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## **Book of Abstracts**



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**Structures and Materials / 11****Weight reduction with Textile conductive and electromagnetic shielding solutions****Author:** Ivano Soliani<sup>1</sup><sup>1</sup> SOLLANI EMC SRL**Corresponding Author:** i.soliani@solianiemc.com

The scope is just to offer a view of the good results involved just in installations made with our fabrics textile electrically conductive with electro chemical treatment with metal nickel to offer a good shielding results from electromagnetics interferences specially in a wide range of weaves from KHz to GHz and with stability in corrosion fog salt in comparison to mesh copper and for installation in combinations with thermoplastic panels where in comparison with metal sheets the weight reduction is very important . the panels that we have just made or the applications involved over textile fabrics in glass . The tests and results made are very interesting to compare to the traditional weave and also for some applications the textile fabrics conductive can offer also a solution for cable shielding results for flexibility . The application was starting in airplane industry as AIRBUS and Agusta Westland and after these we have start to propose and install in some navy military involved for specific requirements from frequencies involved and dB attenuation . The same textile are also qualified for fire resistance for the resin thermoplastic involved to V0 and V1 in accordance with the required test .We are in condition to present photos and test results in dB according the frequencies range .The applications offer a view for more suggestions involve to remove the metal and install composite for weight reduction and also for resistance to corrosion stability .

The Company is qualified En9100 plus NATO supplier and qualified in FINCANTIERI and INTERMARINE and DCN .is a SME PMI company and have take part to the projects for EU 6<sup>th</sup> and 7<sup>th</sup> European Programme ( LIDWINE-MADMAX-SMARTPRO as name of the 3 projects qualified ) Ivano dott eng Soliani CEO of SOLIANI EMC SRL Como Italy

**Ship Efficiency and Renewable Energy / 12****An Alternative Approach for Assessment of the Weather Factor in EEDI Formulation Using Statistical Ranking Theory****Author:** Rumen Kishev<sup>1</sup>**Co-author:** Silvia Kirilova <sup>1</sup><sup>1</sup> Bulgarian Ship Hydrodynamics Centre**Corresponding Author:** r.kishev@bshc.bg

Back in 2012, in its attempt to limit excess fuel consumption and green gas emissions respectively, IMO distributed MEPC.212(63) Resolution for calculation of the attained Energy Efficiency Design Index (EEDI) for new ships, which became mandatory since 2013. Attention has been paid to the account of the environment caused speed reduction, as directly related to the real operational conditions. The guidelines for calculating the speed reduction coefficient  $f_w$  have been outlined in MEPC.1-Circ.796. The recommended procedure, however, has some deficiencies, among which: • The speed reduction coefficient  $f_w$  is to be evaluated at one only (representative) sea condition, which could not be one and the same for ships of various sizes and types • The allowed approaches for estimating the coefficient  $f_w$  are varying broadly, including rigorous theoretical methods, linearized methods, model tests utilizing various experimental methodologies, and even simple empirics, thus giving non-commensurable basis for the estimation In the paper, a balanced alternative solution of the problem is suggested, based on extensive data for speed loss of variety of ships at seas taken both by experiments or series calculations and using statistical averaging of data over operational range in a form of some generalized rank criterion which match to a great extend the weather factor. The method is thoroughly validated by available full scale data.

## Hydrodynamics / 13

**DIFFUSER DESIGN WITH VISCOUS FLOW COMPUTATIONS FOR A LARGE WATER TUNNEL****Authors:** Ahmet Yusuf Gurkan<sup>1</sup>; Cagatay Sabri Koksall<sup>1</sup>; Cagri Aydin<sup>1</sup>; Ugur Oral Unal<sup>1</sup><sup>1</sup> *Istanbul Technical University***Corresponding Authors:** gurkanah@itu.edu.tr, koksalcag@itu.edu.tr

A new research project, involving the construction of a modern, large, closed-circuit depressurized high-speed water tunnel to support the detailed hydro-acoustic, hydrodynamic, cavitation and flow visualization based experimental campaigns, has been started in Istanbul Technical University. The present paper covers the fundamental viscous flow computations concerning the design of the critical criterions of the tunnel, which includes the diffuser and test section. Incompressible Reynolds-Averaged-Navier-Stokes computations were performed for the analyses. The simulations were carried out considering the designed contraction and test section geometries from previous study on Hydrodynamic Design of Contraction, Diffuser and Elbow Geometries for a High Speed Cavitation Tunnel. In order to discharge flow from the test section with minimum energy losses, diffuser takes a critical place in downstream side of test section. Therefore, achievable minimum pressure loss is directly related with minimum flow separation region, also this flow phenomenon directly affects the acoustic performance of the tunnel with decreasing overall back noise level. Three steps expansion of diffuser was determined aiming minimum separation flow region in diffuser. The effect of several design parameters, such as the length and expansion ratio of the diffuser as well as each steps' diffuser angle properties, were analyzed in order to determine the best diffuser geometry. The influence of the introduction of chamfer at corner of the cross section is also discussed.

## Structures and Materials / 15

**ON THE DECK STRUCTURAL LAYOUT OF MEGAYACHT****Author:** Gianmarco Vergassola<sup>1</sup>**Co-authors:** Dario Boote <sup>2</sup>; Lisa Ricci <sup>3</sup>; Tatiana Pais <sup>2</sup><sup>1</sup> *University of Genova*<sup>2</sup> *University of Genoa*<sup>3</sup> *Naval Architect***Corresponding Author:** gianmarco.vergassola@edu.unige.it

The growing increase in length of super and megayachts has driven structural designer to adopt longitudinal layouts as a main point in the structural scantlings. By the way, the optimization of weights, strength, deformations and dynamic behaviour has to be assessed one off for each new units because of peculiar and unique characteristics of each vessel.

For this assessment, in particular considering the dynamic behaviour of ribbed plates, the use of numerical software based on the Finite Element (FE) Methods is largely used up to the early design stages in order to highlights benefit and weakness of a particular structural design.

In this paper, two different structural layout for a superyacht deck have been studied and tested by using a FE software: the first one has been created with longitudinal and transversal stiffeners with the same cross section. In the second layout, transversal stiffeners are smaller in dimension but with lower span. The comparison has been made in terms of maximum strength, deformation and dynamic behaviour.

## Ship Design / 16

## POSSIBILITY OF PLACING A RETRACTABLE SAIL SYSTEM FOR AN OIL TANKER TO OPTIMIZE ITS EFFICIENCY

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Nowadays, self-propelled maritime transport increasingly depends on the use of new technologies and energy from renewable sources. The Action Plan clearly shows that the vision of building a ship that does not release emissions is realistic. As far as manufacturing time is concerned, it is not only a question of technology development, but also of the advancement of economy, infrastructure, laws, the freight market, etc. This paper aims to analyze a VLCC ship in terms of energy efficiency by introducing innovative systems on board and correlating with the classical systems of the ship. Also, the paper presents theoretical and practical considerations for optimizing the operation of energy systems at a VLCC of 305000 dwt. The paper introduces an innovative VLCC concept where, through on-board innovative power systems, bring major improvements to this type of ship.

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## THE IMPORTANCE OF MEASURING THE PERFORMANCE OF THE MAIN NAVAL ENGINE AND PRACTICAL MEASUREMENT METHODS

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Today, the primary source of propeller power is the diesel engine, and the power requirement and rate of revolution very much depend on the ship's hull form and the propeller design. Therefore, in order to arrive at a solution that is as optimal as possible, some general knowledge is essential as to the principal ship and diesel engine parameters that influence the propulsion system. The efficiency of any machinery on board ship is directly related to its performance. In order to get the best out of marine engines, it is very important to monitor their performances and take measures to achieve an efficient combustion. The paper aims the importance of measuring the performance of the main engine and practical measurement methods using the NHX program. NH-X device measures the cylinder internal pressure by utilization of the pulse signal from Top Dead Center (TDC) of No1 cylinder. Also, the program analyzes the afterburning period at combustion stroke of each cylinder.

Hydrodynamics / 18

## An Investigation on The Effects of Various Flow Parameters on the Underwater Flow Noise

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The prediction and reduction of underwater noise is commercially, militarily and ecologically a very critical issue for maritime industry. Machine noise, propeller noise and flow noise are the main components of underwater noise for submerged bodies. Especially at high flow velocities, flow noise becomes dominant source of underwater noise radiated from these bodies.

In this paper, the effects of the fluid temperature, salinity of the fluid and fluid velocity on the underwater flow noise are investigated, numerically. A circular cylinder is selected for the validation studies of the noise model used in the acoustic analyses. The flow characteristics are obtained by solving governing equations of fluid using Computational Fluid Dynamics (CFD). The turbulence is modelled by using a two-equation turbulence model. The Ffowcs Williams and Hawkins (FW-H) noise model is applied to predict the sound pressure levels at the receiver points defined various locations, numerically. The monopole, dipole and quadrupole sound sources are taken into consideration for acoustic analyses.

## Machinery and Systems Design / 19

### High Efficiency Waste Heat Recovery from Dual-Fuel Marine Engines

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In recent years the International Maritime Organization (IMO) has introduced increasingly stringent regulations regarding sulphur oxides (SOx) and nitrogen oxides (NOx) emissions from the marine engines. Also the theme of reducing carbon dioxide (CO<sub>2</sub>) marine emissions is considered with increasing attention. A reduction of the above emissions, as known, could be achieved by adopting more efficient ship systems and using fuels with low carbon content, for instance natural gas (NG). This paper presents the application to dual-fuel marine engines of an original Variable Layout Waste Heat Recovery (WHR-VL) steam plant, designed considering the different exhaust gas stack temperature limits depending on the used fuel type: generally no less than 160 °C for diesel fuels, without limits in case of natural gas fuel. When using diesel fuels, a single pressure, superheated steam plant scheme is adopted, while a dual pressure one is used for engine fuelled with NG. In both configurations the produced steam is sent mainly to a steam turbine (for electric energy production), while a part is used to meet the on-board uses, as required by the type of vessel. A quantitative evaluation of the proposed installation is presented.

## Hydrodynamics / 20

### The use of modern computational tools in the design process of unconventional propellers for performance prediction and full-scale extrapolation

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Most of the traditional procedures for the design of conventional propellers do not yield reliable outcomes in the case of unconventional propellers, for which high-fidelity prediction of performance characteristics are necessary. It is generally understood and recognized, for instance, that the standard ITTC'78 procedure for model to full-scale extrapolation of performance is not reliable in case of unconventional propellers.

CFD calculations, on the other hand, are becoming a standard analysis tool to be used for unconventional propeller design and performance prediction.

In the present paper, it will be shown, for both a CLT and a new generation CLT propellers, that the extrapolation from model tests to full-scale cannot be reliably carried out by standard procedures.

A CFD calculations campaign is, consequently, carried out to simulate the performance of both designs in Open Water condition, both at model and full-scale, incorporating transition models to determine with more detail laminar, transitional and turbulent flow areas. Results are also compared with the performance predictions obtained with empirical and strip method scaling procedures developed by SISTEMAR. The comparison shows that both methods are sufficiently reliable in the early design stage and for the extrapolation and comparison of model tests.

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## Non-Linear Metamodels for Resistance Prediction of Post-Panamax Containership

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The scope of this paper is the development of nonlinear meta-models for the prediction of the resistance of a Postpanamax Containership.

The goal is the creation of new systematic series for modern hull, using CFD simulation instead of experiment in towing tank, in order to have the possibility to take in account more geometries in less time.

In order to consider different hull geometries, several different deformations are applied on the original shape. Then, a huge amount of geometrical coefficients and the resistance are evaluated and used to create different metamodels.

For each metamodel, different sets of geometrical coefficient are used. The sets are created starting using only global coefficients (CB, CP, CV, LPP/LOS) finishing to consider also more local one (CB, CP, etc. for After body, Fore Body and Parallel Body and Bulb Coefficients), in order to create simpler or more accurate prediction.

This hierarchical division can help in the use of the different metamodel for the resistance prediction in the different design phases, in according with the increase of the design knowledge, starting from the concept design, where CFD Simulation cannot be performed, due to the absence of a complete geometry.

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## Simplify Optimization using Hierarchical Free Form Deformations and Metamodels

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Hydrodynamic performance optimization of ship hulls is becoming popular in modern naval architecture, but for the cost, time and knowledge required, only research centers and big shipyards can afford it.

In order to help Companies in CFD Simulations, predefined templates created by software experts are becoming more and more available in CFD Solvers.

In parallel, in order to simplify the use of optimization algorithms, an increasing number of optimizers use metamodels, so to reduce the number of CFD calculations required.

Furthermore, parameter reduction techniques can reduce the number of total simulations needed. The idea is to reduce the simulations requested through the reduction of the global investigation domain, using less parameters, reducing their domain and using different deformations.

In particular, Hierarchical Free Form Deformation can be used to perform multilevel deformations, from global to very local ones.

This paper describes the validation of a framework created using a commercial solver template, the kriging surface created by DAKOTA and the Hierarchical Free Form Deformation as reduction parameter technique for the resistance optimization of the Duisburg Test Case Containership in rough water, helping Companies to be more aware and confident in the use of these techniques.

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## **Sensitivity Analysis of the Resistance of a Post-Panamax Containership**

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The democratization of CFD simulations helps the evaluation of several ship hull forms in few time.

With the post-processing of the resultant data, it is possible to understand better the influence of the geometry on the resistance, helping engineers in the configuration of good geometries also in early design stage. During this phase it is necessary to use tool derived from statistical analysis.

For this paper, it is studied the influence of the geometrical coefficients on the resistance.

As original hull, in order to give results derived from a modern hull form, the Duisburg Containership is used.

In order to achieve results independent of the transformation applied, the hull is deformed using different Free Form Deformation.

The results are later studied with two kind of correlations, i.e. Parsons' and Spearman's ones, linear and non-linear multivariate regressions and "What-If" analysis.

The results are given for each deformation and for all combined together.

The tools and the framework proposed can be used also for other studies, helping engineer in an analytic analysis of the problem, very useful in particular for innovative design, where it is not possible to rely on experience and old results.

## Electrical Systems / 24

## Shore-to-ship power supply integrating conventional and distributed generators along with storage

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The need for reduction of pollution when ships are in port requires the use of a shore-to-ship power system for supplying energy to the onboard grid. The latter is normally fed at 60Hz, so a frequency conversion is needed. Power can be taken from the public power grid available on shore. In order to reduce the environmental impact, this power system can be integrated with local, distributed generators that produce energy from renewable sources. Energy storage can also be added in order to smooth power peak demand and production from not programmable generators. The paper shows a system built around an Energy Box that manages the duty of all the power source in parallel and provides the frequency conversion. A parallel on dc or on ac side is considered, according to the power installed in a wide range from few MW up to 20 MW. The Energy Box is controlled by its own Power and Energy Management system in order to get the best efficiency and lower energy cost, along with a strong reduction of emissions. An example of this technology is also shown.

## Ship Design / 25

## A new escort tug family designed to anticipate new safety requirements and operational needs

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The aim of the paper is to describe an industry-academic collaboration to conduct a research project whose main goal is the design of a new escort tug family characterized by high intact/damage stability margins, good maneuvering capability and stable behaviour during escort indirect assistance. The project is focused on three main research areas: hydrodynamic design and internal subdivision of the hull, simulation of the escort capabilities in different operational scenario, development of control logics that will allow autonomous or unmanned operations.

The paper describes the methodological approach adopted for the design and will show some preliminary results.

The tug has been designed to be in compliance with new amendments of the 2008 Intact Stability Code (Res. MSC.415(97) which will enter into force on 1st January 2020) both for towing and for escort operations. Furthermore, a significant step towards enhancement of ship's safety is granted by tug's capability to withstand a damage in accordance with criteria applicable to OSVs.

In particular, the propulsion and maneuverability aspects in escort operations are deeply investigated.

## Ship Efficiency and Renewable Energy / 26

## Nonlinear computations of heave motions for a generic Wave Energy Converter

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A benchmarking activity of numerical methods for analysis of Wave Energy Converters (WEC) was proposed under the Ocean Energy Systems (OES) International Energy Agency (IEA) Task 10 in 2015. The purpose of the benchmark is to do a code-2-code comparison of the predicted motions and power take out for a WEC. A heaving sphere was used as a first simple test case. The participants simulated heave decay and regular and irregular wave cases. The numerical methods ranged from linear methods to viscous methods solving the Navier-Stokes equations (CFD). An overview of the results from the first phase of the benchmark was reported in (Wendt et al 2017).

The present paper focus on the simulations of the sphere using one fully nonlinear time-domain BEM method one transient RANS method and one transient Direct FE method with no turbulence model. The theory of the three methods as well as the modelling of the sphere are described. Heave decay and heave motions for steep regular waves were selected as test cases in order to study and compare the capability to handle nonlinear effects. Computational efficiency and applicability of the three methods are also discussed.

**Comfort on Board / 27**

## ENVIRONMENTAL MONITORING HELPS INCREASING CONFORT IN A SHIP CABIN

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Many environmental data can affect the comfort of a guest in a cruise ship: cabin temperature, humidity, light intensity, noise, and air quality. Possible environmental discomfort may also have negative effects on the quality of the passenger's sleep, which is an important aspect of the overall concept of "human well-being". In this article, we describe both an environmental monitoring system for a closed environment, such as a ship cabin, based on sensor networks, and a minimal invasiveness approach for a robust monitoring of sleep quality, which integrates signals from different types of sensors to estimate physiological parameters (movements, heart rate, respiratory rate and their variability) correlated to the sleep stages (light sleep, deep sleep, REM sleep and wakefulness). Real-time measurements and analysis of the ambient noise in the passenger cabin is important to characterize the noisiness perceived by the passenger and to compare the measured values with ISO parameters, thus determining the acoustic bands that mostly impact on the passenger perception. The characteristics of a low-power sensor platform for the air-quality monitoring in a ship cabin will also be presented, together with the other networks of sensors and actuators for the environmental monitoring.

**Navy and Cyber Security / 28**

## At-sea NATO operational experimentation with interoperable underwater assets using different robotic middlewares

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Autonomous Underwater Vehicles (AUVs) are offering new capabilities for a wide range of military and civilian applications. The interoperability of heterogeneous AUVs with different skills is critical to accomplish such complex tasks. Indeed, the proliferation of AUVs with their own mission control interface and communications protocol makes it difficult to operate them within operational experiments, which requires joint management and coordination.

This problem was approached during the ASW-ODC17 (Operational Deployment of Concepts) sea trial, which aimed to demonstrate the interoperability of an external AUV (the Folaga WAVE [1]) within the CMRE heterogeneous ASW network [2] during a NATO operational exercise. WAVE vehicle and CMRE network use respectively ROS and MOOS as middleware, therefore a ROS-MOOS bridge was installed on a buoy acting as a gateway between underwater assets. The gateway was equipped with acoustic modems working on different frequencies, due to the different AUVs equipments.

Remarkable recent bridging works can be found in [3] and [4]. To the authors' knowledge, no national interoperable approach has been fully demonstrated in an operational exercise. All the AUVs were successfully operated during the joint NATO exercise through the same mission control station, unconcerned by differences in acoustic modems and middleware.

### Ship Digitalization and Unmanned Vehicles / 29

## Wetlands monitoring with innovative autonomous vehicles

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Wetlands are geographic areas where water meets the earth. They cover between 5 and 8% of the Earth's surface. These include mangroves, bogs and marshes, rivers and lakes, alluvial plains and flooded forests, shallow coasts and coral reefs. They are essential ecosystems for human life. In fact, rich of life, these zones are very important sources of freshwater, but also natural purification systems and carbon resources for fauna but also commercially for fishing. Various international conventions, directives and projects work on their protection that can help fighting the disasters resulting from climate change. However, the acquisition and monitoring of environmental parameters in these areas is difficult and ineffective. Classical vehicles (boats or wheel vehicles) are not effective and sometimes these areas are inaccessible or dangerous to human beings (critical or extreme environments). The development of innovative unmanned technologies can make surveys faster, efficient, less costly, and more precise. Robots work over extended periods of time and less staffing is required due to the high level of robot autonomy. In this study, several technological solutions are explored and an unmanned modular and portable vehicle with an innovative propulsion system suitable for working in shallow water is described.

**Ship Design / 30****U-SWATH, the innovative CNR research UMV****Author:** Bruzzone Gabriele<sup>1</sup>**Co-authors:** Angelo Odetti <sup>1</sup>; Claudio Lugni <sup>2</sup>; Danilo Calcagni <sup>2</sup>; Emilio Fortunato Campana <sup>3</sup>; Ivan Santic <sup>2</sup>; Marco Bibuli <sup>1</sup>; Massimo Caccia <sup>1</sup><sup>1</sup> *CNR-ISSIA*<sup>2</sup> *CNR-INSEAN*<sup>3</sup> *CNR-DIITET***Corresponding Author:** angelo.odetti@ge.issia.cnr.it

In the framework of the RITMARE Italian Flagship Project, CNR INSEAN and ISSIA developed U-SWATH (Unmanned Small Waterplane Area Twin Hulls), an innovative Unmanned Marine Vehicle for institutional research purposes.

USWATH is 5 m long and 4 m wide with a maximum weight of 1.4 t. The SWATH non-conventional design ensures good seakeeping and good efficiency. Each of the submersible hulls, connected to the bridge via two struts, is composed of modular and interchangeable elements that can be outfitted with different payloads, equipment, propulsive or manoeuvring elements. The propulsion is based on new azimuthal thrusters. Its wide bridge is covered with solar panels supplying power to the batteries.

The vehicle is studied for different purposes: coastal monitoring of waters, seabed, chemical-biological environmental parameters also in protected areas, first emergency monitoring for oil-spill, patrolling, docking of UAV (aircrafts) and UUV (submarines). U-SWATH will be the multi-purpose platform where researchers of CNR and other institutions will be able to perform their experiments: a laboratory for bio-chemical measurements, for testing of new materials, motors, propulsion systems, stabilizing control surfaces, optical and electromagnetic instruments, new sensors or study of hydrodynamic noise.

**Ship Design / 31****Towards A New Toll Calculation Method For Transiting The Suez Canal - Bulk Carriers****Author:** Maged Abdel Naby<sup>1</sup>**Co-author:** Mayar Ali <sup>2</sup><sup>1</sup> *Alexandria University*<sup>2</sup> *Alexandria Shipyard***Corresponding Author:** maged\_abdelnaby@yahoo.com

Tolls paid by the vessels passing through the Suez Canal (SC) represent an important source of income for the Egyptian Economy.

The current research makes use of the current boost in the information technology and the timely published international scales and indices for calculating the earnings and the costs a ship incurs during her service to suggest a new toll calculation method. This new method will respond to the volatile maritime transport sector and guarantees an equality of chances for the vessels transiting the canal. The method focuses on calculating the transit tolls on a case by case basis for each vessel.

Bulk Carriers are taken as a case study to calculate the savings and compare them to the tolls enforced by the SC. The study includes historical and recent data for the savings and the tolls already collected. The Energy Efficiency Design Index will be involved in the calculation of the vessel fuel consumption including the wave effect.

**Ship Design / 32****Developments of new patented ice breaking devices for ice going vessels.****Author:** gianpiero lavini<sup>1</sup>**Co-author:** gennaro avellino <sup>1</sup><sup>1</sup> *Fincantieri S.P.A***Corresponding Author:** gianpiero.lavini@fincantieri.it

Arctic and Antarctic areas are getting more and more attractive for cruises. The vessel designed for the operations in these and other ice areas like Canada and Baltic Sea must sail in ice in a safe and efficient way, as far as possible, without support of ice breakers. At the same time they should be quite efficient also in open waters. However the hull hydrodynamic shape of an efficient vessel designed for the open sea operation is normally not suitable to operate in ice, while a vessel optimized for proper sailing in ice normally suffers from strong penalties when sailing in free waters. This paper deals with the development of new patented devices applied to the bulb and to the stern of the ship which can provide at the same time excellent performances in ice breaking without any detriment when the ship is operated outside ice seas. The new devices are called ICE SABRE, applied to the bulb and ICE MIRROR installed on the stern transom. A comprehensive ice model testing description of two devices shall be given including tests in pack ice, brash ice and manoeuvre against ice ridges.

**Hydrodynamics / 33****Gain in Fuel Consumption with Frictional Resistance Reduction by Air-Bubbling Technique****Author:** Enrico Ravina<sup>1</sup>**Co-author:** Sofia Guidomei <sup>1</sup><sup>1</sup> *DITEN, University of Genoa (Italy)***Corresponding Author:** enrico.ravina@unige.it

The paper refers on a research activity developed at DREAMS Lab of the University of Genoa (Italy), focused on experimental application of air-bubbling technique on a hull model. With this method the injection of compressed air on the bottom of the model generates air bubbles modifying the boundary layer; measurements are implemented in towing tank.

The hull model has got a large flat bottom that is particularly suitable to this application and a customized pneumatic circuit was created to allow the injection of compressed air.

The design of the pneumatic unit is made to allow to make tests in different operating conditions with a flexible distribution of air in different areas of the hull.

Seven different operating conditions at three different levels of speed were measured at the towing tank with the goal to estimate the changes in local frictional drag at different levels of flow rate and pressure of injected air in different areas of the bottom.

In particular the most favourable combination can reach a frictional resistance reduction about of 13%.

This hull equipped with pneumatic circuit can be used in future to arrange new systematic experiments oriented to optimize the gain related to air bubbling technology.

**Comfort on Board / 34**

## Ontologies' definition for modelling the cabin comfort on cruise ships

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The evolution of sea cruisers' research considers the possibility to provide more comfortable cabins to the passengers. This goal can be achieved by providing the sea cruiser with the possibility to acquire, manage and reason over data deriving from the cabin environment, its passengers and their activities. A promising approach to deal with the information belonging to these domains is represented by Semantic Web technologies, in particular the exploitation of ontologies. The use of these technologies can provide, from the one hand, a sound model of the comfort metrics to be enforced inside the cabin, while on the other hand it leverages the exploitation of reasoning processes in order to adjust comfort metrics to passengers' desires.

This work describes a set of domain ontologies developed to address these purposes; starting from a motivating scenario, the paper illustrates how domain knowledge can be modelled to take into account the passenger's desires, limits and activities in relation to the comfort metrics provided by the cabin; furthermore, the work provides some examples on how reasoning processes can infer new knowledge and provide changes in the cabin environment.

Hydrodynamics / 35

## Fluid dynamics optimization of a shaft-less rim-driven thruster

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The shaft-less rim-driven thruster (RDT) can provide many advantages over traditional ship propulsion plants including enhanced onboard comfort and propulsion efficiency, locations arrangement flexible installation, light weight and compact size. For this reason, during last years it became an attractive ship propulsion device in the marine industry.

Within the project P. E. R. Na. (Propulsore elettrico reversibile per la Nautica) financed by the FvG region with Uni-TS, Uni-UD and MW.FEP as partners, a hydrodynamic optimisation (DoE) was developed with the aim of determining the feasibility of this type of thrusters for propulsion of sailing boats.

The electric motor will have the possibility of generating electricity by extracting energy from the boat's motion when it sails. For this reason, from a hydrodynamic point of view, the best compromise has been reached between these two operation modes.

A completely parametric model of the rotor (blades and rim) has been created with Grasshopper inside the Rhinoceros 3D environment, a selection of variables has been included in the multi-objectives optimization process carried out through Mode Frontier (ESTECO) by measuring the parameters chosen by performing CFD simulations with the Star-CCM+ solver (SIEMENS).

Offshore / 36

## Effect of propeller modelling on station- keeping thruster allocation strategy

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In preliminary Dynamic Positioning calculations, quasi-steady prediction approach is commonly used to figure out the system capability. Thrust allocation solver is usually modelling the thruster devices as pure force generators, considering empirical general formulations to correlate delivered thrust with absorbed power. In such a way, a rough estimate of the power demand during station-keeping operations can be made. Once allocation algorithm is using minimum power demand as objective function, then a more precise modelling of the thrusters can be helpful since preliminary design stages. In the specific, by using an allocation algorithm capable to manage nonlinear objective function and constraints, several types of propellers can be modelled, considering differences between tunnel thrusters and azimuthal thrusters, or the differences between fixed pitch and controllable pitch propellers. An example of the effect of propeller modelling is given, considering an Offshore Supply Vessel mounting steerable thrusters equipped with controllable pitch propellers, highlighting the differences with a standard allocation approach.

Offshore / 37

## Evaluation of extreme wave loads for slender tubular structures

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To design particular Offshore Vessels appendages like stingers, it is common practice to search extreme values of wave induced loads. The standard methods applied are performing the analysis by means of a Weibull distribution. The necessity of offshore industry to operate with severe sea state and the complexity of the considered geometry can be source of evident nonlinearities in the peaks distribution of the exciting force. In the specific, the adoption of a standard Weibull approach is not indicated for accurately predict the extreme load value. The adoption of more accurate distributions suitable to capture peaks non-linearity will ensure to overcome or capture possible multi-modal behaviours of the considered population. Such techniques can be applied since early design stage also to calculation results. In the present work a methodology is applied to calculation results for a stinger geometry, where Morison theory is applied to evaluate wave loads considering shield effects between the single elements.

Ship Design / 38

## Analysis of the Influence of Pressure Field on Accuracy for On-board Stability Codes

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Over last decades, due attention was paid to development of new stability criteria, especially probabilistic rules for damage stability, strongly influenced by the loss of many ro-ro ships in last decades of past century. In the last years, also a revision of intact stability code started and proposals have been implemented introducing stability in waves. These proposals deal with the equilibrium of a ship in regular waves to evaluate initial stability (GM) as well as righting arm curve in waves (GZ). This paper is not intended to critically review the present and proposed initial stability code, but is limited to assess how expected behaviour of intact ships in waves is affected by accuracy in computer programs for assessing actual hydrostatic properties. An updated computer code, designed for onboard application and based on 3D pressure integral, has been developed and tested in still water for a ro-ro ship. Then a comparison between static and Airy effective waves has been carried out to analyse the relevance of differences between the two correspondent pressure fields affecting the equilibrium position and hydrostatic properties. It is demonstrated that these differences appear relevant beginning from sea state 4.

## Ship Design / 39

### Systematic analysys of geometrical characteristics of hulls for displacement yacht.

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As well known Italy is one of the leader in construction of large yachts, this market became bigger in the last decades not only in terms of number of constructions but also in terms of size of the ships. In '80s main part of Yachts were 30-40 mt. in length, megayachts over 60 mt. were unusual, then the size of yachts increased to the actual 100m and over. Same way the cruising speed raised, from 12 to 20 knots and over. This made necessary developing new types of hulls, able to operate at Froude number relatively high for a displacement hull, around 0.34-0.38, but with ratios L/B quite low in order to guarantee the stability.

The purpose of the research was to examine several hulls of yachts, from 32 to 80 mt, all tested at model basin and following built and make a statistical examination of the main geometrical data, and geometrical coefficients: Position of LCB respect to the Lenght, Ratios  $Am/T^*B$ ,  $C_b$ , etc, in order to define a "line guide" for the design of this kind of hulls and to find, if possible, common aspects to consider.

## Structures and Materials / 40

### Surface treatments for ship hulls – present situation and trends

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Targets of the surface treatments of marine hulls have always been to preserve the structural capacity of the hull envelope and to maintain a smooth and clean external surface, thus minimizing the frictional component of motion resistance.

These objectives are pursued since a couple of millennia by fighting the chemical and biological phenomena inducing various forms of degradation in the hull base material and/or in the external surface smoothness. As regards the latter aspect, in particular, a most negative effect is represented by the adhesion of biofouling, jeopardizing the resistance performance of the hull. In the past, solutions to this specific problem were found in biocide-releasing paintings, practice that is nowadays unacceptable because of its high environmental impact.

New challenges in the field are represented by the possibility of not only maintaining, but also decreasing, the frictional coefficient intrinsic of the hull surface, while preserving excellent properties against fouling adhesion, without environmental damages.

The paper, based on publicly available data, analyses recent trends in the commercially available hull coatings and depicts possible development lines for new types of treatments aimed at reducing frictional resistance.

## Structures and Materials / 41

### **An innovative thermal and acoustic insulation foam for naval fire doors: characterization and study with FEM analysis**

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An innovative acoustic and thermal insulating foam was developed starting from fibreglass waste. In this work, the thermo-mechanical response of a fire door containing the foam as insulating material is considered and also the acoustic properties are investigated. In order to comply with the certification process provided by 2010 FTP Code, fire doors must undergo a standard fire test where a prototype is subjected to temperature up to 945°C. A realistic simulation of the heating process is useful during the design phase for the evaluation of the fire door behaviour without prototype construction. A RINA report of a standard fire test performed on the same fire door containing rockwool as insulating material is used to validate the model. Foam thermal and mechanical properties needed for the numerical analysis (e.g. thermal conductivity, specific heat capacity, Young's modulus) are obtained through experimental tests. The results pointed out an improved acoustic insulating performance respect to rockwool and comparable thermo-mechanical properties. The foam is a promising alternative to rockwool thanks to the environmental benefits derived from fibreglass recycling and the absence of fibre release.

## Offshore / 42

### **MODULAR PLATFORMS FOR EARLY PRODUCTION / FULL FIELD APPLICATIONS**

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Previous works have shown that the use of floating modular platforms (FMP) can represent a valid approach to the development of human activities at sea, near and off shore, both in civil/residential or industrial applications.

In particular, FMP technology provides a solution that allows the development of offshore fields in sequential stages. This will allow a shortening of the time for the First Oil, reducing the initial investment and starting to produce positive cash flow from the beginning.

During the Early Production phase are furthermore gathered more information on the field that will allow a more accurate and precise planning of the Full Field development by reducing the risks to the oil companies. In addition, modularity of the solution allows a sequential implementation of the system in accordance with the field development, and a potential reuse and relocation of the facilities at the end of the field.

This paper presents the results of a prefeasibility study jointly developed by Fincantieri and eni with the scope of evaluating, as alternative to conventional FPSO concepts, an innovative flexible solution based on several modules connected together to compose an Early Production platform expandable into a Full Field configuration at a later stage.

**Comfort on Board / 43**

## **Cruise cabin as a home: smart approaches to improve cabin comfort**

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Information and Communications Technology (ICT) has an impact on nearly every aspect of people's lives – from working or learning to socializing – and makes people's lives easier and more comfortable. In particular, smart home devices can handle environmental characteristics (temperature, etc.) increasing the people's comfort and can also help in reducing costs.

In order to increase passengers' comfort in the cruise ship cabins, this study proposes the design of an App that provides high quality products and services.

Smart home, ambient intelligence and IoT are the starting knowledge to create a smart space without re-designing all the cabin environments. The App brings real added value compared with the existing domotic systems, because it considers not only environmental characteristics but also the personal features of the passengers and their activities.

The aim of the proposed system is to improve passengers' comfort in order to increase the perceived quality, acting as a real time Decision Making System. It receives information from several devices and, according to the passengers' preference and activity, it decides how to create a suitable environment and healthy space. The App follows both the necessity of increasing passengers' satisfaction and the cost reduction for the ship owner.

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## **Toward personalized comfort definition in cruise ship cabin using a novel living space classification**

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The cruise ship sector is becoming a major part of the North Americans' tourism industry. In order to guarantee passengers' enjoyment of the travel experience, the cruise operators consider the comfort perception as a key quality attribute to increase the cruise attractiveness and, therefore, rise their income. However, there is a gap in the literature between the importance of the comfort quality and definition typical used in the naval registers. Only noise and vibration are usually examined; some registers also introduce an experimental regulation considering some climate parameters. This study intends to address comfort as an holistic experience embracing ergonomic factors (space and furniture) and psychological factors (the space might affect passengers' perception of comfort). These factors facilitate to design ships that are not only comfortable from an objective perspective, but could also feel comfortable.

The aim is to increase the passengers' comfort satisfaction both on the cruises still in construction and on the fleet already in use, by considering the reduction in cost for the ship owner. The study proposes a novel cabins comfort classification and it has been based on the Fincantieri cruise ships as case study.

## **Weather Routing and Environment Modeling / 45**

### **“Climate changes and maritime transportation: a state of the art”**

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In the next years, the worldwide fleet will be called to adopt drastic measures to reduce the emissions of pollutants. In order to comply with the Paris Agreement and keep the average increase in the earth's temperature below 2°C, emissions will have to drop significantly from 2020 onwards. At the end of 2018, the UNFCCC expects the IMO to communicate its intentions regarding the Paris Agreement. During the last session of MEPC(71) guidelines have been set for the purpose. While waiting for regulatory updates in the maritime world, the study aims at interpreting the present position of IMO on the subject within the framework set by the IPCC's last Assessment Report, AR5. The third IMO study on GHG will be analyzed in details, covering the inventory for the period 2007 to 2012 of GHG and of non-GHG emissions in the world's fleet and the forecast scenario for years 2012 to 2050. A last part of the work will concern the effects of these pollutants, with reference to the impact on human health and on environment. A state of the art of the quantification of the social costs of this type of emissions will be presented.

## **Hydrodynamics / 46**

### **Fully Automated Ship Resistance Prediction using the Naval Hydro Pack**

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A unique numerical environment for assessing ship resistance using CFD is presented in this paper. Predicting ship resistance in calm water with the Naval Hydro pack can be performed within few hours, including computational grid generation, simulating and result post-processing. Being able to predict the ship resistance within few hours renders CFD a cost-effective design tool, since a hull form designer can test multiple variants of hull geometry quickly. The process of setting up, running and post-processing is accelerated by automating the process to a high level, significantly decreasing the number of required man-hours. In this paper the capabilities of Naval Hydro pack are demonstrated by calculating steady resistance for three different benchmark hull forms, where time for pre-processing, processing and post-processing is reported. Results are compared to available experimental data for validation.

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## Project SOPHYA - Progress in seakeeping of planing hulls

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Project SOPHYA (Seakeeping Of Planing Hull Yacht) has as its general purpose the improvement of comfort and propulsion performance of pleasure motor planing craft, through the study of the correlation between the performance in rough sea and the state of the sea.

The project is founded by the FvG region with Monte Carlo Yachts, Uni-TS and SISSA as partners. During the study, a hydrodynamic optimisation (DoE) was developed with the aim of determining the link between the hull parameters and its behaviour in rough seas.

To validate the study, towing tank tests in still water, regular waves and irregular waves and sea trials in rough sea were carried out on a boat whose hull was chose as a mother hull for the optimisation.

Then, a completely parametric model of the hull has been created with Grasshopper inside the Rhinoceros 3D environment, a selection of variables has been included in the multi-objectives optimization process carried out through Mode Frontier (ESTECO) by measuring the parameters chosen by performing CFD simulations with the Star-CCM+ solver (SIEMENS).

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## Predictive model for Maneuvering Risks Assessment.

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The use of simulation instruments which allow to predict or analyze the maneuvers to be performed on a real vessel are very common in the naval sector. Such a practice results from the need to make navigation increasingly safer, in order not only to avoid collisions between vessels in the open sea, but also to evaluate the most convenient maneuvers in confined spaces, such as for example in harbors and canals.

Traditional simulation systems produce a simple prediction of the future motion of the vessel without offering any qualitative analysis about the risks of safety related to the manoeuvre.

To solve the aforementioned problems CETENA's naval simulator includes a patent method that offer a highly reliable predictive model with regards to the risks connected to a given maneuver.

The developed system generates at different intervals of time, one or more virtual disturbances in the virtual simulated vessel, producing an unexpected deviation of the vessel from the path followed by the pilot.

All generated virtual scenarios, in which the behavior of the vessel is influenced by one or more virtual variations, could be evaluated in order to obtain a manouvre "Performance Index".

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## Simulating with MANTA: so far from ordinary simulators, so close to reality

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Simulation and multimedia devices are nowadays essential features to be used both for design assessment and for training activities. In the naval field, the prototype of the ship is usually the ship herself, therefore a detailed simulation framework is becoming an essential tool to be used as a testbed in the design process. The same approach could be also applied for training phase, giving to the entire crew the chance to train themselves in operations and behaviour they will have onboard before really sailing on the actual ship. In this perspective a comprehensive simulation approach was developed in order to cover the most advanced needs. This framework, called MANTA (Multipurpose Advanced Naval Training Architecture), was born by the cooperation between CETENA and IBR-SISTEMI. MANTA represents the ultimate simulation environment which follows both the designers and the operators together with the complete crew from the beginning to the end of ship lifecycle. The MANTA architecture was also designed to allow the cooperation with different simulation systems; particular importance should be paid to the Full Mission Simulator which is the most complex component of the MANTA infrastructure, since it is a set of interconnected and highly reconfigurable simulators and instructor stations.

## Hydrodynamics / 50

## Shape optimization by means of proper orthogonal decomposition and dynamic mode decomposition

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Shape optimization is a challenging task in many engineering fields, since the numerical solutions of parametric system may be computationally expensive. This work presents a novel optimization procedure based on reduced order modeling, applied to a naval hull design problem. The advantage introduced by this method is that the solution for a specific parameter can be expressed as the combination of few numerical solutions computed at properly chosen parametric points. The reduced model is built using the proper orthogonal decomposition with interpolation (PODI) method. We use the free form deformation (FFD) for an automated perturbation of the shape, and the finite volume method to simulate the multiphase incompressible flow around the deformed hulls. Further computational reduction is done by the dynamic mode decomposition (DMD) technique: from few high dimensional snapshots, the system evolution is reconstructed and the final state of the simulation is faithfully approximated. Finally the global optimization algorithm iterates over the reduced space: the approximated drag and lift coefficients are projected to the hull surface, hence the resistance is evaluated for the new hulls until the convergence to the optimal shape is achieved. We will present the results obtained applying the described procedure to a typical benchmark ship.

## Hydrodynamics / 51

### Theoretical and experimental investigations of appendages and heeling angle influences on the hydrodynamic resistance of a sailing yacht

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The hydrodynamic resistance of the sailing yacht is strongly influenced by both the large appendages and significant heeling angles, respectively.

In order to evaluate the components of the hydrodynamic resistance the theoretical approach was based on the method proposed by Larson and Eliasson. The residuary resistance was calculated by using the regression formula proposed by Gerritsma which was obtained based on systematic experimental tests on models, known as Delft series.

The experimental approach is based on model tests results which have been carried out using the existing facilities provided by the Towing Tank of the Naval Architecture Faculty of "Dunarea de Jos" University of Galati. An important number of tests, for different combinations with/without appendages and a range of heeling angles were performed.

The comparative results are presented in synthetic diagrams revealing some important differences between the theoretical and experimental approaches. Thus, the influences of the appendages dimensions and heeling angle were clearly pointed out.

Consequently, it can be now concluded that the level of accuracy of the theoretical methods, to be used during the preliminary design stages, has to be significantly increased

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### Propeller diameter selection based on numerical analysis of wake and induced-pressure on blades and on tunnel stern surface

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Aim of this work is the analysis of the flow in the stern region of a by simulations.

In this work will be reported the numerical analysis of the flow around the propeller working in a stern-tunnel of a fully appended twin-screw fast displacement M/Y. Particularly, the aim of the study is the evaluation of the effects on the pressure and on the wake in the tunnel region, due to the diameter variations of the propellers.

The U-RANSE simulations will be performed in time domain in order to investigate the interaction between tip clearance reductions and increasing of pressure pulsations on the tunnels surface and on the propellers' blades.

The increasing pressure variability - that potentially will increase noise and vibrations, will be evaluated in parallel with the expected improvements of the thrust and of the wake fraction.

## Hydrodynamics / 54

### CFD Automated Self Propulsion Test

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CFD simulations are becoming more and more reliable and the increasing computational power are making them a convenient tool to investigate complex phenomena and to reproduce the experimental tests. In the hydrodynamic design process the correct evaluation of the self propulsion performance is an essential item to access the true performances of the ship. This paper deal with a CFD methodology, developed in STAR-CCM+, that reproduces the self propulsion experimental test. The variation of propeller rpm has been automated in order to achieve the self propulsion condition. Ship motions and free surface are take into account to study the behavior of the propeller in the real wake and to compute the propeller efficiency and the absorbed power. A sliding rotating mesh encloses the propeller while the mesh motions, necessary to simulate correctly the ship trim and sinkage, are managed by a STAR-CCM+ proprietary algorithm. The towing force has been take into account in order to reproduce the load variation test. The numerical results are presented in this article and are compared with the experimental results. The good match proved that the numerical self propulsion simulations are getting an extremely useful tool in the hydrodynamic design.

## Hydrodynamics / 55

### THE EFFECT OF THE LONG-PERIOD COMPONENTS OF ADDED RESISTANCE IN IRREGULAR WAVES

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Added resistance in irregular waves is generally calculated as the mean value with wave spectrum and frequency response of the added resistance in regular waves. In the calculation, the added resistance in regular waves is assumed to be proportional to square of wave height based on the wave theory. However, from the experiment it is not always proportional. Therefore, the mean

value from the calculation is different from the time averaging value in consideration of long-period components of added resistance in irregular waves.

The long-period components of added resistance in irregular waves have been rarely considered. Since the experimental technique with appended restoring force has not been established, calculated results is not validated.

In this paper, the long-period components of the added resistance in irregular waves is evaluated with Newman's approximation that has been used for the estimation of the drifting force acted on an offshore structure. And the analysis method for tank tests which employs the modification of inertia force in order to eliminate the effect of appended restoring force. The comparison of the present estimation method with tank test results and the effect of the long-period components are examined.

## Hydrodynamics / 56

### COMPUTATIONS OF ROLL MOTION IN WAVES USING A FULLY NONLINEAR TIME DOMAIN POTENTIAL FLOW METHOD

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Optimization of modern hulls when moving in a seaway puts new demands on the computational methods used. Nonlinear effects become important for wave loads and added resistance in waves in presence of large motions.

The purpose of this paper is to present a method which aims to fill the gap between RANSE methods and partly nonlinear panel methods. The method solves the fully nonlinear free surface time-domain potential flow problem including a hull undergoing rigid body motions. Nonlinearities under the hypothesis of potential flow are taken into account, i.e. higher and lower frequency components, hull shape above calm water line and interaction between incoming, radiated, diffracted, reflected and ship generated waves.

The potential flow method alone cannot handle roll motion since roll is dominated by viscous effects. Two methods to include roll damping within the potential flow code are used: the first one obtains roll damping coefficients through inertial and geometric characteristics of the ship. The second one uses model test results. Numerical results using both methods are compared.

The code has already been tested in head seas. In this paper, numerical simulations of roll decay and roll motion in beam sea are compared to model test results.

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### Augmented reality for training and managing emergency conditions on cruise ships

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All over the world the tendency is to bring ships to be increasingly safe. Regarding cruise ships the safety has two different aspects to deal with: the first one is during the design of the ship, the second one is during ship operation. Cruise ships are able to carry on board thousands of people, with different behaviors. The interaction between them, in case of emergency, may worsen the situation. The ship has to be safe and, to damp the panic level, the passengers have to feel safe. The ICT technology may help in this respect. Passengers and crew can be educated on the principles of ship safety through Apps. In this paper we present the Emergency Virtual Training Tool App for mobile devices, which can provide suggestions, tips and instructions about the use of ship services and emergency management. It may communicate with the ship data platform, deriving the necessary information about the ship, such as alarm specific features. It may exploit an environment with sensing and communication capabilities (RFID, beacons, etc.) to visualize emergency virtual entities through augmented reality. Using this App, users familiarize with the ship emergency environment and feel safer.

## Ship Design / 58

### Towards building an attained index of passenger ship fire safety

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Protection against fire is one of the pillars of maritime safety. Although the legislation requires compliance with prescriptive regulations of fire prevention, protection and extinction, the concept of “safety equivalence” has enabled substantial innovations in the design of modern passenger ships, where catastrophic consequences may occur. The assessment framework could be improved by introducing a probabilistic formulation (Themelis&Spyrou 2012). This study is an attempt for a step forward, aiming to develop the elements and the structure of a probabilistic attained fire safety index. The probability of fire ignition, the reliability of the suppression systems and the expected loss due to fire development, are key elements contributing to the new index. The index is sensitive to design detail, such as the space layout and the interior design materials used. The distribution of fatalities has been selected as the most appropriate “cost” function. As an application, two adjacent fire zones accommodating passenger spaces will be examined. The “cost” distribution is derived from a batch of fire and evacuation simulations. The method is extendable to address the entire ship.

Reference: Themelis,N. and Spyrou,K.J. (2012). Probabilistic fire safety assessment of passenger ships, Journal of Ship Research, 56(4):252-275.

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### Crashworthiness assessment of naval structures subjected to a variety of maritime accidents, Part I: hard grounding

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Ship grounding still possibly takes place even though attempt to improve structural safety is conducted. This situation leads to sustainable research to estimate structural consequences during a naval structures experiences accidental event, such as collision and grounding. Pioneer works in this field have considered conical and prism indenters as idealization of the seabed. However, possibility to contact with reef-shaped has not widely used as assumption for grounding action. In this work, hard grounding is considered, and reef geometry is selected as the indenter for composed scenarios. Before grounding analysis is performed, configuration and setting of the numerical method are verified by benchmark particular of a scaled panel experimental test. The naval structure is idealized based on double bottom structure of a non-ice class chemical tanker using thin-walled concept in finite element method. External parameters represented by impact location and striking velocity are embedded on the model to compose several scenarios. Results indicated that higher structural crashworthiness is shown by longitudinally strengthened component on the double bottom. Structural breaching during underwater impact with waterway side produces very high energy, and furthermore it concludes that resistance of the side part of the double bottom is recorded as the best.

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## **Crashworthiness assessment of naval structures subjected to a variety of maritime accidents, Part II: bow-hull collision**

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Besides double bottom, accidental impact load may target double side of any ship during a voyage and possibly triggers remarkable chain reaction, such as oil spill, life loss and carrier damage. Operation in several high-traffic routes makes passenger ship can be a target of various accidental events. However, considering to the research trend, researchers yet to conduct many works to estimate crashworthy double hull of passenger-ship type.

This work is addressed to conduct structural assessment of passenger ship subjected to accidental collision. Interaction with other ship is assumed as bow-hull interaction which a container carrier is selected to be the striking ship. Deformable structure is applied to the passenger ship which is observed as the struck ship. Several scenarios are built based on variety of target location and ship material to estimate crashworthiness criteria. The results concluded that bulbous bow of the striking ship produces severe indentation on lower hull of the struck ship. The indentation is wide enough for sea water to enter the ship. It is recommended based on results of this part that the lower structures on side skin to be applied by with high strength material to increase structural resistance against side penetration.

Hydrodynamics / 61

## **System for speed/power trials measurement and analysis in accordance with international recommended procedure**

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The last international recommended procedures and normatives provide detailed guidelines and formulation for the execution of speed and power sea trials and the analysis of the results. For this reason it starts to be necessary to analyze the data directly onboard as the trials are completed and define the effective contractual speed and power condition of the ship. CETENA recently improved its technical equipment for sea trials measurements, including the custom software "SPEED" aimed to be directly connected with the acquisition one and provide ship performance analysis consistent with both ITTC and ISO normative. In order to guarantee high accuracy in measurement and analysis, each instrument (torquemeter, anemometer, flowmeter, gyro, etc) has been calibrated and certified by accredited laboratories. The analysis software "SPEED" has been certified by the rules ABS and RINA.

The ship speed and power performance analysed by SPEED and thus referred to ideal condition - i.e. with no waves, no wind and prescribed load condition - can be used for verifying the Energy Efficiency Design Index (EEDI) of the ship.

## Safety and Security / 63

### SRtP 2.0 – The Evolution of the Safe Return to Port concept

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In 2010 IMO (International Maritime Organisation) introduced new rules in SOLAS with the aim of intrinsically increasing the safety of passenger ships. This requirement is achieved by providing "safe areas" for passengers and "essential services" for allowing ships to Safely Return to Port (SRtP). The entry into force of these rules has changed the design of passenger ships. In this respect big effort has been done by the shipbuilding industry to address design issues related to the impact on failure analysis of the complex interactions among systems. Today the research activities are focused to face operational matters in the design stage. This change in research focus was necessary because the human factor and the ship operation itself after a casualty on board may have a big impact on the design of the ship and the systems. Also the management of the passengers after a casualty is becoming a major topic for safety. This paper presents the state of the art of the Italian knowledge, addressed to safety improvement and design reliability, in the field of system engineering applied to passenger ships. An overview of the present tools and methodologies will be presented together with future focuses in the research activity.

## Ship Design / 64

### THE APPLICATION OF GOAL BASED DESIGN FOR PASSENGER SHIP SAFETY IMPROVEMENT.

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SOLAS (International Convention for Safety Of Life At Sea) Chapter II-2/Regulation 17 and Chapter III/Regulation 38 allow for the adoption of "Alternative designs and arrangements" that deviate from the ones permitted by prescriptive regulations. The process to be used for the Alternative Design

engineering analysis is documented by SOLAS by means of guidelines and requires a holistic and consistent risk assessment to demonstrate that the risk introduced by the novel design is less or at least equal to the one guaranteed by the prescriptive reference design. This activity de facto introduces the Goal-Based Design into the traditional design process by evaluating safety as a main goal in the ship design. This approach is possible thanks to the research activity aimed at improving the application of the simulation tools that are used to quantify the risk level of a specific design solution and its variants by evaluating the human element in the design. In this paper examples of shipbuilding application of goal based design are presented together with an overview of the new frontier in the adoption of these approaches for the improvement of safety and the maximisation of the ship payload.

Offshore / 65

## Heavy-lifting: coupled stability & structural analysis in a load-out operation

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The economic and technical challenges of large-scale load-in/out operations require the assurance provided by specialized and integrated engineering software that provides leading-edge support to preparation and planning and helps ensure enhanced safety and quality control.

This case-study describes the planning of a loadout operation by a Self Propelled Modular Trailer (SPMT), for which all technical and environmental constraints are integrated in a quasi-dynamic model, developed in a combined GHS (hydrostatics & stability) and MAESTRO™ (ship-specialized FE) environment. Model and calculations address and cater to tide, wind, mooring forces (winches, anchors,), ballast, pump capacity, verification at each stage of the loading of draft and trim, stability, hull girder bending moment and deflection, compliance with operational limits and Regulations, etc. The realistic Finite Element structural model of the ship is loaded in synchrony with the GHS (hydrostatics and SPMT). The integrated GHS and MAESTRO environment allows tracking and managing the combined hydro and mass loading effects in quasi-dynamic mode: based on the same hydrostatic balance, MAESTRO receives tank loads from GHS, and runs detailed stress analysis and limit state evaluation of the structure, thereby ascertaining the structural integrity and girder deformation patterns of the carrier

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## An Experimental Study on Hydrodynamic Performance of Flexible Model Propellers

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Marine propellers operating in the ship stern wake generate an unsteady propeller fluid force and cause a hull vibration. The deformation of metal marine propeller is not considered, because it is sufficient stiffness. However, marine propeller using the composite material called flexible propeller

appeared, by controlling the actively blade deformation in response to load changes in one propeller rotation, the possibility of flexible propeller with excellent hydrodynamic performance than enough rigid propeller came into sight.

In this study, we made elastically deformable highly skewed model propellers, the model propellers were made by resin with smaller flexural modulus than metal, and it was carried out propeller open water tests, fluctuating pressure measurements and blade deformation measurements in uniform flow and wake in cavitation tunnel.

As a result, it was found that the flexible propeller with high skew had a high risk to lower the thrust, torque and efficiency than the metal propeller by the blade tip deformation, but it had a possibility greatly improved cavitation performance. Further, at the time of the propeller reverse it was found that there was a risk of unstable vibration occurs in blade tip part.

## Ship Digitalization and Unmanned Vehicles / 67

### 3D Adaptive Coverage Planning for Confined Space Inspection Robots

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The manual inspection of confined spaces, such as ballast tanks, for corrosion is a hazardous, time consuming, expensive, and subjective process. Robotic inspection techniques are being considered as they promise greater objectivity and comprehensive coverage as well as repeatability, reduced risk, and shorter maintenance downtime. To enable a robot to comprehensively inspect all surfaces within the tank, it needs a route-plan. Although coverage path-planner algorithms can be used to automatically generate optimal plans, complex environments and robot kinematics can make the problem challenging. Most existing coverage algorithms can only produce offline plans that cannot cope with unforeseen obstacles and would consequently fail. Such problems present the need for adaptive coverage-planning algorithms that can replan routes autonomously. To date, the focus of our research has been to evolve the offline Redundant-Roadmap algorithm into an enhanced algorithm capable of adapting its plan online. The online solution utilises LIDAR scan updates to rectify compromised paths through region-based replanning, allowing localised replanning around identified areas of change without recalculating the whole tour from scratch. Preliminary results reveal that the online planner is capable of replanning multiple regions concurrently, faster, and with minimal path degradation compared to its offline counterpart.

## Structures and Materials / 68

### PLM implementation: case study of a success

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The Design, Production & Operation Single Environment connects the PLM universe. The 3D model supports similar design and production roles: drawings, count hours, end-treatments, BOMs, drive

robots, non-Engineering consumable forecasting (paint, blasting, welding, etc.), human resource requirements (manhours, special skills, inspections, etc.). Non-engineering Data & information contributes to the product model: lead time, availability, problem areas, etc. The 3D model is the visual representation of different types of data & information generated and required by different Departments, exploited with today's EnterprisePlatform-ShipConstructor, AutoCAD, Navisworks, etc. by Autodesk/SSI.

EnterprisePlatform-ShipConstructor and Autodesk platforms are the DNA of the open-PLM, handling product model and lots of related meta-data via the Marine Information Model. The complete enterprise solution includes other software, people, tasks, deliverables, customers, subcontractors, suppliers, weather, coffee supplies, etc. All consumers receive data & information from the MIM via PublisherLT, with customized content and format.

In the many-to-many setup, all stakeholders add and combine their own meta-data & information in many data repositories: textfiles, Excel, ERP, PLM, Document Management, etc..

The SSI Information Hub automatically uploads input via the EnterprisePlatform Server with Nodes, Connectors and Operations. Semi-automatic processing of User Defined Attributes is another strategy.

## Weather Routing and Environment Modeling / 69

### Optimal navigation with ocean currents: the VISIR ship routing model

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A new development of the VISIR ship routing model (Mannarini et al, Geosci. Model Dev., 9(4):1597-1625, 2016) is here presented.

The first version of the model has powered an operational service in the Mediterranean Sea ([www.visir-nav.com](http://www.visir-nav.com)) for about 3 years. Its source-code is distributed with an open policy ([www.visir-model.net](http://www.visir-model.net)).

The new developments target large ocean-going vessels (such as cargo vessels, tankers, and cruise ships) and also accounts for ocean currents. In order to effectively use currents in a graph-search method, new equations are derived and validated versus an analytical benchmark. Also, a case study is computed in the Atlantic Ocean, using surface current fields from a data-assimilative global ocean model.

The results are discussed with a focus on assessing limits and potentiality of the algorithm for solving a path optimization problem in presence of dynamic currents.

VISIR as a community model will contribute to the energy efficiency of vessel operation (IMO SEEMP) through optimization of the route duration on the basis of forecast ocean state.

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### OPTIMIZATION OF THE VENTILATION PLANT OF THE HSC ENGINE ROOM

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Engine room is one of the most important space of a hydrofoil. It hosts all the mechanical components for the propulsion and for the technical facilities of the vessel, such as marine engines and electrical generators. In order to ensure the proper functioning of these components, an adequate air supply has to be guarantee. This is achieved thanks to the ventilation system, which provides the air flow not only for the engines aspiration but also for cooling the room. In fact, each mechanical component produces a certain amount of heat that warm up the engine room. The result is an increase in temperature which may be critical, especially for the engine crew and for the air aspiration conditions. This is a relevant problem for a small engine room, like that one of a hydrofoil where it is necessary to limit the air's warm up in order to ensure a good engines yield. In this paper using a CFD code the optimal design of the ventilation system is carried out in order to assure both the room accessibility to the engine crew that the proper functioning of the engines and the generators.

## Ship Digitalization and Unmanned Vehicles / 71

### Launch and Recovery for Ship-Deployed Autonomous Underwater Vehicles

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Autonomous underwater vehicles (AUVs) are increasingly being used for underwater survey and exploration missions. The expanding mission scope for AUVs highlights the need for a long-endurance operational capability, which mainly depends on propulsion efficiency and battery capacity. For most deployments, AUVs are launched and recovered from a mothership. While the launch process is relatively straightforward and automated, the recovery process is more risky and conventionally involves man-in-the-loop intervention to ensure that the AUV can be recovered safely. The use of submerged docking stations permitting battery recharge, data transfer and vehicle recovery offer a means of enabling persistence while also reducing associated deployment/recovery costs and risks. Autonomous docking with a submerged dock towed behind a ship is however complicated by the presence of currents, wave action, propeller wash and by the tow behaviour, all of which combine to cause disturbances that create misalignments in pose between the dock and the incoming vehicle. A robust docking guidance system is identified as a core and crucial component for ensuring successful AUV docking. This paper proposes an efficient and universal docking guidance framework that can help to address the limitations of existing docking guidance solutions.

## Structures and Materials / 73

### Innovative material design for marine engine non-structural components

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Marine engine industry researches for continuous improvement of efficiency and performance. Currently, all components of marine engines are made in metallic alloys. To reduce costs and weight, new materials for non-structural components must be identified. The new materials, e.g., nano-engineered thermoplastic polymers (NETP), will allow additional benefits due to drastic weight reduction and simplified maintenance and inspection operations.

Advancements in NETP design and application in marine engine industry relies on computer-assisted multiscale material design (CAMMD). Indeed, by advanced CAMMD techniques, the structure of NETP materials can be tailor-fitted to achieve the expected performances required by specific, advanced applications.

Since the introduction of plastic materials in the construction of non-structural components for marine engines constitutes an element of great innovation, a specific rule framework must be defined yet.

In this paper, starting from the analysis of the regulatory context currently used for metallic alloys a certification procedure is proposed and applied to a case study related to the cylinder head cover of a four-stroke marine engine. In particular, the mechanical properties of a new NETP material designed by CAMMD have been verified through a finite element simulation carried out on the relevant model.

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## Prediction of propeller shaft vibration using potential panel method and FEM

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Propeller shaft vibrations can be an issue on many types of ships, specially passenger vessels. The main cause of this problem can be due to unsteady hydrodynamic forces acting on the propeller surface.

The problem is assessed first using a BE model to predict propeller forces and moments on the hub and then using FE model to predict vibration on places of interest, inside the vessel.

The hydrodynamic part uses a potential panel method formulation where (locally) constant source and doublet panels are distributed on the propeller surface to fulfill the no penetration boundary condition. The Kutta condition is fulfilled shedding a force-free wake of doublet panels iteratively, until periodically stable forces on hub are detected. These periodic forces are then used as the input data for a FEM vibratory analysis of the structure. At the end, the vibrations are evaluated on places, where measurements were physically taken during sea trials.

Simulation results are compared with measured data and results are presented and discussed.

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## Correlation between FEM calculated and on site measured natural frequencies

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In the last years, the ship builder trend is to realize light structures in order to optimize the weight distribution on board. Since the early stage of the ship design process is very important to understand the dynamic behaviour of the different typology of ship structures.

For this reason, the importance of an accurate prediction analysis of the natural frequencies has become fundamental, as the resonance phenomena, that can occur due to the structure geometry and main exciting sources present on board, have a dramatic consequence on the vibration levels amplitude.

This typology of problem is faced by performing FEM analysis but, due to the complexity of ship structures, it is also important to verify the FEA obtained results by measurements of the natural frequencies and mode shapes on board during the different phases of the construction. This paper will show the methodology and procedure for natural frequencies measurements and also the correlation between the FEM predicted and on site measured natural frequencies.

As final result of this analysis, the level of accuracy between the theoretical model and real structural response of the ship structures will be established.

## Interior Yacht Design / 78

### Interior Yacht Design: evolution and new scenarios

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The recreational craft market (for boats longer than 24 metres) is particularly interesting as it continues to grow, displaying an ongoing positive trend since 2010 (source: Altagamma and SBI) with motor yachts constituting the major segment. These boats offer several points for consideration, particularly regarding their interior design, a topic of great interest nowadays.

The interiors of large boats were characterized for decades by recognizable aesthetic traits that led to the definition of a proper nautical line: lacquered mahogany for furniture and bulkheads, white ceilings, blue and white striped fabrics, and bright brass handles all make up what has been called "Old Navy Style".

In the last twenty years, however, there has been a real revolution in the interior design of these boats.

Various key points underlie this new concept of Interior Yacht Design: a renewed interest in synergy between domestic interior and nautical styles (with the arrival of a new generation of designers eager to present something different: starchitects, famous fashion designers and well-known civil architects), the search for the most suitable materials and technologies, and a desire to open up the boat outwards.

In this varied panorama, what are the possible future scenarios of Interior Yacht Design?

## Ship Efficiency and Renewable Energy / 80

### Monitoring systems at the service of ship's energy efficiency: measurements campaign and analysis of the actual electrical absorptions on board

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The awareness of ship's energy efficiency is undeniably one of the top priorities of ship-owners, designers and operators; the aim is to comply the continuously updated regulations and to optimize the configuration of electrical machineries and their consumptions to reduce emissions and costs. Therefore also monitoring systems, historically connected to the ship structural condition, have been recently employed to assess the energy efficiency collecting information to improve it. In particular, one of the energetic monitoring branches is to monitor the actual electrical absorptions of on board consumers for a selected ship. In order to have impartial empirical information about operating absorption of consumers, a long-term measurements campaign have been organized and carried out with specific instrumentation based on ship's operating availability. The samples acquired during monitoring campaign have been combined with data from ship automation system, integrating the analysis with details of machineries concurrently operating (utilization and contemporary factors). This kind of analysis leads to results suitable for designers to benchmark the foreseen required electrical load on board: the subsequent possible impact on diesel generators' sizing and performance optimization and/or electrical system configuration, could lead to weights, volumes and cost efficiency.

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## On the accuracy of unsteady RANS to predict hull-pressure fluctuations induced by a cavitating propeller

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Unsteady cavitation on ship propellers operating in behind-hull condition can induce large hull-pressure fluctuations. The hull forms at the stern together with the propeller characteristics determine the severeness of the excitation forces; hence the pressure pulses must be considered at design stage to avoid undesired vibrations. Computational Fluid Dynamics (CFD) simulations proved successful in the prediction

of the pressures at frequencies corresponding to the first harmonic component of the blade passage frequency (BPF) 1. However, the method, based on the unsteady Reynolds-Averaged Navier-Stokes(RANS) equations, underpredicts the higher harmonic components [3][4].

In this study, a multi-phase unsteady RANS approach is employed for validation of the pressure pulses on a model scale container vessel; the model was tested at the Hamburg Ship Model Basin as part of the European project SONIC[5]. The amplitude of the first, second and third harmonics of the BPF are large due to the extent of sheet and tip vortex cavitation, which poses a challenge for the computational method. The accuracy and the numerical requirements (hence the cost) are studied, in anticipation of including the pressure fluctuations in automated design-optimization techniques.

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## Analysis of the safety conditions for ship mooring during strong wind events: MOORWIND Project

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The knowledge of the dynamic behavior of a moored vessel under strong wind conditions is of great importance for the safety of personnel and passengers and the structural integrity of ships and shipyards both during the ship construction phase and along its operating lifetime. The evaluation of such behaviour, which is very complex and strongly non-linear, is usually carried out through simplified models of the wind velocity based on the assumption of simple logarithmic vertical profiles. This simplification increases the uncertainty on the estimation of the actual forces acting on the ship, which is usually taken into account oversizing the mooring system to guarantee safety conditions. The MOORWIND Project, which is being developed through a joint collaboration by CETENA and the University of Genoa, aims at evaluating the real wind actions on a ship during its construction phase by means of wind climatological analyses, numerical simulations, wind tunnel tests and in-situ measurements. The area chosen as test case is the Fincantieri's Monfalcone (Italy) shipyard, which is affected by very strong Bora wind events during the winter season. The results will be finally used to propose a general procedure to analyse this kind of issue in whatever context.

## Ship Design / 83

### Comparison of Marine Technologies for Mediterranean Offshore Gas Export

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This paper seeks to assess and identify the most viable marine technology to transport natural gas within the Mediterranean Sea. Pipeline, LNG and CNG solutions are put in competition. Techno-economic modelling of each technology is performed to evaluate corresponding Capex and Opex. To enable comparison among the alternative supply chains, estimations of the total cost of investment, shipping tariff, and facilities tariff were taken as primary attributes in the ranking process. Various project fundamentals, e.g. different distances from origin to destination together with different volumes of gas to deliver on an annual basis, are foreseen to highlight which of the three delivery solutions offers the specific minimum supply chain cost. Time to market, technical difficulties to implementation, and footprint are considered too. Number of LNG and CNG ships are developed at conceptual design level and stored in databases which feed optimal composition of fleets, both to compete with subsea pipeline projects whose main technical and cost parameters are available from different sources. Pipeline and LNG cost reductions are considered to make more reliable comparison of these technologies with ready advances in CNG technology.

## Machinery and Systems Design / 84

### TECHNICAL AND ECONOMIC AND ENVIRONMENTAL FEASIBILITY OF AN INNOVATIVE INTEGRATED SYSTEM OF MANAGEMENT AND TREATMENT OF WASTE ON BOARD

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The purpose of the project is to carry out the technical, economic and environmental feasibility of an innovative integrated management and treatment system on waste from modern cruise passenger ships.

The benefits of the new configuration compared to the traditional one will be identified by analyzing the entire waste chain from on board production to final disposal, through the various energy recovery phases and treatments required for best exploitation of the same.

Consideration will be given to the potentiality of waste addressed to treatment, the flows and mass and energy balances, and the operation of the system, defining technologically advanced and innovative systems, and their application scenarios, with particular attention to safety and hygiene in rooms on board involved in the process.

Finally, the economic outcomes of the innovative configuration will be analyzed and the environmental sustainability will be evaluated, referring to the existing regulations both in IMO and in existing mooring ports involved in the disposal of residual waste.

## Ship Design / 85

### PAST, PRESENT & FUTURE IN NAVAL SHIP DESIGN

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This paper traces the history of ship design since Roman times, when ship designers began to use curves for drawing frames, through the Venetian techniques (XIII-XVI centuries) reusing templates, to the most modern methods for ship design.

Throughout the first half of the 20th century, ships were getting bigger; so it was necessary to work on larger scales. The templates allowed working on different scales, such as widely used 1:10 scale. But with growing ship size, the moment came it was no longer practical to use templates. This happened at a time when the first computers came to our industry, promoting the development of ship design CAD systems.

There are many advantages of using CAD in shipbuilding: ease of design, speed of construction, use and reuse of information, etc. It is expected that in the future CAD tools will advance further and allow greater information management and virtual access through smart devices. In general, CAD systems provide tangible benefits while the process is optimized, reducing design time and production, and therefore costs.

## Machinery and Systems Design / 86

### Economic impacts of the ballast water treaty: a case study for The Netherlands and Belgium

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On 8 September 2017, the Ballast Water Treaty was officially ratified by IMO. The goal of this Treaty is to protect the marine environment. Exceptions to this Treaty are allowed, on condition that the risk of inventorisation of species is not increased. This research focuses on the economic (and societal) cost-benefit analysis of possible exceptions to the Treaty, in particular the possibility to introducing a so-called 'Same Risk Area' (SRA). The research approach consists of two main steps: problem identification on the one hand, and economic impact analysis on the other. Step 1 entails unraveling what the operational side of the Treaty looks like, with focus on The Netherlands and Belgium. For step 2, an identification of the shipping origins, destinations and routes within the identified geographical area, as well as the fleet sailing on these routes and its characteristics, will be elaborated. That is the basis for an economic cost/benefit impact assessment of ballast water zones and exceptions to them, under three identified geographical scenarios. The results shed useful insight to national authorities and concerned shipping companies, so as to judge on the wider impacts the Treaty and its exceptions might generate.

## Ship Efficiency and Renewable Energy / 87

### Implementation of Ship Energy Efficiency requirements in off-shore shipping industry

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The International Maritime Organization (IMO), through its Maritime Environmental Protection Committee (MEPC), has been carrying out substantial work to provide the fundamental conditions for the reduction of greenhouse gas emissions from international shipping since 1997, following the adoption of the Kyoto Protocol and the 1997 MARPOL Conference. Many documents, issued in this respect, are dedicated to different types of vessels.

More of the requirements and regulations for establishing of efficiency criteria are based on commercial activities of the vessels and respective fuel consumption. There is the big difference between offshore vessels and all other vessels. Offshore shipping industry has another criteria for effective fuel consumption. As long as the job is with very high risk Safety is with high priority. The offshore industry try to find another way and means for implementation of MARPOL Annex VI requirements.

The article summarizes Classification Societies requirements regarding offshore vessels. The requirements are compare with IMO Resolutions in this field and conclusions are made. The authors has made proposals to education system which are related to STCW Convention Code, Part B.

## Hydrodynamics / 88

### Comparative test in design of hydrofoils for a new generation of ships

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Compared to all traditional fast ferries, Hydrofoil represents the best solution for the fuel economy and reduction of ship motions. These advantages are still undisputed primates of the wing supported means.

It is then wondering why hydrofoils are not so used in modern commercial fleets even despite the high management costs from the maintenance point of view, the initial acquisition cost higher than other similar solutions.

The article shows results of a tank tests campaign performed by Liberty Lines on new class of hydrofoils "Admiral-250", designed and built by Liberty Lines, where fundamental points have been touched upon, such as: the wing hydrodynamic optimization by means of model testing; the structural study of new wing systems and the update of the production processes with new construction techniques, and the improvement in comfort for passengers in terms of accelerations and vibrations.

The tests for above outlined hydrofoil projects have been carried out in main towing tanks in Europe, showing a significative gain for new projects.

The know-how achieved, following the definition of the "Admiral-250" project, has made it possible to develop a challenge: the "Admiral-350" class, the largest passenger cargo hydrofoil ever produced, equipped with POD propulsion.

**Hydrodynamics / 89**

## TIME DOMAIN ASSESSMENT OF VERTICAL MOTIONS OF PLANING HULLS

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Operating in high speed regime leads to hydrodynamic lift and displaced volume diminution, consequently the boat experiences the changing of trim, rise of centre of gravity and wetted surface decreasing. Standard linear model, for planing hulls seakeeping assessment, based on the linear free surface condition and small changes in wetted surface are not applicable at all.

This work is focused on the comparison of two mathematical models for planing hulls vertical motions. Both mathematical models make recourse to the "Strip Theory", at each instant the effective immersed volume is computed, taking into account the non-linear effects. Main differences between them are in pitch small angle assumption and in hypothesis of horizontal velocity equal to ship's speed.

The developed mathematical models have been validated against experimental results for modern warped hull form at different speeds. The availability of specific and dedicated experimental tests allowed to compare time series of experimental and numerical data results, not only typical values reported in literature, and furthermore to analyse them in the same manner.

Comparing the results was possible to assess the quality of the codes, commenting on the applicability and sensibility of them for planing hull vertical motions assessment.

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## Advanced HVAC solutions for Efficient Vessels

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In passenger vessels, Heating Ventilation and Air Conditioning (HVAC) system is the second largest consumer of energy after propulsion. It can be estimated that up to 30% of the total energy consumption of a passenger ship comes from HVAC systems for cabins, public areas and galley ventilation. When the ship is berthed in the port, the HVAC system becomes the main energy consumer. ABB can offer a wide range portfolio of Energy Efficiency solutions, providing specific technologies and services for the HVAC systems in marine vessels. The solutions will help ship owner and operators to reduce power consumption through the optimization of HVAC system, and consequently reducing CO<sub>2</sub> emissions and fuel consumption.

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## Cybersecurity for Marine & Ports Service

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Cybersecurity and IT Security are no more an option.

ABB as automation maker, is driving the market awareness. We're building specific product resilience, in order to enforce business continuity in a fast growing digital environment.

Training, specific products and continuous asset management are the pillars to grow confidence on advanced services.

Ship Design / 92

## NON LINEAR AND MODULAR PLANNING

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Shipbuilding is a nonlinear and modular process. Activities in production, design, management and finance are interlinked and interdependent. That has been, but only partially, already tackled by PERT and net diagrams depicting interdependence of activities, but in the production process mainly.

We deem it desirable and indispensable to introduce all activities not only during the production process but in preparatory stage as well, i.e. design, development of drawings, class and government bodies' approvals, purchase of materials, finance i.e. cash flow. The shipbuilding process in broader sense includes also after delivery activities which should be also be part of planning and prediction process. If we use a theory of games to predict economic consequences and, instead of enemy substitute it with any form of problem, such as but not exclusively, errors in production, failure to satisfy quality control, delay in material supply, delay in production etc., we can for any of the problem have a pre-calculated and predicted deviation from the ideal path, planning.

Our response time i.e. countermeasures could and should be instantaneous. Shortening of the reaction time is the key to the success.

Hydrodynamics / 94

## ON UNDERWATER GLIDER'S STABILITY IN BALANCING MODE OF MOTION

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This study defines hydrodynamic characteristics of underwater gliders based upon numeric solution of Reynolds-averaged Navier-Stokes equation. Methodological aspects of determination of coefficients of rotary derivatives of hydrodynamic forces and moments of underwater objects based on mechanism of "sliding computation meshes" implemented in many computing software packages of mechanics of fluids are examined. The paper identifies the main stages of development of the calculation model for solving similar tasks. The non-stationary calculation of the flow of viscous fluid past the underwater object resulted in determination of velocity and pressure fields in the stream. Ratios have been obtained which allow to determine coefficients of rotary derivatives of hydrodynamic forces and moments based on the preset values of hydrodynamic impacts.

Mathematical model of glider's motion was designed. Glider's motion parameters dependences on effect of alternating excessive buoyancy are presented. Based on analysis of roots of linearized system's characteristic equation the glider's stability zones in balancing mode of motion are determined under varying values of excessive buoyancy, metacentric height and excessive buoyancy arm.

**Comfort on Board / 95**

## Comfort class assessment: acquisition procedures and harmonization for effective passenger comfort

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To assess passengers comfort on board of cruise ships, Classification Societies recommend specific aspects of ship design and layout, to comply with a set of suitable criteria.

These criteria take into account ambient aspects and disturbances such as whole-body vibrations, noise, indoor climate and lighting. The proper combination of those should create a suitable environment for the passenger well-being.

However, there is not much harmonization among the different requirements, with respect to the entity of the disturbing factors and the different cabin's comfort classes.

To carry out the mentioned assessments, the Classification Society allow for very short data acquisition periods, hindering the understanding the evolution of the disturbances and the averaging effects of the transients in the ships operation and activities. Combined, these effects will lead to poorly meaningful indicators' values, misrepresenting the actual cabin comfort.

The paper will show how transients in the data could modify the assessment and how very high segmentation of the comfort classes is behind human perception.

The authors would like to sensitize operators on the need of more apt measurements procedures and to ensure that the differentiation, among the cabins' comfort classes, is linked to passengers sensitivities more than instruments capabilities.

**Structures and Materials / 96****LOCAL STRAIN APPROACHES FOR LCF LIFE PREDICTION OF SHIP WELDED JOINTS**

**Authors:** Eugenio Guglielmino<sup>1</sup>; Pasqualino Corigliano<sup>1</sup>; Pingsha Dong<sup>2</sup>; Vincenzo Crupi<sup>1</sup>

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Welded joints in ship structures are subject to several variable loadings which may lead to fracture after a relatively low number of cycles. This behaviour is not always fully described by high-cycle fatigue predictions, so low-cycle fatigue has also to be assessed, considering plastic deformation. Local approaches, mainly based on local displacement and strain measurements by strain gauges, are applied in these cases. These approaches have physical limitations when high stress concentrations regions are analyzed.

The aim of this research activity is to predict the low-cycle fatigue life of welded joints used for ship structures, applying two methods: the effective notch strain approach and the structural strain approach. The first method was applied performing elastic-plastic finite element analyses (FEA), using different cyclic stress-strain curves for base material, heat affected zone and weld metal, while the second method requires only elastic finite element analysis and is mesh insensitive. The geometry used for the elastic-plastic finite element analysis was acquired by means of a 3D scanner. The finite element analyses were validated by the experimental data. Effective notch strain results and structural strain results were compared and their values were used to predict fatigue life.

**Structures and Materials / 97****Analytical formulation of plating ultimate strength with pitting corrosion wastage**

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The assessment of plating ultimate strength with pitting corrosion wastage is a basic issue for the proper scantling and design of ship structures. In the past, several nonlinear FE analyses have been performed to investigate the incidence of pitting degree and corrosion depth on plating ultimate strength, with the main aim of providing some approximate formulations, useful at least in a preliminary project phase. Based on actual state of art, the main aim of current research is to provide an analytical solution for the ultimate strength of platings with random pitting corrosion wastage, by solving the Marguerre nonlinear governing differential equations for large deflection analysis of platings in the post-buckling regime. A comparative study with several well-known FE results available in literature is performed and a simplified formulation to assess the plating ultimate strength reduction, as a function of pitting degree and corrosion depth to gross thickness ratio, is proposed.

**Offshore / 98****Station-keeping calculations in early design stage: two possible approaches**

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The continuous increase of offshore operation in deep or ultra-deep waters, makes, for modern units, Dynamic Positioning (DP) analysis mandatory since early design stage. The necessity to provide reliable solutions for the DP system to mount on board in order to maintain position requires the implementation of simulation codes to reproduce the dynamic behaviour of the unit under variable environmental circumstances. Usually, it is common practice to perform simplified quasi-steady calculations during the early design stage, in such a way to obtain a sufficient amount of indications, necessary to a rough estimation of DP system capability and dimensioning. Besides, time domain calculations can be also adopted, once sufficient information are already available, at the considered design phase, regarding hull form, thrusters system and superstructure geometry. In the present work the two mentioned approaches are compared in terms of the resulting capability plots evaluated for a reference ship. The results have been obtained from two self-developed codes (one quasi-steady and one dynamic), which are adopting the same thrusters allocation algorithm.

## Ship Design / 99

### A NEW APPROACH FOR HUMAN FACTOR INTEGRATION INTO SHIP DESIGN PROCESS

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Ship safety and operational aspects are driving issues of ship design and at the same time it is well recognized that such performances are strongly related to the Human Factor (HF) element. In the paper a methodology to integrate HF into the ship design process since an early stage is proposed, with the aim to improve the overall ship resilience when dealing with uncertainty implied by HF performance.

The System-Theoretic Accident Model Process (STAMP, Leveson 2003) is investigated as a suitable methodology that combined with risk analysis can provide a significant improvement to decision making during the ship design process. To better frame pros and cons of such approach, selected application cases from other industrial and transportation fields will be analysed and commented. Furthermore in the attempt to define a comprehensive procedure, specifically for a "design for operations", models suitable to classify the human behavior will be considered with specific focus on the reasons for degrade (ETTO - Efficiency Through Trade Off, Hollnagel 2009; SRK - Skills, Rules, Knowledge, Rasmussen 1983). For the context description the SHELL (Software, Hardware, Environment and Liveware, Hawkins 1987) model will be introduced since it is very effective to represent interactions of human beings, also at organizational level.

## Hydrodynamics / 100

# Model order reduction by means of active subspaces and dynamic mode decomposition to parametrized hull shape into hydrodynamic design problems

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We present the results of the application of a parameter space reduction methodology based on active subspaces (AS) to the hull hydrodynamic design problem. Several parametric deformations of an initial hull shape are considered to assess the influence of the shape parameters, considered on the hull wave resistance. Such problem is extremely relevant at the preliminary stages of the ship design, when several flow simulations are typically carried out by the engineers to establish a certain sensibility with respect to the parameters, which might result in a high number of time consuming hydrodynamic simulations.

The main idea of this work is to employ the AS to identify possible lower dimensional structures in the parameter space. The complete pipeline involves the use of free form deformation to parametrize and deform the hull shape, the high fidelity solver based on unsteady potential flow theory, with fully nonlinear free surface treatment directly interfaced with CAD, the use of dynamic mode decomposition to reconstruct the final steady state, given only few snapshots of the simulation, and the reduction of the parameter space by means of AS. A response surface methods can then be employed to perform minimization of the hull shape.

**Machinery and Systems Design / 101**

## A Shared Immersive Virtual Environment for Improving Ship Design Review

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Ship design review (SDR) involves extensive collaborative and participatory processes requiring all SDR actors (designers, stakeholders, end-users) to manage a large complex decision space and to cope with heavy cognitive demands. Here, we present a novel framework for the development of a system whose purpose is to optimize the balance between SDR complexity and users' cognitive effort. The system will exploit the power of interactive multi-user immersive 3D environments based on efficient immersive Virtual Reality Mock-Ups (VRMU) from CADs. The remote multi-user cooperative interaction will be supported by tools like Oculus Rift and Oculus Touch/Leap Motion, as well as by avatars to overcome geographic distance and increase social proximity. This will likely facilitate joined decision processes and, through enactment, the visualization of environmental features (error/feature detection, information search), thus promoting the project development towards success.

**Safety and Security / 102****Fuzzy Analytical Hierarchical Process to Assess Weights of Importance in an Operative Risk Assessment****Authors:** GIORGIO TRINCAS<sup>1</sup>; Jasna Prpić-Oršić<sup>2</sup>; Luca Braidotti<sup>3</sup>; Marko Valčić<sup>4</sup>; Vittorio Bucci<sup>5</sup><sup>1</sup> UNIVERSITY OF TRIESTE<sup>2</sup> Faculty of Engineering, University of Rijeka<sup>3</sup> University of Trieste, University of Rijeka<sup>4</sup> Faculty of Maritime Studies, University of Rijeka<sup>5</sup> University of Trieste**Corresponding Author:** luca.braidotti@gmail.com

To evaluate the safety state of the ship in a generic operative or emergency condition is a very complex issue due to the huge number of attributes involved in the problem, uncertainties on their values and assessment of their mutual importance. The safety of the ship shall be presented in a simple and immediate manner in order to provide a useful decision support to onboard personnel. This is why, a hierarchical risk assessment procedure has been developed selecting a set of attributes which are grouped in criteria and sub-criteria. The attributes are fuzzified and combined in order to obtain a risk index for each sub-criterion and criterion. The mutual importance of criteria, sub-criteria and attributes is assessed by means of a fuzzy Analytical Hierarchical Process (AHP), which rationally incorporates and treats the experience of masters and officers collected by a survey. This process allows summarizing experience and proficiency into a decision support system devoted to increase ship safety, while providing an interesting representation of the onboard perception about risk and which are its main causes.

**Structures and Materials / 103****STRUCTURAL ANALYSIS OF EXPLOSIVE WELDED JOINTS FOR SHIP STRUCTURES****Authors:** Eugenio Guglielmino<sup>1</sup>; Pasqualino Corigliano<sup>1</sup>; Vincenzo Crupi<sup>1</sup><sup>1</sup> Department of Engineering, University of Messina**Corresponding Author:** pcorigliano@unime.it

Aluminum superstructures and common steel hull connections are of fundamental importance in ships. Traditionally they were performed by riveting, leading to corrosion phenomena and stress concentration sites. Structural transition joint obtained by explosion welding can overcome these problems giving a good compromise in terms of mechanical strength and corrosion resistance. This study regards the structural analysis of explosion welded joints, made of three layers (ASTM A516 low carbon steel, pure aluminium, A5086 aluminium alloy) and used in ship structures. Experimental tests (static bending, fatigue bending and buckling tests) were carried out on explosion welded specimens. Two full-field techniques were applied during the tests: Digital Image Correlation for the detection of displacement and strain fields, and Infrared Thermography in order to detect the superficial temperature of the specimens. Furthermore, a finite element analysis, considering the different mechanical properties of the explosive welded joint, was performed and was validated by means of the experimental results.

**USING GAME THEORY FOR CHOOSING THE OPTIMAL STRATEGY FOR IMPROVING SHIP'S ENERGY EFFICIENCY**

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Ship Energy Efficiency is the IMO topic of the day since 1997 after Kyoto Protocol issuing. All ships with gross tonnage 400 and over have to meet MARPOL Annex VI requirements. The Companies create and develop their own strategies based on personal experience.

The article describes a method for evaluation of the energy efficiency of maritime transport in the spirit of the Kyoto Protocol since 1997 and Paris Conference since 2015 and IMO requirements to the Maritime industry. The assessment uses mathematical game theory and makes it possible for quickly and easily selection an appropriate vessel operating strategy in order to meet both the ever-increasing international demands and the efforts of the shipping companies to reduce fuel expenses.

## Hydrodynamics / 106

### Hydrodynamic noise from a propeller in open sea condition

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In the present work simulations of an isolated marine propeller are carried out using Large Eddy simulation and the acoustic field is reconstructed by applying the advective Ffowcs-Williams and Hawkings equation. We reproduce a propeller well studied in literature (<https://www.sva-potsdam.de/en/potsdam-propeller-test-case-pptc/>) for a single value of the advance ratio.

We use the dynamic Lagrangian model for the closure of the subgrid-scale stresses and a wall-layer model to skip the resolution of the viscous sub-layer. A grid of about 5x10<sup>6</sup> cells is used for reproducing accurately both the stresses over the propeller and the wake, the latter responsible of quadrupole noise. The equations are solved in a fixed-to-the-body frame of reference.

The different noise generation mechanisms are investigated separately. Thickness and loading terms are related to the propeller shape and velocity, they provide significant pressure disturbance in the near field. The quadrupole noise component is obtained by integrating either the volume surrounding the propeller or an external permeable surface. Its contribution is investigated in relation to the presence of vortex persisting in the wake. A discussion of the results will be included in the paper.

## Ship Design / 107

### Vertical motions assessment of an Offshore Supply Vessel in concept design stage

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The main hydrodynamic characteristics of an Offshore Vessel are mostly referring to motion behaviour in rough sea. For such kind of ships, good seakeeping performances are mandatory, and, besides dynamic positioning quality, maybe more relevant than purely propulsive issues. The seakeeping performances of a ship are strongly influenced by main geometric parameters selected since concept design stage. Means that, to improve the designers' ability to properly select the best preferred design, enhanced methods should be implemented in such a way to accurately determine seakeeping performances as function of the more significant geometrical parameters and non-dimensional ratios. In the present work a procedure, based on the determination of multiple regression models with different parameter combinations, has been developed to reproduce the vertical motions transfer functions of a generic supply vessel at different encounter angles and operational speeds. The regressions have been obtained from 2D strip theory calculations on a family of supply vessels, ensuring a sufficiently accurate estimate of heave and pitch motions since concept design stage.

**Interior Yacht Design / 108**

## Interior design of motor yacht, evolution of style and typology

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The analysis of the furnishing system in relation to the evolution of the motor yacht can propose several insights. Firstly, on the aesthetic evolution of furnishings, in relation to the construction systems and materials used, secondly, the evolution of the organization of living spaces in relation to the general proportions of the boat. Ultimately, the study of the evolution of the concept of life on board. If we consider the purpose of modern pleasure crafts -and theirs evolution over last decades- the nautical space could be considered as a derivation of residential architecture, from which it takes living and functional standards. Every form and functional solution of yacht interiors appear nowadays a derivation of "home typology" configuration. In general terms, the aesthetic outcome of living spaces is influenced, in turn, by the change of vogue, sociological implications, technological evolution of building processes and materials.

The evolution of inhabited spaces also influence the general aesthetics of the modern yacht, so the interior design nowadays is a increasingly determinant part within the general planning, whereby the geometrically regular shapes of hull and superstructures are the outcome of a common projectual vision that characterizes the entire project through a unified style concept.

**Machinery and Systems Design / 110**

## Fuel cells and shipping emissions mitigation

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Data analysis of vessels routes show that shipping is responsible of about 3% of world CO<sub>2</sub> and other pollutants production. The effect on environment is increased as most of the emissions are concentrated in coastal areas. IMO and other bodies are making growing efforts to impose severe

limits on shipping pollutions. Different technical and operational improvements have been made but hydrogen and fuel cells still remain one of the best candidates to substantially reduce emissions and fuel consumption. This paper gives an updated review of the fuel cells applications in the marine sector and analyses the potential of different fuel cells technology for the on board installation. The analysis shows the advantages that fuel cells can give in terms of emissions reductions and fuel saving. The benefits are dependent on the type of ship and the operating profiles. Nevertheless, even if some fuel cells types are today ready for marine application, costs, hydrogen availability and certifications issues still hamper the full exploitation of the technology.

## Machinery and Systems Design / 111

### A simulation model for hybrid-electric inland waterway passenger vessels

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The increasing focus on air pollution reduction for transportation systems requires to adopt new technologies and innovative solutions to limit vehicles emissions. In case of inland waterway transportation (IWT), once vessels have to operate close to urban areas or in natural reserves, the necessity to provide a “green navigation” is of primary importance. With this specific aim, especially for small crafts, the adoption of an hybrid-electric power system grant a significant pollution reduction, leading also to a possible Zero Emission Mode (ZEM) navigation. However, the particular configuration of inland waterways makes the estimation of vessels’ hydrodynamic performances harder compared to a seagoing ship, because of restricted waters effects, affecting both resistance and manoeuvring characteristics. For this purpose, time domain simulation program has been developed to estimate the effective power demand of an inland vessel during a specific route. The program has been tested on the specific case of a passenger vessel designed for the Grado lagoon, where all the reference route bathymetric data were available. By means of the simulations it has been possible to state whether the vessel is suitable to operate in ZEM mode during the service.

## Ship Design / 112

### GASVESSEL - CNG sea transportation project

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GASVESSEL project aims to prove the techno-economic feasibility of a new CNG transport concept enabled by a novel patented Pressure cylinder manufacturing technology and a new conceptual ship design including safe cargo handling.

It introduces an innovative solution for manufacturing Pressure cylinder that are 70% lighter than state-of-the-art alternatives. These superlight Pressure cylinders enable new ship designs with much higher payloads and dramatically lower transportation costs per volume of gas.

Where the exploitation of stranded gas is currently economically not viable, GASVESSEL brings a

solution, as a cost-efficient and flexible CNG transport system that can unlock energy resources and decrease Europe's dependence on a single supplier by serving as a flexible interconnector, which enables energy to flow freely across the EU.

The project supports the EU's Maritime Transport Strategy in which maritime transport is considered key to securing Europe's energy supply.

The validation and proof of concept of the GASVESSEL project is performed by a cost-benefit analyses (financial viability), safety assessment, environmental impact analyses and value chain business cases development in relation to real-life geo-logistic scenarios.

The project is carried on by 12 European Partners and coordinated by Navalprogetti.

## Safety and Security / 113

### Risk Based Designs (RBD)

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The shipping industry is going through a period of rapid technological change, and the rate of change is accelerating. This change is making it impossible for traditional prescriptive class and statutory requirements to keep pace with engineering advances. LR have developed a new ShipRight Procedure Risk Based Designs which is intended to provide a consistent and transparent process to assist both clients and surveyors when working on projects for which prescriptive rules does not exist or where these rules are not in themselves suitable and sufficient.

This process is not intended to replace traditional rules, but rather to manage the process of implementing technology. This will allow Class societies and other bodies of the industry to achieve the knowledge/experience necessary for the development of prescriptive rules. Whilst the final objective is to develop prescriptive rules for emerging technologies a process to manage deviations and the application of risk based principles will be needed even after such prescriptive rules are published. Paper will provide background on why the RBD process has been developed along with its basic principles. Typical field of applicability is any innovative field as for instance Low flash fuel systems (LNG, methanol, hydrogen, etc) and IGF code.

## Ship Efficiency and Renewable Energy / 114

### Application of a Passive Control Technique to the ISWEC: Experimental Tests on a 1:8 HIL Test Rig

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In this work, we address the use of Hardware In the Loop test rig for renewable energy application. Such test rig is designed to evaluate the performances of the wave harvesting system called ISWEC. The ISWEC is a floating, slack-moored, gyroscopic Wave Energy Converter. The full-scale prototype has an electric-mechanical Power take-off (PTO) composed by a gearbox and a brushless torque motor. The system is torque controlled to keep the gyroscope in the desired position range and to obtain maximum productivity. In order to obtain this, two different control methods are under study:

a proportional-derivative (PD) law and a passive control method. The PD control law regulates the torque on the PTO providing a stiffness term to recall the gyroscope in the vertical position and a damping term to extract power.

In this configuration, the PTO performs the recall effect, resulting in an increase of the torque load. To overcome such problems, the use of an eccentric mass to provide the stiffness term is analyzed.

The experimental tests demonstrate the reduction of the PTO torque, justifying the gap in the system productivity provided by the passive control as assessed with the numerical model.

## Navy and Cyber Security / 115

### Definition and development of the modularity features for the Italian Navy Multirole Patrol Vessel Stern Mission Bay

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All NATO navies are facing the challenge of meeting current and future operational requirements while reducing procurement and life cycle cost of naval platform.

To this regard, the Italian Navy has adopted, over the last years, new design concepts in order to maximize operational flexibility for future needs by an extensive use of modularity features on its platforms.

During 2016 through 2017, the activities performed in the NATO Mission Modularity Specialist Team, NATO Total Ship System Engineering Specialist Team and in the procurement activities for the Italian Navy Multirole Patrol Vessel project, allowed to define a collaborative multi-disciplinary team between Italian Navy and Italian companies (Fincantieri) in order to identify and develop an exploratory approach for assessing the capabilities and functionality features of newly designed mission bays.

This paper aims at underlining the Italian innovative approach to obtain the insights necessary to procure more effective and affordable naval units, using this exploratory approach.

This paper aims, thorough a deep insight on whole-warship design impact of Mission Bays and standardized modular areas, at underlining the Italian innovative approach to obtain maximum versatility of operational use of its military ships.

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### Stern flap solution to contain the speed performance loss due to the ship weight growth (Case study: De La Penne Destroyer Class)

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It is well known that during the life-cycle the growth of the ship weight is one of the main source of the performance-loss. Stern flaps have been used in many recent designs of transom stern vessels, in particular by the US Navy, to increase top speed or to realize improvements in fuel economy over the operating range. Furthermore, stern flap implementation has also become a practical retrofit on

existing platform because significant improvements can be achieved at minimal cost. According to the US Navy experience, in order to analyze this aspect, the Ship Design Office of the Italian Navy General Staff has been performed a preliminary evaluation of the application of this device on own Destroyer hull (De La Penne Class), using the CFD U-RANSE approach. This preliminary study was conducted in model and full scale: several flap angles have been tested with a fixed NACA profile. The results have shown that the major improvements, in terms of power reduction, have been obtained for the interest speed range ( $Fr_V = 0.94 - 1.18$ ).

## Navy and Cyber Security / 117

### Naval automation cyber defence guidelines

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It's been 15 years since "cyber risk" was identified as the new millennium threat, potentially affecting organizations, industries, governments and society. Despite choral worries, the naval context has seemed to remain unaffected for years, as long as ships could have been considered "isolated systems" floating offshore. But, as new technologies (either commercial or military) had spread out on in this rapidly becoming "information-dependent" and "inter-connected" shipping industry, cyber risk finally become a threat. As the matter turned into business, many solutions have been developed in order to grant cyber-security, at user level (i.e.: personal, office, enterprise, server farm..). Could these solutions completely protect a ship themselves? How much a shipowner has to invest in cyber-security? How he could efficiently face cyber-threat? This kind of questions generally have no straight answer because nobody can find a proper solution without an assessment, tailored on the specific case of context. This work is intended to advise ship owners on the importance of an effective cyber-risk assessment before the choose of a cyber-security solution and, in the meantime, it suggests an easy way to conduct it, formulated on the basis of classical risk-assessment procedures.

## Navy and Cyber Security / 118

### Italian Navy future fleet - Analysis of on board electrical systems and cold ironing

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Shore connection has become a topic of huge technical interest both for merchant ships and for military ships. The Navy's fleet renewal program offers the opportunity to reconsider this aspect within the main naval bases of the Italian peninsula. In particular, the presentation analyzes the overhaul project of the Stazione Navale Mar Grande's electrical system in Taranto with the aim to be ready to host the future fleet in 2027.

Starting from cost-efficiency and versatility point of views, in order to reach the least infrastructural impact on the station and considering the cold ironing current standards (e.g. IEC/ISO/IEEE 80005 "Utility connections in port"), a working methodology is proposed to optimize the final results for several future scenarios, in order to guarantee the maximum flexibility and interchangeability for the mooring and shore connection services to be provided for different ship sizes and electrical power levels.

Finally, further improvements in the electricity grid are considered (potential "spin off"), such as energy efficiency systems, green energy sources and distributed cogeneration integrations to meet the needs and to gain the desired load shaving.

## The Green Fleet Project – Energy Saving Measures

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The Italian Navy has always had, among its mission, the safeguard of the marine environment, and it is strongly oriented in giving its contribution to the targets fixed from the European Parliament with the “2020 Climate and Energy package”.

In 2012 ITN has launched the “Flotta Verde” initiative, with the purposes of reducing gas emissions and improving the national energy security. To achieve these goals, ITN follows three main strategies : adoption of a renewable synthetic fuel; innovative eco-design technologies (LED lighting, SCR, silicone paints); energy saving operating procedures. The paper presents an overview about the Flotta Verde initiative and a case study aimed to optimize the power consumption of Engine-room ventilation Plant for ITN ships. In particular, the study analyzes the energy needed to ensure the proper air flow in the engine-room as a function of the ship operating conditions.

Aboard a navy ship, the aim of an engine room ventilation plant is to provide comfortable working conditions, and to ensure the necessary air flow to prevent heat-sensitive apparatus from overheating. The case study compares traditional solutions with new technologies in the field of energy saving and calculates the time for ROI (Return of investment).

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## Numerical simulations of fully-appended BB2 submarine at high-Reynolds number flow at 0° and 10° yaw

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We study hydrodynamics of a fully appended submarine using numerical simulations. First, we solve the Reynolds Averaged Navier-Stokes (RANS) equations, and successively we use Large-Eddy Simulations (LES). The Reynolds number of the flow is  $Re_L = 9.57 \times 10^6$  and we consider two angles of yaw, 0° and 10°. The wall-layer approach is used to skip the direct solution of the thin viscous sub-layer. Numerical simulations are carried out using OpenFOAM framework. In RANS, the k-omega SST closure is adopted; in LES, the Lagrangian dynamic subgrid-scale model is used. The main differences between the two methodologies consists that RANS solves a flow field which, on average, is steady, whereas, LES provides the possibility to achieve a better understanding of the intrinsic unsteady nature of this flow, including three-dimensional turbulent vortical structures, wake and induced noise. On the other side, LES can be computationally much more expensive than RANS. Here we show the advantages and drawback of the two methodologies, in terms of accuracy and computational cost; the flow field over the submarine will be then fully characterized, quantifying the unsteady submarine's footprints in terms of their statistics, intensity and location.

## Comparative Study of Hydrodynamic Performance for Site-Specific Optimal Designs of Catamaran and SWATH

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Due to the request of energy source diversity, in addition to traditional oil/gas exploitation offshore industry has started to outspread to different energy areas such as gas hydrate and renewable wind energy in open sea. Foreseeably, as the demands of clean energy become more and more ardent under the pressure of environment protection, the offshore activities will extend more to renewable energy development. The recent years' rapid increases of offshore wind farms in North Sea and East China Sea are two representative examples.

In this paper, two typical ship types commonly used for offshore service activities, namely Catamaran and SWATH (Small Waterplane Area Twin Hull), are focused to compare their hydrodynamic performances in a specific site - East China Sea. Optimizations of the hulls for both Catamaran and SWATH to minimize their resistances in clam water and seaway conditions are performed and using the available wave scatter diagram of East China Sea, the hulls are further revised to fulfill the best sea-keeping performance characteristics. Through the comparisons of the optimal designs, this paper attempts to provide a detailed procedure to guide the concept design for ship type selections of offshore vessels operating in site-specific conditions.

**Machinery and Systems Design / 122**

## Engineering progress measured on 3D model data rather than drawings

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Current CAD/PLM technology is finally allowing to perform engineering progress evaluation based on the model data rather than on traditional drawings and human subjective estimation. The paper illustrates the applied method, the requirements posed on the CAD/PLM solution to guarantee the applicability, a solution already available on the market and a real case study.

**Safety and Security / 123**

## LNG OPPORTUNITIES FOR HARBOR DEVELOPMENT

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Today a "Green" vision of the Port becomes fundamental and LNG is more environmental friendly than any other fuel for its reduced emissions (nitrogen oxide, sulfur oxide and particulate matter).

In the Mediterranean Sea, the environmental legislation has not yet imposed strict limits like it happened in the ECA / SECA zones. However, starting from 2020 or in any case by 2025, new regulations are planned to come into force.

The distance of the LNG suppliers from the terminals and the LNG demand itself strongly affect the whole supply chain. One key point to consider for competitive planning and development of the LNG supply chain is that LNG carriers can supply connected harbors thus reducing the number of vessels involved and optimizing the quantity of LNG carried.

The choice of using LNG as a fuel is growing because it reduces pollution and operative costs. The technology is ready to be used, but the port infrastructures have to face new challenges in the days to come.

This study shows the possible scenarios (LNG supply system and pollution reduction) if using LNG in four different types of port.

## Electrical Systems / 124

### A mixed AC/DC low voltage electrical distribution architecture for increasing the payload on ships

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This paper presents the development of a novel architecture for the low voltage electrical distribution on board using a mixed AC/DC approach. The design of the proposed solution is based on a real-world case study, i.e. the electrical distribution grid of a main vertical zone of a large cruise ship. The new electrical architecture is designed with the aim of obtaining a gradual transition toward a totally DC electrical distribution grid on-board. Furthermore, according to the selected technical criteria, the proposed scheme can be implemented on a real ship by using devices either available in the market or easily adaptable from commercial items. The impact of the proposed electrical design on technical volumes and weights of the electrical equipment is evaluated in comparison with the existing solution. Such a comparison shows that the proposed scheme allows a reduction of electrical plant volume and weight of about 30%. Finally, it is worth noting that the presence of several power electronic converters in the proposed electrical architecture increases the level of flexibility and controllability of electrical power flows on board representing a fundamental step in the transition toward a paradigm of smart electrical distribution and utilization in ships.

## Hydrodynamics / 125

### Numerical Predictions of a Model Scale Propeller in Uniform and Oblique Flow

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In modern market scenarios, the competitiveness of an enterprise is determined, beyond the quality of the product, by its time to market. Thus, nowadays, the computational fluid dynamics (CFD) technologies are extensively used for design purposes allowing the - in general - more expensive and time consuming experimental tests to be performed only at the final stages of the project.

Recognizing the added value of reliable CFD simulations, the University of Trieste (Italy) and the Slovenian private company Kolektor-Turboinštitut of Ljubljana (Slovenia), joined in the EU project ACCUSIM (Accurate Simulations in Hydro-Machinery and Marine Propellers – EU FP7-PEOPLE-2013-IAPP) in order to develop reliable, high fidelity methods for the accurate predictions, and optimization, of the performances of hydro-machinery and marine propellers.

In this paper, selected results, obtained by the synergic collaboration between the two partners, are presented for the propeller case. In particular, the simulations carried out for the PPTC model propeller, recognized as an international test case, are discussed. Numerical results are presented for the propeller working in both uniform as well as non-uniform inflow conditions. The predicted propeller performances and characteristic local flow details are compared with the available experimental data.

**Hydrodynamics / 127**

## Experimental investigation of blade and propeller loads during straight ahead sailing

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During operative scenarios, the propeller can experience an inflow substantially different from the one considered in the design phases and the 3D character of the flow gives onset to a complete system of loads. The quantification of these loads is of paramount importance to assess the reliability of mechanical structures, the comfort on-board due to vibrations and the effects on the dynamic response of the vessel.

CNR-INSEAN Manoeuvring basin allows testing large free-running models, simulating a wide set of operative situations: the authors focused their attention on the forces generated on the propeller and the shaft-line during off-design conditions. Recently, an experimental setup for the evaluation of propeller in-plane and bearing loads in operative, behind hull, conditions has been developed by using a novel patented transducer. This activity evidenced interesting hydrodynamic phenomena occurring during transient phases of manoeuvres. These results fostered a new research activity, for the first time carried out by free running, self-propelled model test, aimed to a more detailed investigation by means of measuring single blade loads. In this paper, the setup and the analysis of the straight ahead motion, as part of an extensive experimental campaign, are presented.

**Machinery and Systems Design / 128**

## Recent Advances on Propeller Shaft lines for the Marine Industry

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A vital component on the CP propeller shaft line is the gear box. The gear box is nowadays developed as a high- technology product being integral part of the shaft line system allowing: a) optimal rotational speeds for the propeller and the engine; b) configurational arrangements (e.g. twin- in, single- out layouts); c) two- propeller speed operation; d) integration of propeller hydraulic systems and d) integration of machinery room power systems (power take- in/ power take- out).

The added functionalities require advanced product development tools and robust manufacturing technologies. On product development, the design party needs to possess significant product knowledge through applications in lengthy periods of time. The design party must also have significant knowledge of all relevant machinery room equipment – from the propeller to the power supply unit - allowing the best integrated solution. The manufacturing party needs to have adequate tools and experienced personnel on gear technologies. In our recent working arrangement, Wartsila selected Flender GmbH, which is now responsible for the production and delivery of the product.

The paper presents the technical advances for a number of marine market applications showing the added value of the gearbox technologies to the customer.

## Ship Efficiency and Renewable Energy / 129

### PeWEC: preliminary design of full-scale plant for the for the Mediterranean Sea

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Nowadays, atmospheric pollution and climate changing have encouraged Governments to invest in renewable technologies for clean energy production.

Wave Power constitutes an interesting option in the panorama of renewables and starting from the first results achieved in the '70s, in the last and present decade the major efforts have been concentrated to make Wave Energy Converters (WECs) more protable and predictable.

The research activities described in the present work are concerned with the development of a pendulum converter (PeWEC: Pendulum Wave Energy Converter), specifically designed for the Mediterranean Sea scenario.

In the first part of the paper, the mathematical model of the system is presented and benchmarked against the experimental campaign results carried out at the INSEAN wave basin (Rome), in 2015.

Numerical models proved to be in good agreement with experimental data and thus suitable for the implementation of a model based design and optimization methodology. The latter is constituted by three different tools, with increasing degree of fidelity, that combined together allows to optimize the device performances on the installation site chosen.

Lastly, the optimizations tools previously described are used to evaluate a preliminary full-scale PeWEC layout, suitable for the Pantelleria Island (Italy) installation site.

## Hydrodynamics / 130

### A Numerical Way for a Stepped Planing Hull Design and Optimization

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Stepped planing hulls enable the feasibility of running at relatively low drag-lift ratio by means of achieving more optimal trim angle at high speeds than a similar non-stepped hull. Furthermore, stepped planing hulls ensure good dynamic stability and seakeeping qualities at high speeds. However, there is no precise method to analyze these hulls over the full range of operating speeds. For the above-mentioned reason, in this study, a CFD-based design approach was presented, starting from a non-stepped hull configuration, a multiple step solution was developed and an optimization of the unwetted aft body area behind the steps was performed. The goal of the optimization is the drag reduction and a dynamic stability. The CFD results was compared with the well-known empirical approach and a novel 2D+T analytical method.

## Weather Routing and Environment Modeling / 131

### Kotor Bay area hydrodynamics and pollutant dispersion simulations: a tool for contingency plans

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Harbor and coastal areas, according to ITOPF statistics, are frequent scenarios of small oil spill accidents, usually caused by oil tanker collision in maneuvering or during oil download. For sake of marine environment and human activities, contingency plans are required to minimise the damages of oil spills. In this regard numerical simulations are a useful tool to explore both the worst or more probable accident scenarios.

We present the case study of Kotor Bay, a semi-closed basin in the Adriatic Sea, an environmental and historical heritage, under UNESCO protection.

LESCOAST model, a LES model suitable to simulate sea currents in harbor and coastal areas is adopted to reproduce the hydrodynamic. The sea surface stress, required by the model, of the most frequent wind conditions is computed through preliminary low-atmosphere simulations which account for the surrounding orography.

Hydrodynamic and wind stress maps give an accurate input to a state of art model for the prediction of oil spill dispersion which account for the main forcing on the oil, namely gravity and friction. Finally, the computed pollutant dispersion process is used to map the sensitive areas and intervention time in the Kotor Bay.

## Machinery and Systems Design / 132

### Hybrid energy- and propulsion system for vessels in timetable operation

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The energy consumption of propulsion and all on board systems is becoming more and more into the focus of attention in shipbuilding and operation.

After some ample and intensive analysis and measurements of multiple operational profiles of ships, it was determined that a new, hybrid propulsion system, will be the optimal solution to reduce fuel consumption in timetable operation.

This parallel hybrid system which incorporates propulsion as well as the general energy management of all energy consuming parts on board as a holistic system, so that the distinct, transient processes can be smoothed out as much as possible. This allows the multiple diesel engines which are the main energy producers, to work at their most efficient operating point (or they shut off entirely due to battery buffers). The focus of the project is set on considering the integration of the different systems, their optimal cooperation with each other and the required system dynamics.

First measurements at the pilot vessel show that fuel consumption can be reduced by up to 22%. Also they show that, with the additional help of downsizing relevant components, the costs of operation can be reduced up to 40% (excl. crew costs).

## Structures and Materials / 133

### FEM-aided structural design of a natural fiber composite made skiff

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In racing boat design, the research is moved to find always the best compromise between performance and safety. The present work focuses on the description of the structural design cycle used by Polito Sailing Team during the realization of its new skiff, a high-performance sailing dinghy, built mainly with natural composite material like balsa wood and flax fiber. The whole boat was completely designed by students, according to eco-sustainable principles, to participate in a universities competition called 1001VelaCup.

To determinate the sandwich composite stratification, a benchmarking of materials was made by mechanical tests run according to ASTM 3039 and 3518 regulations. A finite element (FE) model was built to evaluate the static response of the structure, aiming to obtain a safe and light hull. The fluid (sea) interaction is modeled with a linear springs system. The crew, rig and rigging loads are obtained from a one-dimensional model and hydrodynamics pressure from ISO 12215:2014:5.

The outputs obtained are consistent with the physics of the problem. The stresses distribution shows that the maximum stress is in the proximity of the mast base. This work constitutes the first step to obtain a correct, reliable and innovative design tool.

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## SAN MARCO PROJECT

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All world countries, excluding the USA, are committed to reducing the GHG emissions of our planet. If this should not happen, the water level will rise and VENICE will need the help of the whole world for its survival. Venetian families are already fighting because the pollution caused by Diesel engines of the boats are higher than the maximum levels allowed by law, with serious consequences for the health of the inhabitants.

The SAN MARCO PROJECT involves the transformation of the "Vaporetti boats" into hybrid powered natural gas / electricity vessels to reduce consumption and engine noise and ensure a better air. This system allows: reduced waiting times, maneuvers, downtime and more agility. The Vaporetto's propeller will be moved by the electric motor. The Natural Gas engine drives a generator that produces electricity to power the electric traction motor. The batteries will add extra power to aid the acceleration phases. If necessary, the Vaporetto can proceed in zero emission mode. The complete operation involves the transformation to Natural Gas also of the Diesel engines of Buses and Service Trucks on the mainland. VENICE will become a worldwide symbol against climate change.

**Hydrodynamics / 135**

## EVALUATION OF PROPELLER INDUCED VIBRATIONS

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During the early design stages a fairly evaluation of propeller induced forces on the aft part of a Ro-Ro ship could become of paramount importance and, often, very difficult to be handled. The complex hydrodynamic interactions and the limited ways of wake factor evaluation, when experimental values are not available, lead to the necessity to consider Computational Fluid Dynamic tools in order to have a first input for the global vibration problem.

The paper is focused on the determination of propeller induced pressures based on a CFD approach, as a viable alternative of the experimental tests. By considering the calculations of the pressure field developed in the aft part of the ship, the results are further used as input data for the dynamic linear analysis performed by a Finite Element solver. Consequently, appropriate technical solutions and a preliminary structural optimization become affordable. The paper is presenting comparative results. Mention should be made that such an approach can provide reliable results for a better EEDI and, from this point of view, is line with the higher requirements regarding the marine environment pollution and greenhouse gases emissions. Better on-board comfort indexes can be also attained.

**Machinery and Systems Design / 136**

## Alternative fuels: present and future of containment technologies and impact on shipbuilding.

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In recent years there has been a strong move toward the adoption of LNG and other alternative fuels in the marine industry, mostly driven by new environmental regulations and the possibility, by doing so, to have overall cost competitive power systems. Different fuels have different storage requirements which may have a large impact on the ship design. Industry is now pushed both toward the introduction of containment technologies already used in other sectors, and the development of new ones. While today the mainstream technology is still based either on liquid fuels or physical containment means, such as liquefaction or compression of gases, future technologies may exploit chemical processes to absorb and release fuels in liquid or solid matrixes. This article provides a review of existing technologies and an oversight of the most promising coming ones, based on the experience and industry knowledge gained by Lloyd's Register in classing and working with ships projects involving the use of LNG, Ethane, Methanol and Hydrogen fuels.

**Electrical Systems / 137**

## **Integrated Ship Design and CSI Modeling: a New Methodology for Comparing Onboard Electrical Distributions in the Early Stage Design**

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In recent years, the MVDC distribution has been proposed as a viable solution for the redesign of the shipboard Integrated Power System (IPS). Indeed, there are relevant advantages promised by the innovative DC concept, among others a desirable reduction in the electric power system size. For providing a virtual proof-of-concept of this technology, parametric and interactive 3D models can be developed by a new Computer System Integrator (CSI) software. The latter may give the possibility to quantify the expected onboard benefits (i.e. increase of pay load) already during the early-stage design, thus opening interesting evaluation since the very first stage of ship design. By exploiting the capabilities offered by the integrated design methodology, a comparative analysis between a conventional MVAC electrical distribution and an innovative MVAC/MVDC hybrid system is performed in this paper. In particular, a significant Main Vertical Zone of a large cruise ship is modeled by the CSI software for providing a detailed comparison (volumes/weights) among the two power distribution architectures (MVAC vs hybrid MVAC/MVDC)

**Hydrodynamics / 138**

## **Extensive cavitation tunnel acoustic characterization of controllable pitch propellers for the development of a machine learning tool**

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For the propeller acoustic characterization, experimental tests in model scale are the currently established methods, however they are affected by uncertainties mostly due to scale effects. For this reason, it is difficult to consistently reproduce in model scale some of full scale functioning conditions.

To overcome this it is interesting to define empirical formulations to shape the most significant cavitating phenomena in terms of URN spectrum. A suitable approach for the determination of such formulations may consist in the experimental characterization of model propellers collecting a large amount of data such to accurately describe propeller functioning conditions and related noise emissions. Collected data should be then analysed to extrapolate desired formulations exploiting advanced data analysis techniques. Within these, machine learning methods represent one of the most promising solutions.

In the present work the acoustical characterization of two propellers, performed at the University of Genoa cavitation tunnel, is presented. The collected sample includes cavitation buckets, noise spectra, pressure pulses and photos picked up at various pitches, different incoming flow and in many functioning points, even in off design conditions.

## Weather Routing and Environment Modeling / 139

### Numerical simulation of hot smoke plumes from funnels

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The flow around ship over-structures is characterized by both separation phenomena with recirculation regions at high Reynolds number, and the fast ejection of hot smokes from funnels. These two features are of the utmost importance for two linked goals in the ship design, namely the aerodynamic drag reduction and the preservations of passengers' comfort. In particular, the latter depends on different flow aspects, among the others: the turbulent fluctuations intensity, the smoke temperature and pollutant dispersion and the flow induced noise.

In this work, we present an open-source solver developed in OpenFOAM® that is especially suited for the analysis of ship over-structures. It adopts Large-eddy simulation approach and implements an in-house version of the dynamic Lagrangian Sub-grid Scale LES model along with an equilibrium stress wall function in order to deal with high Reynolds number simulations. Furthermore, a synthetic turbulent inflow generation has been developed to provide a more realistic condition. The hot smoke plumes are reproduced considering the buoyancy effect through the Boussinesque approximations. The model has been validated on different benchmark cases and an analysis of a real ship over-structure is presented.

## Electrical Systems / 140

### A case for innovation in environmental protection, electric systems and energy design efficiency for yachts

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Yachts enjoy a history of development and advancement, as All it takes is a vision of what can be, belief that it can be done and the persistence and drive to make it happen.

Demands for exploration are expanding. Conventional yacht design & technology will no longer be enough. Hybrid power generation, using renewable energy resources and efficiencies are the solutions to tomorrow's expedition and adventure yachts.

#### Innovation

New technologies capex & opex don't include intangibles such as emissions reductions, back up power options, reliability, flexibility, sustainability as well as corporate social responsibility cannot easily be quantified or qualified.

Hybrid technology enablers such as power electronics & Lithium Ion Batteries optimize fuel efficiency, Enhance system protection / automation, reduce vessel operating costs, improved safety and control systems, reduced emissions and Weight/space savings

Energy generation technology without advances in energy storage systems are meaningless.

Hydrogen fuel cells can supply efficient, clean power for a wide range of fluctuating loads.

#### Summary

Energy generation, storage technology are pushing the boundaries of scalability offering yacht owners options not even dreamed of in years past. The future of expedition and adventure yacht design is only limited by imagination.

## Ship Design / 141

### Ballast Allocation Technique to Minimize Fuel Consumption

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Nowadays fuel consumption reduction is a primary concern in order to minimise operative costs and emissions during navigation. On this purpose, ballast management play an important role, in order to find the best configuration for ship navigation. An optimal ballast water distribution ensures to find a floating position having the minimum fuel consumption while assuring the fulfilment of rules requirements related to strength and stability. Since ships are operating also in adverse sea state condition, optimal ballast conditions should be found also for service conditions, considering the impact of added resistance due to waves on the propeller and consequently to fuel consumption. Within an emergency decision support system, an optimum ballast system has been developed satisfying the above mentioned requirements. In order to assess the optimal ballast allocation in a fast and accurate way, the equations are linearized and solved by means of pseudo inverse matrix. The target of this process is to find for a defined set of ballast tanks the level, or rather the volume, of water to reach the optimum floating position. The procedure has been tested on a reference ship and the results are here reported and described.

## Weather Routing and Environment Modeling / 142

### Air quality simulations and forecasting of along-route ship emissions in realistic meteo-marine scenarios

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In the present study, scenario simulations are performed by integrating ship performances prediction models with meteo-marine forecasting and pollutants emissions transport models. By considering the detailed simulation of seakeeping and powering performances of a ship along predefined routes, in different realistic meteo-marine conditions, the concentration of the emitted pollutants and their fate in the atmosphere are analysed in order to investigate the relationship between the increase of pollutants emissions due to adverse meteo-marine conditions and the corresponding pollutant diffusion characteristics of the ensuing atmospheric dynamics.

In this paper the authors report the results of the first part of the study, finalized to better comprehend the numerical implementation details of an integrated system aimed at forecasting the powering performances and corresponding pollutant emissions impact based on realistic meteo-marine conditions and ship data.

## Safety and Security / 143

### Hybrid Life-Saving Appliances: a Novel Evacuation-System Concept Solution

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This paper explores the benefits and challenges associated with the installation of an Alternative Evacuation System (AES) in lieu of traditional survival craft on a modern passenger ship covering three different configurations and layouts (All AES, AES and Life rafts, AES and Life rafts and Lifeboat / tenders). The discussion will include an overview of the Type Approval process and detailed insight into the regulatory framework governing design. It will also address the considerations for operation, maintenance and survey of the asset throughout its life. This paper will assist the overall maritime community in further understanding this disruptive innovation.

## Hydrodynamics / 144

### Numerical investigation of 2D Vortex Induced and Wake Induced Vibrations of two circular cylinders in tandem arrangement

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In ocean and offshore engineering, Vortex and Wake Induced Vibrations (VIV, WIV) are serious issues related to the design and operational safety of offshore installations/structures.

Vortex Induced Vibrations occur when vortices shed by a blunt freely-moving structure in steady (or unsteady) flow induce an oscillatory force on the structure, mostly in the direction perpendicular to the ambient flow. WIV take place when the oscillatory wake shed on the leeward side of a structure hits a secondary element of the structure, inducing an oscillatory force on the latter.

VIV of a single elastically-mounted 2D cylinder has already been investigated by the authors and here used as reference case.

In this work, the crossflow motion of two elastically-mounted 1-DOF 2D cylinders in tandem arrangement is investigated via CFD URANS-based simulations. Two relevant cases are presented, the first one in which the upwind cylinder is fixed and the downwind cylinder is free to move and the second one where both are free to move.

Considering the strong complexity of the phenomena involved in WIV, the results are in close agreement with experimental data, allowing a close insight in the coupling between wake and cylinder motion.

## Ship Design / 145

### Effect of different propulsion systems on CNG ships fleet composition and economic effectiveness

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The compressed natural gas (CNG) transport is becoming nowadays an attractive solution not only for stranded gas shipping where current technologies like liquefied natural gas (LNG) and pipe lines are not economically competitive, but also for long-enough distance transport of large volumes of natural gas, where LNG still represents the most economical solution. In fact, recent studies on pressure vessels (PV) materials allow to slightly reduce the displacement (PV Type 4) leading to design completely different hull forms, compared to existing prototypes (PV Type 1, 2 and 3). Since CNG vessel design is a new research field for Naval Architecture, the concept design phase assumes an even higher importance compared to conventional projects, not only for the main parameters determination and performances assessment, but also for the study of completely different solutions for some subsystems. To this purpose, the present study is presenting the comparison between two different kinds of propulsion systems: conventional diesel drive propulsion with propellers and a complete diesel electric solution with pods. The differences between the two solutions are influencing both internal layout and ship dimensions, leading to two completely different ship concepts. The two solutions have been compared in such a way to determine the most cost effective solution not only for the single CNG ship but mostly for the fleet composition in a given transport scenario.

## Ship Digitalization and Unmanned Vehicles / 146

### Assessing business cases for autonomous and unmanned ships

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Public interest in autonomous ships has grown significantly since 2012, when the MUNIN project started to investigate the concept. In 2017, the first concrete project, Yara Birkeland, was published. Other projects are also under development. However, the business case for autonomous ships is not obvious: Benefits are no crew cost and no accommodation section or safety equipment for crew. However, it requires expensive shore infrastructure, it cannot be maintained during the voyage, needing more redundancy and often more expensive fuels than the normal heavy fuel oil, and the approval process may be costly. This may be the reason why several projects, like Yara Birkeland, is not initiated by the conventional ship owners, but by other parties in the supply chain, like the fertilizer manufacturer Yara. This illustrates one aspect of autonomous and unmanned ships: They are much more an integrated part of a transport system rather than a ship as we know them. This paper will go through the most important benefits and cost factors for autonomous and unmanned ships and assess what business cases may be suitable for this technology: “An unmanned ship is not a ship without crew – it is a new factor in waterborne transport”.

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## NUMERICAL INVESTIGATION OF SHIP'S HULL AIR LUBRICATION SYSTEM EFFICIENCY

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This paper presents results of application of air lubrication method as one of the methods for ship water resistance reduction. The research was performed for a ship designed for shallow waters. Water resistance analyses were carried out for a certain range of speeds with air injection and without. Investigation was carried out using computational fluid dynamics software FLOW – 3D. Results presented graphically and in absolute values are showing the efficiency of applied method.

**Structures and Materials / 148**

## Interaction between Industry and Class Societies in Cruise Ships Structural Design: A Positive Fincantieri Experience

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The paper illustrates the developments in rules and design lifecycle of modern cruise ship, resulting from the cooperation between industries and classification societies. Fincantieri S.p.A. experience together with Lloyd's Register and RINA technical background, worked side by side in order to overcome not harmonized rules and regulation not specific for this type of ships. Latest IACS example in Common Structural Rules for Bulk Carrier and Oil Tankers development combined with understanding of cruise ship peculiarities have been the basis of the present work. Results of cooperation have been the development of two direct analysis procedure (LR Structural Design Assessment, Procedure for Primary Structure of Passenger Ships, 2017; RINA Guide on Complete Ship Model Calculation of Passenger Ships, 2017), a guideline (LR Ship Rules applicable to Modern Passenger Ships, 2017), and the monitoring of the effects of their application on new buildings. The obtained harmonized rules and specific regulation highlights the importance of an active role of industries in the rules development that nowadays must be oriented to modern ship business.

## Safety and Security / 149

### Dealing with novel and emerging threats in the maritime industry: The need for an alternative Life – Cycle Risk Management Framework

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Developments in the maritime industry, such as the increasing size of container and cruise ships, and the automated/autonomous ship concepts, yield technical and operational challenges throughout the life-cycle of ships. New interactions increase complexity, resulting in unforeseeable system states and risk fluctuations. Despite the development of approaches that address some of the limitations of current risk management, the human element and the ship are mostly treated separately with only partial consideration of interactions between risk factors. The main goal of this paper is to introduce a novel framework for managing life-cycle risk in the maritime domain, where the ship and the human factor are viewed as an integrated complex system that is subject to change throughout its life-cycle. The focus is on enhancing the adaptive capability of the system to respond to evolving dynamics and deal with unknown and emerging safety threats. In addition, to avoid potential problem shifting between life-cycle stages, interactions between risk factors and risk propagation are considered. In this context, a change in perspective for maritime safety is also proposed, based on the concept of biomimicry, considering that biological systems typically adapt in a dynamic environment to deal with emerging threats.

## Navy and Cyber Security / 150

### The Cyber Risk and its management in the Marine Industry

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In the latest years a number of incidents affecting both the information and operations of several industry and business sectors stimulated the needs for taking into consideration the risks associated to

the use of innovative technologies in a number of production and business processes. The maritime sector is potentially exposed to a number of hazards that need to be assessed and treated. Passenger and cargo ships, yachts, supply and offshore vessels so as waterways transports, harbour facilities and infrastructures are included in international programs for the assessment of cyber risks as having assumed that the latest years Information and Communication Technologies (ICT) are widely applied in processing information and support operations. Similar to hazards associated to other technologies and activities, the 'cyber environment' needs to be considered by appropriate risk assessment processes and the risks that are identified need to be mitigated by appropriate measures. The rapid evolution of digital and information technologies that attract marine operators and owners by optimising and improving their business is asking for a continuous likewise evolution of protection techniques and testing means and procedures. This paper will explore the cyber environment and focus on the management of the cyber risk in the marine industry.

## Interior Yacht Design / 151

### Inclusive Yacht Design

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The proposal focuses on the definition of a new approach for the design of accessible and inclusive sailing yachts that takes into account the typical problems of users affected by permanent and temporary disabilities, as well as children, the elderly and pregnant women. Starting from the analysis of the current state of the art relating to sailing yachts ranging from 33 to 78 feet, it is possible to determine a series of cases in which the user, depending on his limit, may encounter problems of accessibility or use of external and internal spaces. The research aims to define the most suitable solutions for each of them, in order to create a reference standard in the field of nautical design to promote accessibility and inclusion. The deepening of this theme, which is not easy due to the numerous variables that make up the disability framework and the peculiarities of the "boat" environment, leads to the drafting of a manual that analyzes a series of design solutions applicable to narrow spaces like that of yachts, respecting the rules of ergonomics applied to the dimensions required by the particular conditions of the user, in order to eliminate the architectural barriers present on board.

## Electrical Systems / 152

### Innovative Energy Systems: Motivations, Challenges and Possible Solutions in the Cruise Ship Arena

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The effort on environmental issue in the maritime field has led to more stringent regulations on greenhouse gas emission (GHG). The International Maritime Organization has developed regulations intended to increase the ship's efficiency and reduce GHG emissions in a design phase. In

this perspective, several approaches and technologies adopted in land-based engineering can also be advantageous for marine applications. This is the case of Distributed Energy Resources (DER) solution applied in land electrical solutions, based on microgrids, which increases both the system's efficiency and reliability. In fact, also shipboard power systems are microgrids with large centralized generation units and distributed loads. This work is primarily focused on methodological aspects of a DER solution on-board cruise ships, with the aim to permit the integration of different energy sources (e.g. fuel cells, micro-turbines and energy storage systems) pursuing more flexible, reliable and sustainable ships. At the same time, as another land-base engineering best practice further investigated in the paper, the thermal energy recovery issue on board is going to be revisited. This issue can be in fact be better studied and implemented thanks to the DER solution.

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## Diagnostic and Failure of on-board high-voltage electric rotating machines

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High voltage rotating machines are widely used for electric propulsion and generation on-board ships. Following to some failure, investigation started to determine the root cause, and diagnostic measurement campaigns started to get information of the machine healthy and reliability. Environmental aspects are to be considered: vibration coming from the reciprocating machines, the particular operation mode characterized by many load variations, starts and stops, the possible presence of harmonics in the grid. Passenger ships will be involved in the investigation in January.

Electrical Systems / 154

## Distributed Energy Resources On-Board Cruise Ships: Integration into the Ship Design Process

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An intense innovation is characterizing energy system solutions on board ships, especially in the case of large passenger ships due to the significant total amount of installed power and the variegated typology of electrical loads.

In the paper a distributed energy system will be considered for a 140.000+ GT cruise ship, in the perspective of a superior performance in terms of safety and energy efficiency.

The target is to overcome the traditional concept of power generation based on large diesel gen-sets located in few compartments. The innovative proposal is to integrate it, for the hotel needs, with a superior number of power generation units, but of a smaller size, properly distributed on board.

For the application, a reference cruise ship will be considered, characterized by LNG propulsion. Number, typology, size and integration on board of the generation units will be defined in relation with aspects of zonal independence, electrical load, weights, volumes, fuel tanks, supply systems, auxiliaries, with the minimum possible impact on commercially valuable space. Fuel cells technology

will be particularly taken into account. The critical issues in relation with the present safety rules and the whole ship design process be addressed as a fundamental aspect.

## Hydrodynamics / 155

### Performance prediction of the DTMB 5415 model in irregular waves via URANS simulations

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Simulation-based methodologies are widely used for the design of marine vehicles to alleviate the costs of the traditional build-and-test approach. Within this context, high-fidelity simulations are required to accurately predict and possibly optimize the performance of naval vehicles. The objective of the present work is the prediction of resistance and motions of a destroyer-type hull, namely the DTMB 5415, in irregular head waves. A significant condition of sea state 5 and Froude number 0.3 (equal to 22kn for the full scale model) is considered. The performance is evaluated using both irregular waves simulation and stochastic multiple regular wave simulations with metamodel. Specifically, the expected value of the mean total resistance and the significant single amplitude of pitch, vertical acceleration at the bridge, and vertical velocity at the flight deck are evaluated, as prescribed by the NATO STANAG 4154, and unsteady RANS solver is used for the analysis. This activity is partially conducted within NATO Task Group AVT-252 addressing the “Stochastic Design Optimization of Naval and Aero Military Vehicles”.

## Ship Efficiency and Renewable Energy / 156

### Experimental investigation of the hydrodynamic performance of the ISWEC 1:20 scaled device

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ISWEC (Inertial Sea Wave Energy Converter) is an offshore pitching floating device designed to exploit wave energy through the gyroscopic effects of a spinning flywheel. The annual productivity of the ISWEC is strictly connected to the hydrodynamic performance of the floater, that represents the first step in the energy conversion chain. The hydrodynamic performance can be described by the nondimensional Response Amplitude Operator (RAO). An ISWEC 1:20 scaled model has been tested in the Federico II towing tank in Naples.

Experimental campaign has been performed in regular waves for 3 different wave steepness 1/100, 1/50 and 1/35 in order to identify the pitch RAO and underline the effects of nonlinearities for higher wave steepness. A comparison between experimental results and a linear potential flow theory RAO has been carried out. Free decay tests have been analysed for both pitch and roll to identify the linear and quadratic damping terms and their impact on hydrodynamic performances of the device. Furthermore, the behaviour of the device has been investigated in irregular waves, defined as Jonswap

spectrum. Conclusions are commenting the differences between numerical and experimental results and the impact of nonlinearities on hydrodynamic performances.

**Hydrodynamics / 157**

## Experimental and numerical prediction of the hydrodynamic performances of a 65 ft planing hull in calm water

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An extensive campaign of model and full scale experimental tests as well as of numerical computations, aimed at the prediction of the hydrodynamic performances of a 65 ft motoryacht in calm water and in waves, is undertaken within the framework of the Project SOPHYA - Seakeeping Of Planing Hull Yachts, co-financed by Friuli-Venezia

Giulia Region in the field of joint industrial and academic research.

In this paper, selected results of the numerical computations conducted by HyMOLab-University of Trieste and by the University of Zagreb for the calm water case are presented. The RANS simulations carried out in combination with a semi-automatic optimized mesh generation tool, developed in this project within the Open-

FOAM/foamExtend framework, are described. Different free surface capturing methods are employed and compared, with focus on numerical issues. The numerical results are compared with new experimental data obtained at the towing tank of the University of Naples within the project, with uncertainty assessment.

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## soot Particle filter for cruise ship

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The paper I'd like present want show the latest frontier in term of exhaust after treatment for 4 stroke engines used mainly in cruise and commercial Ships. The paper will collect last achievement obtained in the EU financed project: Leanships, where HUG, together with Fincantieri as technical partner, is developing a Demo Scale unit representative of a very innovative diesel particle filter designed for eliminate soot, Carbon and solid residual coming from engines when operate with the Heavy Fuel Oil. Hug is developing an affordable solution for these problems. The paper will present the solution as designed for solve the main Problems: removal of the ash build-up on the filter wall, regeneration of the soot-carbon with an acceptable energy consumption, introducing a new concept

for Isolation of single filter sections for regeneration and ash extraction. It Will be presented The prototype consistently in a basic unit for demonstration purpose, complete with all necessary devices to represent the full scale system, but with a reduced area and volume, approximately suitable for about 200 / 500kW instead of 10MW target engine. The test bed is finalized on the basis of the results progressively achieved during the EU Leanship project.

## Weather Routing and Environment Modeling / 159

### Preliminary assessment of route optimisation for fuel minimisation and safety of navigation by the use of cooperatively collected data at sea

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The growing pressure of the international regulations on GHG emissions from ships is pushing towards the adoption of a variety of operational energy efficiency measures. The fusion of measurement techniques, smart telecommunication technologies and numerical modelling approaches has a great potential for the implementation of services for the shipping industry. Among these, there are weather routing systems for improving both energy efficiency and navigational safety.

PROFUMO Demonstrator is an ESA ARTES-20 project. Its main goal is to implement a pre-operational system for fleet management and weather routing services, based on the cooperative collection of meteo-marine data from ships, to improve weather forecast. Atmospheric information from GNSS signals (Galileo, GPS) are utilised to improve numerical weather predictions and hence offer detailed Mediterranean route optimization services.

The architecture of the system and some first implementation results will be described, in particular on the integration of meteo-marine forecasting with ship modelling and route optimization, with some sensitivity analyses of the optimization process, under different approaches for modelling wind and waves added resistances and computing the ship powering performances. In perspective we imagine the use of in-service measured data to dynamically improve the ship modelling components of the system.

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## The Integration of Culture in Cruise and Vessels Design

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From the beginning of history, navigating was a unique opportunity for growth and expansion. Thereupon, ships became an important part of civilizations and in them were imprinted unique cultural traits that distinguished them according to geography, historical period and usage characteristics.

As civilizations evolved, so did their cultural heritage, which if successful in design and building techniques, would be spread and adopted by others. The industrial revolution changed ships' overall design and appearance; yet ocean liners represented a nation's power, lifestyle, design and technology. Therefore, following this premise, how does it apply to the contemporary design of cruising vessels?

Cruise ships are the most convenient form of transportation and leisure travel and their interiors have evolved from transportation to emphasis on accommodation. Even though voyages depend entirely on their ships and the people aboard them, as ethnic culture differs from each country so do the standards of living. This has been influenced by globalization, which plays a significant role in the homogenization of cultures and design. This paper seeks to analyze the influence of ethnic culture in cruise vessels design by identifying the differences in their design solutions according to the industry's most renowned markets and their geography.

## Interior Yacht Design / 161

### An Italian Way for Yacht Coding?

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Many international conventions adopted at IMO level were conceived for "merchant" ships and their application to leisure yachts turned out to be challenging. That's why alternative solutions have been explored worldwide. In a nutshell, the idea was to create a set of rules and standards specifically adapted to this genre of vessel. Here, the key issue is represented by the establishment of technical, safety and operational parameters appropriate to the size and operation of the said crafts. A successful example of these attempts is offered by the two Codes of Practice developed by the UK Maritime & Coastguard Agency (MCA): the Large Commercial Yacht Code (LY3) applicable to vessels 24 metres and over in load line length that don't carry more than 12 passengers, and the Passenger Yacht Code (PYC) devoted to rule pleasure yachts of any size, which carry more than 12 but not more than 36 passengers.

The Red Ensign Group (REG) is currently updating them through a new regulatory framework. Could this approach be followed also in Italy?

## Comfort on Board / 163

### Airborne noise prediction of a ro/ro pax ferry in the port of Naples

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The noise emissions from various transportation modes including seaports have become a major concern to environmental and governmental agencies in recent years due to the impact they have on the community. As a result, campaigns and studies have been directed towards the analysis and control of main noise sources. However, few research activities have been carried out on environmental noise exposure due to port activities. In this paper, for a ship ferry, first the main onboard noise

sources in terms of their nature and location have been examined; contemporarily the main characteristics of the ship's outer geometry: side layout, upper deck arrangement and funnel geometry, have been defined. Second, all noise sources data have been derived basing on board measurements of the ship ferry berthed at quay in port of Naples. Then a geometry 3D model has been created including all bodies that lie in the acoustic field in the surrounding area. Finally, each noise source of ship has been characterized by a sound power level and by the directivity and the emission angle and more points have been considered as calibration points of the numerical model.

## Structures and Materials / 164

### Internal forces and moments on hull girder due to parametric roll development

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The accurate prediction of wave-induced forces and moments on a hull operating in severe weather conditions plays an important role in assessing ship structural strength.

For ships prone to large variation of the submerged hull in wave, wave-induced loads could be influenced by the development of parametric roll. This concept is based on the evidence that the combination of all the ship rigid body motions could lead to larger loads on the hull, (such as inertial, restoring and Froude-Krylov loads), and thus to unexpected internal forces and moments on the hull structures.

In this paper, we aim at a fair assessment of the variation of the internal loads in waves of ships, in presence of parametric roll resonance. A numerical model is developed and applied to simulate ship dynamics in wave and estimate the correspondent wave-induced loads on ship structure. Particular attention is given to the horizontal bending moment and to the torsional moment.

The applications are meant to disclose the accuracy of the developed method. Comparison with reference design loads are presented, aiming at disclosing the severity of parametric roll phenomenon on the ship structures.

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### Surf-Riding-Broaching to and Parametric Roll vulnerability on Systematic Series D models

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The development of IMO second generation intact stability criteria is based on a multilevel approach. In each level accuracy of analysis is increased and if a possible vulnerability is detected next level is applied.

A ship, depending on its characteristics and external conditions, may be considered vulnerable to one or more stability failure modes. For each stability failure mode, the study will begin applying the first level of vulnerability, and in case the ship is considered vulnerable, to one or more failure modes, the second level of vulnerability will be applied to specific mode.

This paper focuses on the first and second level vulnerability assessment of Broaching to and Parametric Roll. These two criteria are tested on the semidisplacement twin-screw round-bilge hull forms

of Systematic Series D, by Kracht and Jacobsen (1992).

The operational characteristic important for the “Parametric roll” analysis are taken as “typical” values of naval ships, scaled on 90 meters ship as in original publication.

“Surf-riding/Broaching” criteria is calculated for all seven models of D-series identifying the effect of hull shape on vulnerability level.

Conclusions are discussing obtained results, commenting on the effect of hull form in the two considered stability criteria.

## Ship Design / 166

### An innovative concept for inland waterway vessel

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The European Inland Waterway Transport (IWT) is a viable and effective alternative to road and rail transport of persons and goods on the European network. Currently, the IWT is less exploited than the ‘traditional’ transport despite the European inland waterway network spans more than 29000 km and includes over 400 important ports and terminals. The design of inland waterway vessel is heavily affected by the environmental constraints and the Rule framework. About the latter, in the last few years several organizations played an important role in the definition of the Rule framework in Europe: the United Nations Economic Commission for Europe (UNECE), the European Union and various local area commissions. The tendency of international regulations is to make inland waterway decarbonised by reducing pollutant emissions through ships with zero-emission propulsion. Moreover, the design is also affected by environmental constraints like width and depth of the canals, air draft, etc. In this paper, a ‘new concept’ for inland waterway vessel which considers the modern national and international regulations and the environmental constraints has been defined. A case study and the results obtained have been analysed.

## Structures and Materials / 167

### The strip planking: an eco-friendly solution for the end-of-life of ships

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In the last few years, the International and National attention to environmental sustainability has increased, even in shipbuilding. This aim can be achieved through various manners, for example by green propulsion (hybrid propulsion), by containment of spills and by studying the life cycle of vessels. About the last one, the problem of disposal of ships at the end of life is of high importance:

due to new regulations about the treatment of hazardous materials, the disposal of plastic materials (as the fiberglass) is very complicated and expensive. For this reason, the use of wood for the shipbuilding, especially for small vessels, is a valid and ecological alternative to the use of fiberglass or aluminium. Even though this solution implies higher construction cost, it has the advantage of reducing the risks of disposal of materials at the end of life cycle. The strip planking is a modern process for the construction of wood ships, which provides the vessels with mechanical characteristics comparable to those offered by ships built in fiberglass. In this paper, the description of the construction process and the results obtained in a case study of a vessel built through the strip planking technique has been analysed.

## Ship Design / 168

### The Bucintoro preliminary design: static and hydrodynamic assessment

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The Bucintoro project has been relaunched after years in stand-by under the name of “Bucintoro of the Third Millennium”. Many contributors from Italy and even from France have accepted the challenge with the purpose of building the modern version of the last Bucintoro burned by Napoleon troops at the end of the Venetian Republic. The previous phase of development brought to a business plan aimed at managing the building and management of the new golden vessel. The hull form of the new Bucintoro will be a perfect copy of the historical one with a special double deck galley with a lower deck for 168 rowers seated in four at 21 oars each side and upper deck for authorities, both fitted now with modern systems in order to improve safe navigation. The complete structural scantling drawings with midship section have been already certified by RINA classification society. After a summary on the age-old history of the vessel and a review of technical issues developed up to certification by RINA, this paper addresses primary static and hydrodynamic topics. To this end, optimal subdivision of internal volumes to comply with intact and damage stability rules as well as theoretical assessment of resistance and powering performance are carried out. Since the Bucintoro will sail in an urban area, in the restricted waters of Venice Lagoon and in natural parks, manoeuvring and hybrid propulsion are of major concern also to cut emissions. All these issues will be theoretically assessed by means of analytical and numerical codes.

## Machinery and Systems Design / 169

### LESS: a new simulation environment for the preliminary design of cruise ship energy systems

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The number of cruise ships sailing is growing constantly worldwide driven by increasing number of passengers. Higher attention to this ship segment, runs together with more complex energy systems installed on board due to the need of improving the energy efficiency. For this reasons, ship Owners and Shipyards are involved in the design of power plants and energy management systems that ensure lower fuel consumption and compliance with increasingly stringent IMO regulatory requirements on emissions.

The software LESS (Low Energy Ship deSign tool) is a simulation environment to support the designers to choose among different propulsion/hotel plants solutions in the early stage of the ship design. The software allows to analyze the energy performance of different plant lay-outs and system components. In particular, the components library of the tool includes heat recovery packages such as Organic Rankine Cycles (ORC) systems. The first simulations indicate an energy saving of 5-10% in comparison to state of the art solutions.

**Hydrodynamics / 170**

## **Experimental study of sloshing in rectangular tank under baffles and hydrophobic effects**

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Liquid sloshing cause ship tanks surface damages and affects ship motions. This phenomenon has been analyzed by rectangular tank model experimentally. Partially filled tank have been experienced and excited various frequency range by direction of sway. Experiments have been carried out with ordinary tank and baffled tank which is placed middle of tank base. Four different water levels have been chosen for demonstrate sloshing effects on critical and non-critical cases. Wave path, reaching point of wave and shape of wave during flip-through are followed on high speed camera images. Pressures sensors are applied at lateral surface of tank to measure liquid induce pressure and also strain gages implemented to point reaction of structure during fluid structure interaction. Besides that, all experiments have been repeated by changed surface parameters on two contrast lateral sides on tanks. The surface parameter is modified by applying hydrophobic coat. The coated surface is proposes to increase contact angle between drop of water and surface. The coated, non-coated surface and baffled and non-baffled tank sloshing experiments comparison have been conducted by images and measured results. The results shows that the hydrophobic surface and baffle are decreased the sloshing force on lateral sides. Early wave separation occurs and water cannot reach maximum level of wave as non-coated surface. Also baffle is prevent wave goes through directly to the lateral surface.

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## **Lean transformation using hybrid-laser arc welding in ship panel assembly**

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Many shipyards use the classical submerged arc welding (SAW) or metal active gas (MAG) welding technologies during the assembly of ship panels. However, since the advent of applying advanced hybrid laser arc welding in avant-garde shipyards, it is expected that other shipyards will eventually apply this new technology. Since panel assembly is one of the core production areas in any shipyard, investments in technology improvement could reap significant savings. In this paper, a

case study analysis of panel assembly in a shipyard using the traditional welding methods is made, where the duration time and man-hours are recorded. The replacement of SAW with the latest hybrid laser arc welding is demonstrated using a lean manufacturing methodology for shipyards. The resulting reduction in work man-hours is significant to argue for eventual replacement with the new technology.

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## INVESTIGATION OF FUZZY AHP METHOD OF SHIP FAULTS DURING SHIP MANEUVERS

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Sea transport is a field that requires high cost and frequent accidents. These accidents are sometimes caused by equipment malfunctions and sometimes due to lack of personnel knowledge and experience. One of the regions that frequently have problems during operations is the maneuvering areas of the ships.

In this study; the problems experienced during the maneuvers of the ships and the problems that can be experienced are identified and the importance of the equipments in which these problems are experienced is emphasized. Examination of these accidents was done by Fuzzy Ahp method. Hierarchical structure has been established by assigning the sub-criteria of the equipment and the places where the problems are experienced. In the last step of the hierarchical structure, the losses that can occur in these accidents have been discussed. As a result of all the evaluations, the results are presented considering the losses caused by the accidents during the maneuvers of the ships. As a result of the study, ropes were identified as the equipment with the highest priority within the maneuvering equipment. Another consequence of the work was that the personnel death and injury cases are at the highest level according to the other losses.

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## A Survey on the Difficulties of Marine Service: Case Study for Turkish Seafarers

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By 2015, there are 1 million 650 thousand seafarers globally. The number of Turkish seafarers is about 180 thousand. However, after China, the largest number of seafarer training in Turkey, the sea service time of seafarers is not at the desired level. For this purpose, the physical and psychological difficulties encountered by Turkish seafarers in marine services were researched through

questionnaire. Approximately 600 seafarers participated, 25 questions were asked on different topics such as fatigue, stress, job satisfaction, salary, social life, piracy risk, and the effects of these subjects on their occupational life were investigated. It is aimed to contribute to the maritime industry by this study, which is important in terms of explanation and introduction of the profile of Turkish seafarers.

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## CASE STUDY ON MARINE ACCIDENTS OCCURRED IN VTS AREAS

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### ABSTRACT

During the last decade, it became necessary to create alternative routes for sustainability of safe maritime trade. As a result, alternative routes are increasing day by day, in large marine areas such as open seas and oceans, by evaluating the safety of navigation and the economic efficiency of maritime trade. The other way to make safety sustainable in the growing maritime trade is to provide safer navigation on existing routes. To this end, national/international organizations are developing legal regulations and technological developments being adapted to the maritime industry. One of the most important safety providers is Vessel Traffic Services (VTS), especially since alternative routes are not possible in narrow channels and restricted waterways. VTSs have started to spread all over the world since the late 90s. Today, VTSs are working in more than forty different sea areas and contributing to navigation safety. Despite all the technological developments and legal regulations, however, marine accidents continue to occur especially in narrow channels and restricted waterways. One of the reasons for this is the human interaction between the VTS employees and the vessels involved in the accident. In this study, 3 cases of collisions and 1 case of grounding, in which VTS actions/attitudes were involved in the accident between 2005-2015, were examined with an expert group of 5 persons. Causes and causal factors have been revealed. As a result, recommendations have been identified to improve actual VTS.

**Keywords:** Vessel Traffic Services (VTS), Maritime Surveillance, Sea Traffic Management

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## Evaluation of Bridge Resource Management Failures in Grounding Accidents By Using Fuzzy AHP

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Grounding accidents have an important share among marine accidents. A significant part of the shortcomings identified during grounding accidents concern bridge resource management. IMO

Model Course 1.22 and STCW Section B-VIII / 2, Part 3-1 trainings/regulations have been put into practice for the development of bridge resource management on-board. For this reason, the study has been limited to resource management failures among causes of grounding accidents. In the study, the reasons of accidents were obtained by examining the 130 official accident reports which happened between 2000 and 2015. The hierarchical structure formed by the cause of the accident and the related recommendations for prevention is evaluated with Fuzzy AHP in the context of expert group and results revealed.

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## **PRODUCING ELECTRICITY POWER FROM SHIP EXHAUST GASES: AN APPLICATION ON A RO-ROR CARGO SHIP**

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This paper presents the availability of producing electricity power from ship main engine's waste exhaust gases. Hot exhaust gases reveals from ship main engines during sailing periods. After using waste exhaust gases at turbocharger and exhaust gas boiler, respectively, those gases discard through funnel to atmosphere in spite of still consisting of respectable energy. Therefore, recycling waste exhaust gases in order to produce electricity power have important benefits in both aspects: economical and environmental. Making use of waste exhaust gases for electricity power provides less fuel consumption and as a matter of course less greenhouse gases (GHG) to atmosphere. Producing electricity power works on the principle that Organic Rankine Cycle (ORC). In this paper, this electricity generator system application on a model Ro-Ro cargo ship cost analysis was carried out. Underlying parameters including initial cost and operation cost of system, reduction amount of fuel consumption, ship sailing time were used to determine whether this system is profitable or not.

**Key Words:** Exhaust Gases, Organic Rankine Cycle, Fuel Consumption, Cost Analysis.

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## **A ship energy efficiency analysis by considering trim influence and waste recycling**

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The paper presents an experimental analysis of the trim influence on an existing and operating ship, in order to assess possible fuel consumption reductions. The investigation is based on model tests performed at the towing tank of Genoa University, where the trim influence on the hydrodynamic resistances of a high-speed vessel and a slower mini-cruiser is investigated for various operating conditions. The purpose of this work is to provide possible indications for the operating trim of passenger and/or naval vessels. In this regard, the experimental results of the faster model are compared with the full-scale data of a Ro-Ro Passenger ship, assuming a similar behavior for the two applications. The consistency of the achieved results is shown in the perspective of the different examined hull geometries. To further improve the ship energy efficiency, a particular waste recycling

technology, aimed at obtaining biofuel from sludge, is also considered in the final part of the article. The main idea is to produce biofuel for the ship engines through a pyrolysis process to be carried out directly onboard, in order to obtain further fuel savings from waste products of the vessel.

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## **A comparison of comfort on cruise ships with and without PODS**

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Two cruise ships of the same class have been designed with two different types of propulsion: the prototype, with a conventional shaft lines propulsion system, while the sister ship, at request of the Ship-owner, it has been designed with POD propulsion.

The vibrations on the aft vault are mainly generated by the hydrodynamic pressures induced by the propeller. In that way Fincantieri took this opportunity to make a comparison in terms of comfort between this two types of propulsion.

This paper reports the measurements of noise and hull linear vibrations in the stern area carried out during the official sea trials of both vessels.

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## **The irradiated noise limits of the Rules are very different : how it is possible for cruise shipbuilders to deal with very different technical approach ?**

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Noise pollution under the sea has been far away from all the existing rules up to a few years ago, but with the emergence of links between noise and environmental diseases , this problem is having an increasing attention. In this paper the authors outline the evolution of the international regulation framework , with references to the class notation issued from Registers : but the interest in this field has produced a lot of different noise criteria , practically one for every single Rule .This situation can have, as consequence, many problems for the cruise ships shipbuilders because the limits to be reached are very different from one Rule to the other.

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## **A fast method to estimate acoustic parameters of a cruise ship cabin**

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This article reports a brief summary of the tests and investigation performed to validate a simple numeric method to calculate reverberation time of a cruise ship cabin. The introduction of this method has the objective of creating a simple and fast procedure to estimate various acoustic parameters of interest for a shipyard in a cruise ship cabin without the need of multiple measurements on the field.

**Hydrodynamics / 181**

## **Towards guidelines for consistent wave propagation in CFD simulations**

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While most of the current Computational Fluid Dynamics (CFD) work focusing on calm-water seems to be under control, attention is now brought on simulating ships in waves. However, a lot of scatter exists in how those simulations are performed. In particular, no consensus on grid generation and time-stepping guidelines seems to exist when it comes to includes waves in the simulations. From this observation, we took a step back and attempted to derive consistent guideline for wave propagation in CFD. In this process, linear wave theory helps us with the definition of the grid topology. Using this background, we performed a systematic grid convergence study for 2D waves at zero speed. The results are analysed on basis of the wave dispersion, amplitude diffusion and reflection at the boundaries. The convergence study was then extended with a turbulence model, forward speed and finally in shallow water. Finally the derived guidelines are applied to typical CFD applications : roll motions of a ship section with bilge keels in transverse waves, and a ship at forward speed in incoming waves.

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## **Ship survivability study using high fidelity CFD**

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Safety is integral to the reputation of passenger ship companies making it of paramount concern to them. For this reason passenger ship owners are aiming for safety standards well beyond the statutory requirements. The current methods for assessing ship survivability following a flooding casualty adopts a simplified application to define a complex issue and lead uncertainty and over-design. This study used high fidelity deterministic Computational Fluid Dynamics (CFD) analysis in order to explore the shortfalls of the current design guidance such as SOLAS. A number of flooding scenarios are modelled on a cruise ship at full scale for calm and rough seas

**Machinery and Systems Design / 183****Hybrid system design and performance basing on actual vessel operational data****Author:** Lorenzo Brigati<sup>1</sup>**Co-authors:** Alberto Traverso<sup>2</sup>; Andrea Zotti<sup>3</sup>; Thomas Lamberti<sup>4</sup><sup>1</sup> *Wartsila Italia SpA*<sup>2</sup> *University of Genoa*<sup>3</sup> *Wartsila Italia*<sup>4</sup> *H2Boat Scarl***Corresponding Authors:** alberto.traverso@unige.it, lorenzo.brigati93@gmail.com

The recent trend of marine industry towards more efficient and versatile ships and lower emission has increased the interest in hybrid solutions.

However, the spread of this technology has been limited by several factors both economical and technical.

Among these, a recurrent issue is the sizing of Energy Storage System (ESS) which is strictly connected to the vessel's typology, its operation and its control system.

This paper presents an algorithm, developed within Wärtsilä Italia spa, for the extraction of sequential operating modes

from data recorded on board of vessel, in order to properly design a feasible ESS.

The paper shows a technical economic analysis carried on a small cruise vessel in order to identify competitive hybrid solutions

compared to traditional configurations (engines running on conventional fuel or Liquid Natural Gas).

Finally the paper compares two case studies of a small vessel powered only by fuel cells (in place of conventional engines) and batteries, in order to prove the potential benefits

derived from such innovative technologies with different operational profiles, also in hybrid mode.

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**Investigation Of Piracy between 2008 – 2016 and Evalution of New Risk Category: Maritime Cyber Threats****Author:** arife tugsan isiacik colak<sup>1</sup><sup>1</sup> *Captain LEcturer ( PhD )***Corresponding Author:** isiacik@itu.edu.tr

Today, the seas have become a convenient medium for organizing criminal activities such as terrorism, use of weapons of mass destruction, drug smuggling, movement of refugees and illegal immigration. Within this framework, illegal activities on the seas have become an extremely profitable area for maritime gangs and organized criminal teams. This study is aimed at investigating modern piracy 'Maritime Cyber Threats' but before it will be mentioned the regions that became piracy centers in the world, piracy attacks during 2008-2016, important piracy cases and ISPS Code. Piracy and smuggling were the main threats of the day, but soon other risks appeared. Today, cyber-related risks are unquestionably a large and rapidly growing portion of all the risks to ports, facilities, and vessels. It is important that ship operators, ship managers and vessels' crews as well as terminal operators are aware of the potential threats from cyberattacks on their assets. This paper aims creating awareness about maritime cyber security and defining risks for vulnerable equipments on board.

Key: Maritime Cyber Security, ISPS Code, Piracy, Maritime Cyber Threats

## Ship Design / 185

## Small-scale LNG port facilities, permits, risk assessment, Eastern Mediterranean, LNG bunkering

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One of the key challenges to switch to LNG as fuel era is to create “a safe passage” for LNG bunkering, by designing safe, reliable and operable LNG port facilities and operations. Eastern Mediterranean region brings step changes towards small-scale use of LNG fuel for marine transportation through the extensive groundwork developed within European co-funded Poseidon Med II project. Lloyd's Register, as one of the leading project partners, gauges the risks, by applying efficient tools and advanced methodologies that can accurately model risks and assess potential consequences for LNG bunkering operations in each participating port. This paper features experience gathered from the strategic mapping and approach taken and implemented for all project ports, focusing on the Port of Patras in Western Greece, a port with the plan to combine LNG infrastructure and LNG bunkering operations. There, LR and project experts have undertaken onsite inspections suggesting alternative solutions for infrastructure and operations; have gained experience from the design from scratch of the Shore-to-ship LNG bunkering infrastructure; have set safety and exclusion zones as layers of defence in potential hazards; have safely navigated vessels to/from port installation running real-time simulation scenarios under various environmental conditions; have identified potential hazards and mitigation strategies addressing critical scenarios (HAZID workshops); have developed preliminary hazard & operability (HAZOP) and Quantitative Risk Assessment (QRA) analysis, to evaluate issues and risks to personnel or equipment, and have worked together with the Ministries to create the relevant national legislation for the new supply chain requirements

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## Fastening of the data transmission in high latency satellite networks

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The internet onboard of ships is very slow and uncomfortable. This is caused by the high latency of the used satellite networks. Most internet connections are based on connection-oriented protocols, like TCP/IP, which require positive acknowledgments for each data packet sent. To fasten the data transfer, the use of a connectionless protocol without positive acknowledgments would solve the latency problem. But such a protocol, like UDP, is not secure enough nor supported by most of the web servers.

The aim of the present development is therefore to provide a fast and secure data transmission in networks having a high latency.

This object is solved by a connectionless data protocol having a parallel information channel between the client and a server which is independent of transmission of the payload. Said information channel is e.g. used for negative acknowledgments for lost packets or connection relevant information like the available bandwidth.

Furthermore, to avoid lots of time consuming singular connections for each object of a webpage, a proxy server may be used that collects all relevant data of an external web server, renders the data

in a headless browser, and only sends the completely rendered web-page to the client in one data stream.

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## Welcome Speech

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## **The EU Directive 2016/1629 and the UNECE Resolution 61 laying down technical requirements for inland navigation vessels: the CEMT actions to update and to implement them at paneuropean level**

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