011.].

Unknown, Wavelab, available at: http://www.stat.stanford.edu /_wavelab/, [accessed 12 August 2011.].

ToMS home page, available at: http://www.toms.com.hr, [accessed 12 July 2012.].

Books

Mallat, S., (2009), A Wavelet Tour of Signal Processing, 3rd Edition, New York: Academic Press.

Chapter in book

Hymes, D. H., (1972), On Communicative Competence, in: Pride, J. B. and Holmes, J. (eds), Sociolinguistics, Selected Readings, pp. 269-293. (Part 1 if exists), Harmondsworth: Penguin.

Šoda, J., Beroš, S. M., Kuzmanić, I. and Vujović, I., (2013), Discontinuity Detection in the Vibration Signal of Turning Machines, in: Öchnser A. and Altenbach, H. (eds), Experimental and Numerical Investigation of Advanced Materials and Structures, Advanced Structured Materials (serial name if applicable), 41 (volume number if applicable), pp 27-54. (part if applicable), Heidelberg: Springer., https://doi.org/10.1007/978-3-319-00506-5_3

Conference proceedings

Łutowicz, M. and Lus , T., (2013), Effect of Loss of Cylinder Pressure Indicating Channel Patency on Parameters Values Obtained from Indicating Graph, Proc. 5th International Maritime Science Conference, Solin, Croatia, April 22 – 23, pp. 382-389., available at: http://www.pfst.hr/imsc/archive/2013/IMSC2013_proceedings.pdf

Kingsbury, N.G. and Magarey, J.F.A., (1997), Wavelet Transforms in Image Processing. Proc. First European Conference on Signal Analysis and Prediction, Prague, Czech Republic, June 24 – 27, Birkhauser, pp. 23 – 24., available at: http://www.sigproc.eng.cam.ac.uk/~ngk/publications/ngk97b.zip, [accessed 12 August 2011.].

Regulations, standards or legal acts:

Constitution of the Republic of Croatia, (2010), Narodne novine, 2010(76), pp. (if known).

6.2.2.8. Supplementary materials

Supplementary materials are optional. Authors can submit different types of materials which will be available on-line.

6.2.2.9. Language

Authors may use standard British or American spelling, but they must be consistent. The Editors retain the customary right to style and, if necessary, shorten texts accepted for publication.

This does not mean that we prefer short articles – actually, we do not limit their size - but rather a resection of the obviously redundant material.

The past tense is recommended in the Results Section.

Avoid using Latin terms; if necessary, they should be added in parentheses after the English terms. Real names rather than "levels" or "values" should refer to parameters with concrete units (e.g. concentration).

6.2.2.10. Abbreviations

Only standard abbreviations and symbols may be used without definition and may be used in the title or the page-heading title.

Non-standard abbreviations should not be used in the title or page-heading title. They must be explained in the text in the following way: the term should be written in full when it appears in the text for the first time, followed by the abbreviation in parentheses; from then on, only abbreviation is used in the text. This applies separately to the Abstract and the rest of the text.

6.2.3. Submission of manuscripts

Paper submission via ToMS web page Open Journal System.
www.toms.com.hr