Maritime Technology and Engineering 3

Editors

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T.A. Santos
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Preface

Since 1987, the Naval Architecture and Marine Engineering branch of the Portuguese Association of Engineers (Ordem dos Engenheiros) and the Centre for Marine Technology and Ocean Engineering (CENTEC) of the Instituto Superior Técnico (IST), University of Lisbon, have been organizing national conferences on Naval Architecture and Marine Engineering. Initially, they were organised annually and later became biannual events.

These meetings had the objective of bringing together Portuguese professionals giving them an opportunity to present and discuss the ongoing technical activities. The meetings have been typically attended by 150 to 200 participants and the number of papers presented at each meeting was in the order of 30 in the beginning and 50 at later events.

At the same time as the Conferences have become more mature, the international contacts have also increased and the industry became more international in such a way that the fact that the Conference was in Portuguese started to hinder its further development with wider participation. Therefore, a decision was made to experiment with having also papers in English, mixed with the usual papers in Portuguese. This was first implemented in the First International Conference of Maritime Technology and Engineering (MARTECH 2011), which was organized in the same year as Instituto Superior Técnico completed 100 years, with the presentation of 90 papers. In the Second International Conference of Maritime Technology and Engineering (MARTECH 2014), approximately 150 papers were accepted and compiled in a book, representing thus a substantial increase in the scope and depth of the Conference.

In this Third International Conference of Maritime Technology and Engineering (MARTECH 2016), around 230 abstracts have been received and approximately 150 papers were finally accepted, numbers which show the widespread interest that this Conference continues to raise.

The Scientific Committee has played a major role in the review process of the papers although several other anonymous reviewers have also contributed and deserve our thanks for the detailed comments provided to the authors, allowing them to improve their papers. Participants come from research and industry sectors and from almost every continent, which is also a demonstration of the wide geographical reach of the Conference.

The contents of the present books are organized in the main subject areas corresponding to the sessions at the Conference and within each group the papers are listed by the alphabetic order of the authors.

We want to thank all contributors for their efforts and we hope that this Conference will be continued and improved in the future.

C. Guedes Soares & T.A. Santos
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Harilaos Psaraftis, Denmark
Jonas Ringsberg, Sweden
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Maciej Taczala, Poland
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Nikolas Ventikos, Greece
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Michele Viviani, Italy
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3rd International Conference on Maritime Technology and Engineering

MARTECH 2016

PROGRAMME

4 - 6 July 2016

Holiday Inn Lisboa Hotel
LISBON, PORTUGAL
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Sónia Vicente, IST, Universidade de Lisboa, Portugal
## Monday, 4 July 2016

**Registration** (Hall 01 – from 8h00 onwards)

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**Açores (14h30-16h00)**
- Ship Structures 1
- Plenary Session 1
- **Coffee-break (10h30-11h00)**
- **Lunch (13h00-14h30)**

**Porto Santo (14h30-16h00)**
- Ship Hydrodynamics 1
- Maritime Transportation 1
- **Coffee-break (10h30-11h00)**

**Navegadores (14h30-16h00)**
- Ship Design 1
- Marine Environment 1

**Galeão (14h30-16h00)**
- Plenary Session 2
- **Coffee-break (16h00-16h30)**

### Wedneday, 6 July 2016

**Registration** (Hall 01 – from 8h00 onwards)

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<td><strong>Safety and Reliability 3</strong></td>
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<td><strong>Porto Santo (16h00-17h30)</strong></td>
<td><strong>Energy Efficiency 2</strong></td>
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### Terms

- **JETM**: Joint European Transport and Maritime Conference
- **Shipyard Technology**: Focus on shipyard innovations and technology advancements.
- **Oil and Gas**: Sessions dedicated to the oil and gas industry, including workshops and sessions on various subtopics such as safety, reliability, and energy efficiency.
- **Fisheries**: Sessions related to marine fisheries, including data requirements in fisheries science.
- **Data Requirements in Fisheries Science**: Special focus on the collection and analysis of data in fisheries science.
Sessions in alphabetical order

Coastal Structures – Tuesday, 05/07/2016, 11:00 h – Room Galeão

Data Requirements in Fisheries Science 1 – Wednesday, 06/07/2016, 14:00 h - Room Galeão

Data Requirements in Fisheries Science 2 – Wednesday, 06/07/2016, 16:00 h - Room Galeão

Energy Efficiency 1 – Wednesday, 06/07/2016, 14:00h - Room Galeão

Energy Efficiency 2 – Wednesday, 06/07/2016, 16:00h - Room Navegadores

Fisheries – Wednesday, 06/07/2016, 11:00h - Room Galeão

Keynote Lectures – Monday, 04/07/2016, 09:00h – Room Açores

Marine Environment 1 – Monday, 04/07/2016, 14:30h – Room Galeão

Marine Environment 2 – Monday, 04/07/2016, 16:30h – Room Galeão

Maritime Transportation 1 – Monday, 04/07/2016, 14:30h – Room Navegadores

Maritime Transportation 2 – Monday, 04/07/2016, 16:30h – Room Navegadores

Maritime Transportation 3 – Tuesday, 05/07/2016, 09:00h – Room Porto Santo

Oil & Gas - Wednesday, 06/07/2016, 09:00h - Room Galeão

Oil and Gas Workshop 1 – Wednesday, 06/07/2016, 11:00h - Room Açores

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Oil and Gas Workshop 3 – Wednesday, 06/07/2016, 16:00h - Room Açores

Renewable Energy 1 – Tuesday, 05/07/2016, 14:00 h – Room Galeão

Renewable Energy 2 – Tuesday, 05/07/2016, 16:00 h – Room Galeão

Safety & Reliability 1 – Wednesday, 06/07/2016, 09:00h – Room Porto Santo

Safety & Reliability 2 – Wednesday, 06/07/2016, 11:00h – Room Porto Santo

Safety & Reliability 3 – Wednesday, 06/07/2016, 14:00h – Room Porto Santo

Safety & Reliability 4 – Wednesday, 06/07/2016, 16:00h – Room Porto Santo

Ship Design 1 – Tuesday, 05/07/2016, 09:00 h – Room Navegadores

Ship Design 2 – Tuesday, 05/07/2016, 11:00 h – Room Navegadores

Ship Design 3 – Tuesday, 05/07/2016, 14:00 h – Room Navegadores

Ship Hydrodynamics 1 – Monday, 04/07/2016, 14:30h – Room Porto Santo

Ship Hydrodynamics 2 – Monday, 04/07/2016, 16:30h – Room Porto Santo

Ship Hydrodynamics 3 – Tuesday, 05/07/2016, 09:00h – Room Porto Santo

Ship Hydrodynamics 4 – Tuesday, 05/07/2016, 11:00h – Room Porto Santo

Ship Hydrodynamics 5 – Tuesday, 05/07/2016, 14:00h – Room Porto Santo

Ship Hydrodynamics 6 – Tuesday, 05/07/2016, 16:00h – Room Porto Santo

Ship in Ports – Tuesday, 05/07/2016, 16:00h – Room Navegadores

Ship Machinery 1 – Wednesday, 06/07/2016, 09:00h - Room Navegadores

Ship Machinery 2 – Wednesday, 06/07/2016, 11:00h - Room Navegadores

Ship Structures 1 – Monday, 04/07/2016, 14:30h – Room Açores

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Ship Structures 3 – Tuesday, 05/07/2016, 09:00h – Room Açores

Ship Structures 4 – Tuesday, 05/07/2016, 11:00h – Room Açores

Ship Structures 5 – Tuesday, 05/07/2016, 14:00h – Room Açores

Shipyard Technology – Tuesday, 05/07/2016, 16:00h – Room Açores
### Monday, 4<sup>th</sup> July 2016

**Time: 9:00 to 10:30 h**

**Opening Session**  
Açores Room  
**Chairs:** C. Guedes Soares, Bento Domingues

**Opening Addresses**

**Comparative studies for subsea-to-shore production systems**  
S.F. Estefen, M.I. Lourenço, J. Feng and Y. Wang

**Strategies on improving maritime transportation safety of the Yangtze River**  
X.P. Yan, J.F. Zhang, B. Wu, S.Q. Fan and D. Zhang

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**Time: 11:00 h – 12:30 h**

**Keynote Lectures**  
Açores Room  
**Chairs:** C. Guedes Soares, Bento Domingues

**European Ports: Facilitators or impediments of global supply chains?**  
H. Haralambides

**Computational fluid and structure dynamic methods to assess wave-induced loads and hydroelasticity effects**  
O. el Moctar and J. Ley

**Autonomous surface vehicles**  
S. Brizzolara

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**Time: 14:30 to 16:00 h**

**Ship Structures 1**  
Açores Room  
**Chairs:** S. Estefen, M. Taczala

**Plastic deformation and failure of thin steel plates subjected to spherical and cylindrical indenters**  
B. Liu, A. Ottazzi and C. Guedes Soares

**Experimental and numerical analysis of a laterally impacted square steel plate**  
K. Liu, B. Liu, Z. Wang and C. Guedes Soares

**The behaviour of 5083-H111 naval aluminium alloy square plates under blast loading: experimental and numerical approaches**  
F.C. Salvador

**Experimental and numerical response and failure of laterally impacted composite circular plates**  
F. Alizadeh, B. Liu and C. Guedes Soares

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**Ship Hydrodynamics 1**  
Porto Santo Room  
**Chairs:** O. El-Moctar, S. Sutulo

**Estimation of the maneuvering characteristics of the DTC containership using URANS based simulations**  
N. Fournarakis, A. Papanikolaou, D. Chroni, S. Liu and T. Plessas

**Ship resistance and flow field study of KVLCC2 hull**  
S. Tarbiat and C. Guedes Soares

**CFD assessment of Ropax hull resistance with various initial drafts and trim angles**  
J. Labanti, H. Islam and C. Guedes Soares

**Experimental investigation of roughness effect on the resistance of a flat plate**  

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**Maritime Transportation 1**  
Navegadores Room  
**Chairs:** H. Haralambides, T. A. Santos

**LNG bunkering demand at Iberian Peninsula ports**  
D. Diaz Gutierrez, G. Polo Sanchez and F. de Manuel Lopez

**Refrigerated cargo handling: demand and requirements for Portuguese ports**  
L. Filina-Dawidowicz, T. Santos and C. Guedes Soares

**Capacity analysis of storage area from a maritime container terminal**  
F. Rusca, M. Popa, E. Rosca, M. A. Rosca and A. Rusca

**Feasibility study of MOS in Brazil using roll-on/roll-off vessels between Manaus and São Paulo**  
R. Santana Pelicia, M.A. Perdigão Peli, M. Galdi da Silva, R.C. Botter and N. Narciso Pereira

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**Marine Environment 1**  
Galeão Room  
**Chairs:** M. Bernardino, R. Campos

**Influence of water depth on the characteristics of spectra at the entrance of major Portuguese ports**  
C. Lucas, D. Silva and C. Guedes Soares

**Evaluation of the shoreline dynamics in a coastal sector of the Portuguese nearshore**  
E. Rusu, D. Silva and C. Guedes Soares

**Modelling average conditional exceedances of significant wave heights and associated peak periods**  
G. Muraleedharan, C. Lucas, D. Martins and C. Guedes Soares

**Bivariate distributions of significant wave height and peak peak periods of seastates in deep and shallow off shore Portugal**  
C. Lucas and C. Guedes Soares
| Time: 16:30 h – 18:00 h | **Ship Structures 2**  
Açores Room  
**Chairs:** M. Taczala, S. Estefen |
|-----------------------------|--------------------------------------------------|
| Sensitivity analysis of the IACS-CSR buckling strength requirements for stiffened panels  
B. Gaspar, A.P. Teixeira and C. Guedes Soares  
Static and buckling analysis of stiffened plates built in functionally graded materials  
M. Taczala, R. Buczkowski and M. Kleiber  
Residual ultimate strength of stiffened panels with pitting corrosion under compression  
Xing Hua Shi, Xiaolong Jiang, Jing Zhang and C. Guedes Soares  
Ultimate strength of lightweight asymmetric panels  
M. Elarbi. P.P. Silva and R.F. Martins |

| Time: 9:00 to 10:30 h | **Ship Structures 3**  
Açores Room  
**Chairs:** A. P. Teixeira, L. Sutherland |
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| Effect of uncertainty in the geometry and material properties on the post-buckling behavior of a composite laminate  
N. Kharghani and C. Guedes Soares  
Effect of vacuum bag pressure on the flexural properties of GFRP composite laminate  
F. Alizadeh, L.S. Sutherland and C. Guedes Soares  
Investigating T-joint strength parameters using statistical experimental design and analysis techniques  
L.S. Sutherland and C. Guedes Soares  
Coating breakdown assessment of steel plates in marine structures subjected to compressive load  
S. Sousa and Y. Garbatov |

| Time: 16:30 h – 18:00 h | **Ship Hydrodynamics 2**  
Porto Santo Room  
**Chairs:** O. El-Moctar, S. Sutulo |
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| Analysis of manoeuvrability criteria and standards in view of environmental factors and EEDI impact  
S. Sutulo and C. Guedes Soares  
Preliminary considerations on a unified model for hydrodynamic forces  
V. Ferrari and F.H.H.A. Quadvlieg  
Waypoint-following for a marine surface ship model based on vector field guidance law  
H.T. Xu and C. Guedes Soares  
Study of ship-to-ship interaction in shallow water with account for squat phenomenon  
D.B.V. Lima, S. Sutulo and C. Guedes Soares |

| Time: 9:00 to 10:30 h | **Ships Hydrodynamics 3**  
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**Chairs:** S. Brizzolara, S. Sutulo |
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| Assessment of different methods for the prediction of marine propellers induced pressures  
S. Gaggero, G. Tani, D. Villa, M. Viviani, F. Conti and C. Vaccaro  
New generation of CLT® propellers  
J. Gonzalez-Adalid, M. Pérez Sobrino, J. M. Riola  
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Y.T. Kim, S.I. Won, M.J. Ko, M.T. Jo and H.D. Cha |
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<td>Uncertainty on the bending moment transfer functions derived by a three-dimensional linear panel method</td>
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<td>Inland waterway ports characteristics relevant for classification methodology purpose</td>
<td>Uncertainties related to the estimation of added resistance of a ship in waves</td>
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<td>Conceptual design of a vessel traffic system</td>
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<td>Analysis of maritime accidents in Turkish coastal waters</td>
<td>Hull resistance modeling of flat autonomous underwater vehicle based on response surface method</td>
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<td>M. Taylan</td>
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<td>Chairs: J. Parunov, Y. Garbatov</td>
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<td>Fatigue analysis and optimization of non-load-carrying fillet welded joints based on the effective notch stress approach</td>
<td>Experimental study of a new low reflection breakwater</td>
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<td>C.-S. Ciocan, F. Taveira-Pinto, L. das Neves and P. Rosa-Santos</td>
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<td>Emergency repair of a single hull structure with locked cracks</td>
<td>A comparison between analytical and numerical simulations of solutions of the coupled Boussinesq equations</td>
</tr>
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<td>Calculation of the Stress Intensity Factor of the T-joint tubular in Complex Stress Field based on Weight Function</td>
<td>Numerical modelling of curved-front seawalls under regular waves</td>
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<td>Qingfeng Wang, Xiaoyan Xu and Xiaoping Huang</td>
<td>J.F.M. Gadelho, C. Guedes Soares, K.V. Anand and V. Sundar</td>
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<td>Effect of submerged horizontal flexible membrane on a moored floating elastic plate</td>
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<td>S.C. Mohapatra and C. Guedes Soares</td>
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### Structural design of an adaptable jacket offshore wind turbine support structure for deeper waters

B. Yeter, Y. Garbatov and C. Guedes Soares

Application of polynomial chaos expansions in stochastic analysis of plate elements under lateral pressure

B. Gaspar, E. Bahmyari, M. Reza Khedmati and C. Guedes Soares

On the influence of primary and secondary structural members on the global strength of ship structures

R. Diewald, B. Gerlach and S. Ehlers

Ultimate bending moment capacity of a single hull structure with large openings in side shell

S. Saad-Eldeen, Y. Garbatov and C. Guedes Soares

### Human Centred Design of a mooring winch control station

J. Gaspar, A.P. Teixeira, A.M.P. Santos, C. Guedes Soares, P. Golyshyev and N. Kähler

The application of human centered design in the design and day-to-day operation of a seagoing vessel

N.P. Ventikos, P. I. Sotiralis and G.V. Lykos

Improving ship design process to enhance ship recycling

K.P. Jain, J.F.J. Pruy and J.J. Hopman

A new concept design solution for pleasure sailing yachts

V. Bucci, F. Mauro and A. Marino

### Shipbuilding: from traditional naval construction to offshore wind

L. Carral-Couce, L. Castro-Santos, C. Alvarez-Feal, M. J. Rodriguez-Guerreiro and T.J. de Troya Calatayud

An exploration of the circumstances and changes in the shipbuilding industry in the last decades

A. Graziano, A. Kataria, J-U. Schröder-Hinrichs, A. Koimtzoglou, N. P. Ventikos and K. Zwirglmaier

Reduction in welding induced residual stresses and distortions of butt welded plates subjected to heat treatments

M. Hashemzadeh, Y. Garbatov and C. Guedes Soares

Flux-cored arc welding processes analysis of a shipyard

P.I.D. Lameira, C.M. Benjamín, E.S.P. Loureiro, H.B. Moraes, N.M. Figueiredo and T.L. Porto

### Shipyard Technology

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Non-linear control for the automatic berthing of waterjet catamaran  
*V. Ferrari, S. Sutulo and C. Guedes Soares*

Empirical analysis of the implantation of an automatic mooring system in a commercial port. Application to the Port of Santander (Spain)  
*E. Díaz, A. Ortega, C. Pérez, B. Blanco, L. Ruiz and J. Oria*

Numerical simulation of the motions and forces of a moored ship in Leixões harbor  
*L. Pinheiro, J.A. Santos, J. Fortes and P. Rosa-Santos*

Analysis of the movements and operational limits of moored vessels in Outer and Inner ports of A Coruña (Spain)  
*A. Figuero, E. Peña, J. Sande and F. Costa*

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**Wednesday, 6th July 2016**

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<td><strong>Chairs:</strong> N. Ventikos, S. Haugen</td>
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| Sensitivity analysis on the optimum hull girder safety level of a Suezmax tanker  
*J. Guia, A.P. Teixeira and C. Guedes Soares* |  |
| Fire risk assessment for ship compartments  
*J. Sobral and C. Guedes Soares* |  |
| Safety barriers for risk management of fishing vessels at coasts and open seas of Turkey  
*A. Mentes, M. Yetkin and H. Akyildiz* |  |
| Preliminary risk analysis on handling and storage of butyl acrylate operation  
*P.I.D. Lameira, E.S.P. Loureiro, A. Momose and M.R. Martins* |  |

**Ship Machinery 1**  
*Navegadores Room*

**Chairs:** G. Theotokatos, G. Benvenuto

EfficientShip: A case study for the implementation of ORC technology onboard European fishing vessels  
*E. Notti, A. Leroux, P. Smague, F. Moro, N. Parke, A. Roger, P. Leduc and A. Sala*

On-board measurements of emissions from a ferry  
*S.S. Kalender, M. Durmaz and S. Ergin*

An overall comparison between natural gas spark ignition and compression ignition engines for a ro-pax propulsion plant  
*U. Campora, M. Laviola and R. Zaccone*

Comparison of a natural gas engine with a diesel engine for marine propulsion  
*G. Benvenuto, M. Laviola, R. Zaccone and U. Campora*

**Oil and Gas Workshop 1**  
*Açores Room*

**Chairs:** R. Baptista, C. Guedes Soares

Crude Oil lifting's in the pré-salt Brazil  
*Mário Rocha (GALP)*

Lifecycle Management of Offshore Structures  
*Anderson Christina da Silva (Petrobrás)*
Why we need to change? Transpetro’s Perspective  
Jones A.B. Soares (Transpetro)
Floating LNG: New Challenges, New Opportunities  
Nuno Almeida Fonseca (GALP)

---

**Safety and Reliability 2**  
Porto Santo Room

**Chairs:** S. Haugen, M. R. Martins

- Probabilistic modelling of evasive manoeuvring actions to avoid collisions  
P. Silveira, A.P. Teixeira and C. Guedes Soares
- Norwegian national ship risk model  
S. Haugen, P.G. Almklov, M. Nilsen and R.J. Bye
- Assessment and characterization of near ship collision scenarios off the coast of Portugal  
H. Rong, A.P. Teixeira and C. Guedes Soares
- Study on path planning strategies for search and rescue  
J.F. Zhang, A.P. Teixeira, C. Guedes Soares and X.P. Yan

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**Ship Machinery 2**  
Navegadores Room

**Chairs:** G. Benvenuto, G. Theotokatos

- Numerical study of a marine dual-fuel four-stroke engine  
G. Theotokatos, S. Stoumpos, I. Lazakis and G. Livanos
- Modelling the effect of variable valve timing on exhaust thermal management of a diesel engine  
H.U. Başaran and O.A. Özsoysal
- Assessment of the performance and the exhaust emissions of a marine diesel engine for different start angles of combustion  
M. Tadros, M. Ventura and C. Guedes Soares
- The dynamic behavior of diesel engines on ships in adverse conditions  
S. Kouroutzis and K. Visser

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**Fisheries**  
Galeão Room

**Chairs:** A. Campos, P. Fonseca

- Baltic sprat fishery, stock assessment and prediction  
F. Svecovs O. Ozernaja, M. Fettere, G. Strods and A. Vingovatova
- Perspectives of mariculture development in Polish Baltic coastal zone  
J. Sadowski and A. Tórz
- Developments in Estonian coastal perch fishery in the Baltic Sea during the recent two decades (1994-2015)  
L. Järv, T. Raid, M. Pärnoja and A. Soome
- Central Baltic herring stock: what does the assessment of combined stock say about the status of its components?  
T. Raid, L. Järv, J. Pönni, J. Raitaniemi and G. Kornilovs
Estimation of fishing effort in offshore seamounts using a satellite Vessel Monitoring System
T. Morato, G. Taranto, C.K. Pham, I. Figueiredo and A. Campos

Technologies and techniques as sampling tools in marine habitat mapping
V. Henriques, M.T. Guerra and M.J. Gaudêncio

Reducing fuel consumption in Portuguese coastal trawlers by using trawls with higher tenacity fibres
J. Parente, P. Fonseca, V. Henriques and A. Campos

Time: 16:00 to 17:30 h
Oil and Gas Workshop 3
 Açores Room

Engineering in NOV Portugal-Technical Groups
Presentation
António Sobral (NOV)

Peniche- Industrial Cluster
Francisco Borges / Jorge Saraiva (AMAL)

Underwater Energy – The Subsea Power Grid
Manuel Santos (SIEMENS)

Digital Technology to Transform AIMS
To be defined (Bureau Veritas)

Safety and Reliability 4
 Porto Santo Room

Safety and security in the Portuguese extended continental shelf
J.G. Chilão and J. Lúcio

Use of fuzzy inference approach to estimate maritime security level

Efficiency evaluation of maritime emergency disposal based on revised Petri net and fuzzy evaluation
Tengfei Wang, Xinpeng Yan, Yang Wang and Qing Wu

EEG-based human factors evaluation for maritime simulator-aided assessment
Yisi Liu, Xiayuan Hou, O. Sourina, D. Konovessis and G. Krishnan

Opportunistic maintenance based on CUSUM control charts
S. Lampreia, V. Vairinhos, V. Lobo, R. Parreira and J. G. Requeijo

Energy Efficiency 2
 Navegadores Room

Sensitivity analysis of wind load estimation method based on elliptic Fourier descriptors
J. Prpić-Oršić and M. Valtić

Ship speed power performance under relative wind profiles
L.P. Perera and B. Mo

Analysis of the sensitivity of a multi-objective genetic algorithm for route optimization to different settings
R. Vettor and C. Guedes Soares

Fuel saving-oriented 3D dynamic programming for weather routing applications
R. Zaccone, M. Figari, M. Altosole and E. Ottaviani

Data Requirements in Fisheries Science 2
 Galeão Room

Ocean observation with networked vehicle systems
J. Borges de Sousa

Wireless energy and communications in remote ocean areas: The ENDURE and BLUECOM+ projects
L.M. Pessoa and Rui Campos

Fisheries data requirements under the INSPIRE directive

IMPORTANT CONTACTS:

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<thead>
<tr>
<th>Congress Location</th>
<th>CENTEC</th>
<th>Congress Dinner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holiday Inn Lisboa Hotel Av. Antonio Jose de Almeida, 28-A 1000-044 Lisboa Tel: +351 21 004 4000 Web: <a href="http://www.holiday-inn.com/lisbonprt">http://www.holiday-inn.com/lisbonprt</a></td>
<td>Centre for Marine Technology and Ocean Engineering Instituto Superior Técnico Avenida Rovisco Pais Lisboa 1049 – 001 Tel: +351 218 417 468</td>
<td>Casino Estoril Av. Dr. Stanley Ho Edificio do Casino Estoril 2765-190 Estoril <strong>Telefone</strong>: 214 667 700 <strong>Email</strong>: <a href="mailto:Info.cestoril@estoril-sol.com">Info.cestoril@estoril-sol.com</a></td>
</tr>
<tr>
<td>WIFI: Username – hilisboa Password - hilisboa</td>
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<td>EMERGENCY NUMBER – 112</td>
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</tbody>
</table>
PLAN OF THE ROOMS

1 – Room Açores
2 – Room Porto Santo
3 – Room Navegadores
4 – Room Galeão
5 - Secretariat

CONFERENCE VENUE

The 3rd International Conference on Maritime Technology and Engineering will be held at Holiday Inn Lisboa Hotel close to IST.

SPONSORS
Shipbuilding: From traditional naval construction to offshore wind

L. Carral-Couce & L. Castro-Santos
Departamento de Enxeñería Naval e Oceánica, Escola Politécnica Superior, Universidade da Coruña, Campus de Ferrol, Ferrol, Spain

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Departamento de Enxeñería Industrial II, Escola Politécnica Superior, Universidade da Coruña, Campus de Ferrol, Ferrol, Spain

J. de Troya Calatayud
Departamento de Ciencias de la Navegación y de la Tierra, Universidade da Coruña, A Coruña, Spain

ABSTRACT: The European shipbuilding held a hegemonic position at the beginning of the twentieth century, which has gradually been decreased throughout the last century. They are shipyards fully equipped today and located in geographic communities with adequate training of the workforce and complementary industrial structure. It is necessary to redirect the industrial-maritime activity in these facilities, obtaining the maximum use of these assets. Therefore, the use of offshore wind determine the construction of complex steel structures, whose high size and weight recommend that they should be manufactured in areas close to their final position and easy boarding areas. The present paper aims to analyse the possibilities of adapting the facilities of the former ASTANO, whose location in the Ría de Ferrol (Galician area, NW of Spain) was allocated in the past to the activity of traditional shipbuilding, for their use in the emerging construction activity of offshore wind.

1 INTRODUCTION

1.1 European shipbuilding

The European market of shipbuilding has been changing over the last century. Evidence shows that the dominant position, backed by a market share of 80% at the beginning of the twentieth century (Stopford 2009) has been transformed in a minoritary equal to 6% at the end of 2014 (Organisation for Economic Co-operation and Development 2015). This development has promoted significant changes in the industrial activity, especially in areas with strong shipbuilding tradition, and hence, the gradual decreasing in the activity of industrial facilities of great strategic value (Fornahl 2011). A clear example of this process of gradual decline in this activity has occurred in the ASTANO company.

1.2 Offshore wind

1.2.1 Wind energy

Onshore wind industry is at the forefront of the renewable energy industry in Spain. In fact, the Spanish wind energy industry is highly relevant, being the fourth country with the largest installed capacity having 23 GW. The first positions are occupied by China with 115 GW, USA with 66 GW and Germany with 39 GW (Global Wind Energy Council (GWEC) 2014).

In terms of offshore wind energy, since 2000, offshore wind market has been developed in Europe, being at the end of 2012 1,662 turbines installed and representing 5 GW of installed offshore wind capacity. It produces 18 TWh, the electricity needed for five million households (European Wind Energy Association (EWEA) 2013) (Figure 1).

The majority of the offshore wind farms (65% of the total capacity) are installed in the North Sea. 16% is installed in the Baltic Sea and the 19% in the Atlantic (European Wind Energy Association (EWEA) 2013).

Nowadays, all commercial projects of offshore wind energy correspond to a similar concept to onshore farms (Bussel & Henderson 2001, Jonkman & Buhl 2007, Sclavounos et al. 2010, Guedes Soares et al. 2014), in which the wind generator is founded in the seabed in shallow areas near the coast. In this
sense, for their installation it is necessary to have large coastal areas that allow the temporary storage of the various components, which helps to install vessels or others to have access to them and quickly return to the farm.

The dimensions of the new offshore wind turbines of 5–7 MW require facilities on the coast with specific characteristics which allow the installation, the construction, creating an onshore base where installation can be developed while constructing and that it was subsequently used as a logistical base for offshore maintenance: wide surface, well equipped workshops, powerful cranes, docks with large lifting capacity and specialized workers.

According to the EWEA, in 2020, an installed capacity of 40 GW offshore is expected, of which a quarter will be installed in the Atlantic axis, including Portugal, Northern Spain, South England, the South West Coast of Ireland and France (EWEA, 2013).

1.2.2 Offshore wind structures
An offshore wind structure is composed of four main components (Greenacre et al. 2010):

- Offshore wind turbine: composed of tower, blades and nacelle.
- Offshore wind platform or sub-structure.

The tower is typically manufactured in sections of 20-30 m, which are assembled and later joined by internal and external welding. Their typical weights are 347 t for a 90 m tower turbine with a rotor diameter of 126 m (5 MW) (ECN et al. 2002, Jonkman et al. 2009).

The blades have dimensions of 75 m in length for a 7 MW wind turbine. They consist of a matrix of glass fiber mats impregnated with a material such as polyester.

The nacelle has the main components of the wind turbine, including generator, gearbox and control systems (Ashuri et al. 2014).

Finally, the offshore wind platform will depend on the depth of the location where the offshore farm will be installed. In this sense, there are two types of offshore wind platforms: fixed structures and floating structures (Collu et al. 2010). The first ones are installed in shallow waters up to 50 m and the second ones are installed in deep waters, from 50 m of depth. However, the majority of the offshore wind turbines have fixed platforms. In this context, most of these fixed structures are monopiles, followed by gravity based foundations and space frame structures.

In terms of the floating offshore wind platforms, there are three main types of sub-structures: semisubmersible, spar and TLP (Tensioned Leg Platform) (Jonkman & Matha 2010), as Figure 2 shows.

The goal of EWEA by 2020 is 40 GW of offshore wind, 5 GW in Spanish waters, which will be at a level of annual growth of 28% over the next 10–12 years. This objective is realistic taking into account that the onshore wind sector has grown at levels of 32% annually in the period 1992–2004.

The support of the UE, mainly UK, Germany and Denmark, will develop a European offshore industry which can directly compete with traditional gas and oil industry. This new industry will create thousands of new “green” jobs and will strengthen the European industry as a world leader in the offshore renewable energy sector.

2 OBJECTIVES

The main objective of the present paper is to analyse the possibilities of adapting the facilities of the ASTANO (nowadays named Navantia company) shipyard, whose location in the Ría de Ferrol (Galician area, NW of Spain) was allocated in the past to the activity of traditional shipbuilding, offshore oil construction, military construction and repair of vessels, for their use in the emerging construction activity of substructures for offshore wind.

3 CASE OF STUDY

The case of study considered to analyse how traditional shipbuilding can be changed to offshore wind is the ASTANO (Astilleros y Talleres del Noroeste) shipyard, which is located in Fene, A Coruña (Northwestern Spain). It was founded in 1941 and it began its activity with the construction of fishing vessels and coaster ships, although the shipbuilding boom in the 60s and 70s led to the evolution of its activity and the expansion of its facilities, making important investments, which consequently led the company to build a wider variety of vessels such as tankers, LNG, OBO (ore oil/bulk oil) or bulkcarrier. Therefore, from 1941 to 1983 its main activity was the traditional shipbuilding (Figure 3), with the construction of 288 units.

After the decline of shipbuilding from 1976, the Spanish Government decides in 1984 that the shipyard will be focused on the offshore shipbuilding, beginning an offshore phase from 1984 to 2004. It consists
in performing construction works in the offshore shipbuilding sector, construction works in the industrial sector and integration of naval and industrial systems. From 2004, contracts of new units have stopped. Since this year, the facilities were only allocated to the repair activity and build ship sections for military vessels, which were constructed in the neighbouring shipyard Bazán (nowadays both shipyards belong to NAVANTIA company). This low activity stage lasted until 2014. From that moment, the offshore wind phase started.

4 CHARACTERISTICS IN THE PRESENT

ASTANO has 756,000 m$^2$ of total area, which simultaneously allows to address the offshore shipbuilding and other industrial projects. The size and versatility of its facilities allows to combine several activities in parallel, so industrial modules construction can coexist with projects of vessels and/or floating structures. In this context, it is important to notice the two existing building berths (330 m × 55 m) and the lifting capacity of the gantry crane of 750 t, as Figure 4 is shown.

5 PROPOSED OFFSHORE WIND PHASE

Two strategies of action can be taken into consideration for the new offshore wind energy phase:

- Option 1: considering a production line of 10,000 t/year.
- Option 2: considering a production line of 20,000 t/year.

<table>
<thead>
<tr>
<th>Option (t/year)</th>
<th>Manufacturing/Assembly (m$^2$)</th>
<th>Erection – Building berth</th>
<th>Total (m$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10,000</td>
<td>14,300</td>
<td>40,600</td>
<td>54,900</td>
</tr>
<tr>
<td>20,000</td>
<td>62,100</td>
<td>72,310</td>
<td>134,410</td>
</tr>
</tbody>
</table>

Option 1 consists in the simultaneous use of work areas for manufacturing components for offshore wind, while other spaces are simultaneously dedicated to the traditional shipbuilding.

On the other hand, Option 2 takes into consideration the dedication of the entire surface of the shipyard to the same activity: the offshore wind construction.

Table 1 shows the main characteristics of the two strategies for manufacturing, assembly and erection of offshore wind substructures.

The general strategy in Option 2 is composed of two main steps:

- Construction.
- Load-Out.

The construction step is composed of the following workflow (Figure 5):

1. Cutting – Manufacturing (forming and shaping): The bulk material (plates and profiles) is cut into Flat blocks workshop and Curve blocks workshop.
2. Prefabrication: They are assembled in the Modules workshop, Curve blocks workshop and Prefabrication area 2 to incorporate pipes, equipment, electrical system and instrumentation, forming sub-modules up to 750 t.
3. Assembly: The sub-modules are integrated in the outdoor areas as prefabrication and assembly area Z1 and Z2, prefabrication area 1 and 3, building berth 1 and building berth 2 to their temporary storage, after the completion of the relevant trials. Furthermore, the outdoor prefabrication and assembly areas may be used to manufacture large modules or sub-modules if necessary.
Table 2. Output possibilities of the modules at the shipyard.

<table>
<thead>
<tr>
<th>Weight (t)</th>
<th>&lt;40</th>
<th>40–180</th>
<th>180–750</th>
<th>750–3,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road or railway</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Port cranes</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gantry cranes</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Load-out (Roll on system and special mobile cranes)</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 6. Load-out depending on the type of module.

Table 3. Main characteristics of the facilities for exporting the modules in the shipyard.

<table>
<thead>
<tr>
<th>Concept</th>
<th>Dock 2</th>
<th>Dock 4</th>
<th>Dock 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum draft (m)</td>
<td>5.5</td>
<td>7.5</td>
<td>7</td>
</tr>
<tr>
<td>Maximum draft (m)</td>
<td>9.8</td>
<td>11.8</td>
<td>11.13</td>
</tr>
<tr>
<td>Tidal path (m)</td>
<td>4.3</td>
<td>4.3</td>
<td>4.13</td>
</tr>
<tr>
<td>Cranes (t)</td>
<td>1 × 25</td>
<td>1 × 25</td>
<td>1 × 100</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 × 80</td>
</tr>
</tbody>
</table>

The load-out step is dependent on the delivery of the modules that must be done at the shipyard to a transport barge for transporting them to their final offshore wind farm location. The export capacity of modules is limited by shipyard means of weights, existing the possibilities of Table 2:

If the final destination of the modules were an offshore unit whose hull were located in the shipyard, the integration of the plant could take place in any of the following ways (Figure 6):

- **Modules up to 750 t**: using the gantry crane for units constructed in building berth.
- **Modules up to 3,000 t**: assembly on dock and load out with horizontal movement roll on system, or vertical movement by means floating or mobile crane.

In this context, the main characteristics of the facilities for exporting the modules are shown in Table 3:

Considering modules up to 750 t, the gantry crane would be used for loading and unloading of the modules of the vessel HLC (Heavy Lift Carrier) up to 33 m beam and 6 m draft, reaching 42 m beam depending on the required draft and the height of tide available. The barge or vessel shall be moored between the two slipway of the shipyard, as Figure 7, Figure 8 and Figure 9 are shown.
On the other hand, considering modules up to 3,000 t, the process is done by horizontal or vertical transfer, using mobile platforms, floating or land cranes. There is a great flexibility for handling modules of different sizes and geometries, with a maximum weight of 3,000 t.

6 CONCLUSIONS

This paper has analysed the possibilities of adapting the facilities of the old ASTANO shipyard, whose location in the Ría de Ferrol (Galician area, NW of Spain) was allocated in the past to the activity of traditional shipbuilding, offshore oil construction, military construction and ship repair, for their use in the emerging construction activity of substructures for offshore wind.

The main steps in this analysis have been the construction and the load-out activities. In terms of the construction issue, the areas of manufacturing, prefabrication and assembly have been defined. On the other hand, in terms of the load-out activities, they are dependent on the delivery of the modules that must be carried out at the shipyard to a transport barge from their final transportation to the offshore wind farm. This export capacity is dependent on the weights. In this context, two strategies have been taken into account: using a proper gantry crane for units constructed in building berth up to 750 t and assembly on dock with mobile platforms, floating or land crane, for modules up to 3,000 t.

This study is useful in terms of knowing the facilities, which a traditional shipyard has, in order to adapt its activity to offshore wind building.

REFERENCES


