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Maritime Technology and Engineering 3
CRC Press
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A BALKEMA BOOK
Editors:
C. Guedes Soares
T.A. Santos

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Volume 2

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PROCEEDINGS OF MARTECH 2016, 3rd INTERNATIONAL CONFERENCE ON MARITIME TECHNOLOGY AND ENGINEERING, LISBON, PORTUGAL, 4–6 JULY 2016

Maritime Technology and Engineering 3

Editors

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Centre for Marine Technology and Ocean Engineering (CENTEC), Instituto Superior Técnico, Universidade de Lisboa, Portugal

T.A. Santos
Ordem dos Engenheiros, Portugal

VOLUME 2

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Maritime Technology and Engineering 3 – Guedes Soares & Santos (Eds)
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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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TÉCNICO LISBOA

ORDEM DOS ENGENHEIROS

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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SCHEDULE AT A GLANCE

Monday, 4 July 2016 **Registration** (Hall 01 – from 8h00 onwards)			
Holiday Inn Lisboa Hotel			
Opening Session *(9h00-10h30) – Açores Room* ***Keynote lectures 1***			
Coffee-break (10h30-11h00)			
Plenary Session *(11h00-13h00) – Açores Room* ***Keynote lectures 2***			
Lunch (13h00-14h30)			
Açores (14h30-16h00) **Ship Structures 1**	*Porto Santo (14h30-16h00)* **Ship Hydrodynamics** 1	*Navegadores (14h30-16h00)* **Maritime Transportation 1**	*Galeão (14h30-16h00)* **Marine Environment 1**
Coffee-break (16h00-16h30)			
Açores (16h30-18h00) **Ship Structures 2**	*Porto Santo (16h30-18h00)* **Ship Hydrodynamics 2**	*Navegadores (16h30-18h00)* **Maritime Transportation 2**	*Galeão (16h30-18h00)* **Marine Environment 2**
Tuesday, 5 July 2016 **Registration** *(Hall 01 – from 8h00 onwards)*			
Açores (9h00 – 10h30) **Ship Structures 3**	*Porto Santo (9h00 – 10h30)* **Ship Hydrodynamics 3**	*Navegadores (09h00 – 10h30)* **Ship Design 1**	*Galeão (9h00 – 10h30)* **Maritime Transportation 3**
Coffee-break (10h30-11h00)			
Açores (11h00-12h30) **Ship Structures 4**	*Porto Santo (11h00-12h30)* **Ship Hydrodynamics 4**	*Navegadores (11h00-12h30)* **Ship Design 2**	*Galeão (11h00-12h30)* **Coastal Structures**
Lunch (12h30-14h00)			
Açores (14h00-15h30) **Ship Structures 5**	*Porto Santo (14h00-15h30)* **Ship Hydrodynamics 5**	*Navegadores (14h00-15h30)* **Ship Design 3**	*Galeão (14h00-15h30)* **Renewable Energy 1**
Coffee-break (15h30-16h00)			
Açores (16h00-17h30) **Shipyard Technology**	*Porto Santo (16h00-17h30)* **Ship Hydrodynamics 6**	*Navegadores (16h00-17h30)* **Ships in Ports**	*Galeão (16h00-17h30)* **Renewable Energy 2**
20h00 - Conference Dinner			
Wednesday, 6 July 2016 **Registration** *(Hall 01 – from 8h00 onwards)*			
Açores (9h30-10h30) **JETM** **Opening Session**	*Porto Santo (9h00–10h30)* **Safety and Reliability 1**	*Navegadores (9h00 – 10h30)* **Ship Machinery 1**	*Galeão (9h00 – 10h30)* **Oil and Gas**
Coffee-break (10h30-11h00)			
Açores (11h00-12h30) **Oil and Gas Workshop 1**	*Porto Santo (11h00-12h30)* **Safety and Reliability 2**	*Navegadores (11h00-12h30)* **Ship Machinery 2**	*Galeão (11h00-12h30)* **Fisheries**
Lunch (12h30-14h00)			
Açores (14h00-15h30) **Oil and Gas Workshop 2**	*Porto Santo (14h00-15h30)* **Safety and Reliability 3**	*Navegadores (14h00-15h30)* **Energy Efficiency 1**	*Galeão (14h00-15h30)* **Data Requirements in Fisheries Science 1**
Coffee-break (15h30-16h00)			
Açores (16h00-17h30) **Oil and Gas Workshop 3**	*Porto Santo (16h00-17h30)* **Safety and Reliability 4**	*Navegadores (16h00-17h30)* **Energy Efficiency 2**	*Galeão (16h00-17h30)* **Data Requirements in Fisheries Science 2**

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 Navegadores

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 Galeão

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

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

Oil and Gas Workshop 2 – Wednesday, 06/07/2016, 14:00h - Room Açores

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

Ship Structures 2 – Monday, 04/07/2016, 16:30h – Room Açores

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

DETAILED PROGRAMME

Monday, 4th 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

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

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. Salvado

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

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
E.D. Kiosidou, A.S. Venetis, D.E. Liarokapis, J.P. Trachanas, G.D. Tzabiras and D.I. Pantelis

Maritime Transportation 1
Navegadores Room

Chairs: H. Haralambides, T. A. Santos

LNG bunkering demand at Iberian Peninsula ports
D. Diaz Gutiérrez, G. Polo Sanchez and F. de Manuel López

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

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. Taczała, 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

Ship Hydrodynamics 2
Porto Santo Room

Chairs: O. El-Moctar, S. Sutulo

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

Maritime Transportation 2
Navegadores Room

Chairs: H. Haralambides, T. A. Santos

Determining the size of ferry fleet: Fuzzy logic approach
M. Škurić and V. Mara

Forecasting cargo throughput in Portuguese ports using causal methods
A. Mainardi and T. Santos

Green corridor to Brazil: integrated logistics in maritime transportation
D.A. Moura and R.C. Botter

The impact of the 2008 financial crisis on the Portuguese maritime cluster
A. Simões, R. Salvador and C. Guedes Soares

Marine Environment 2
Galeão Room

Chairs: E. Rusu, M. Gangadharan

Validation of an operational wave forecasting system for the North Atlantic area
C. Guedes Soares, N. Salvação, M. Goncalves and L. Rusu

Comparison of various data assimilation methods to improve the wave predictions in the Portuguese coastal environment
L. Rusu and C. Guedes Soares

A climatological analysis of storms in the North Atlantic
M. Bernardino and C. Guedes Soares

Hybrid model to forecast significant wave heights
R.M. Campos and C. Guedes Soares

Tuesday, 5th July 2016

Time: 9:00 to 10:30 h

Ship Structures 3
Açores Room

Chairs: A. P. Teixeira, L. Sutherland

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

Ships Hydrodynamics 3
Porto Santo Room

Chairs: S. Brizzolara, S. Sutulo

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 Rodriguez, J.J. Diaz Hernandez, L.M. Gonzalez, A. Moran-Guerrero, R. Quereda Lavina and C. Soriano

Design and application of the contra-rotating propeller for VLCC on the structure part
Y.T. Kim, S.I. Won, M.J. Ko, M.T. Jo and H.D. Cha

Ship Design 1
Navegadores Room

Chairs: E. Begovic & M. Ventura

Implementation of second generation intact stability criteria into the stability calculation software
A. Ariffin, J.M. Laurens and S. Mansor

Second generation intact stability criteria for mega-yachts: application and design considerations
N. Petacco and P. Gualeni

Exploitation of SWATH hull form concept for small working/pleasure craft
E. Begovic, C. Bertorello, A. Bove and F. de Luca

Quasi-steady determination of dynamic forces acting on tug during escort operations
V. Bucci, A. Marino and F. Mauro

Yacht mast and rigging system software for design and analysis
D. Soares de Melo and Y. Garbatov

Maritime Transportation 3
Galeão Room

Chairs: R. C. Botter, T. A. Santos

Waterway transport potential in the amazon, case study: The crossing from Outeiro Island to Belém
A.M. Borges, J.R.C. Cunha and H.B. Moraes

Inland waterway ports characteristics relevant for classification methodology purpose
O. Dinu, E. Rosca and F. Rusca

Conceptual design of a vessel traffic system
J. Hough and R. C. Botter

Analysis of maritime accidents in Turkish coastal waters
M. Taylan

Time: 11:00 to 12:30 h

Ship Structures 4
Açores Room

Chairs: J. Parunov, Y. Garbatov

Equivalent design wave approach for fatigue assessment of ship shaped structures
S.E. Heggelund, G. Storhaug, A. Gonçalves and H. Austefjord

Fatigue analysis and optimization of non-load-carrying fillet welded joints based on the effective notch stress approach
Y. Dong, Y. Garbatov and C. Guedes Soares

Emergency repair of a single hull structure with locked cracks
S. Saad-Eldeen, Y. Garbatov and C. Guedes Soares

Calculation of the Stress Intensity Factor of the T-joint tubular in Complex Stress Field based on Weight Function
Qingfeng Wang, Xiaoyan Xu and Xiaoping Huang

Ship Hydrodynamics 4
Porto Santo Room

Chairs: S. Brizzolara, J. M. Rodrigues

Uncertainty on the bending moment transfer functions derived by a three-dimensional linear panel method
H. Jafaryeganeh, A.P. Teixeira and C. Guedes Soares

Uncertainties related to the estimation of added resistance of a ship in waves
N. Vitali, J. Prpić-Oršić and C. Guedes Soares

Uncertainty modelling in ship manoeuvring models
P.P. Silva and C. Guedes Soares

Hull resistance modeling of flat autonomous underwater vehicle based on response surface method
Mengyun Wang, C. Guedes Soares and Songlin Yang

Ship Design 2
Navegadores Room

Chairs: M. Ventura, J. M. Varela

Optimization of ship's bow form for the added resistance in waves
V. Bolbot and A. Papanikolaou

Operational profiles data analytics for ship design improvement
A. Coraddu, T. Cleophas, K. Xepapa, L. Oneto and D. Anguita

A numerical model for compartment assessment of offshore structures with cylindrical hulls
E. Uzunoglu and C. Guedes Soares

Parametric modelling for adaptive internal compartment design of container ships
H. Jafaryeganeh, M. Ventura and C. Guedes Soares

Coastal Structures
Galeão Room

Chairs: J. Fortes, J. A. Santos

Experimental study of a new low reflection breakwater
C.-S. Ciocan, F.Taveira-Pinto, L.das Neves and P. Rosa-Santos

A comparison between analytical and numerical simulations of solutions of the coupled Boussinesq equations
S.C. Mohapatra, R.B. Fonseca and C. Guedes Soares

Numerical modelling of curved-front seawalls under regular waves
J.F.M. Gadelho, C. Guedes Soares, K.V. Anand and V. Sundar

Effect of submerged horizontal flexible membrane on a moored floating elastic plate
S.C. Mohapatra and C. Guedes Soares

Time: 14:00 to 15:30 h

Ship Structures 5
Açores Room

Chairs: J. Parunov, A. P. Teixeira

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

Ship Hydrodynamics 5
Porto Santo Room

Chairs: J. Prpić-Oršić, E. Begovic

Three - dimensional pressure distribution on planing hulls
S. Pennino, H. Klymenko, A. Scamardella, S. Mancini and E. Begovic

Estimation of current loads on an offshore supply vessel
M. Asghari, M. Sohrabi, M. Mohammadzadeh and C. Guedes Soares

Effect of wing geometrical parameters on the aerodynamic performance of wing in ground marine craft
M. Mohamed and I. Amin

Motion response of round shape FLNG due to interaction with another floating structure
J. Koto, S.C. Loon, C. Guedes Soares, H. Yasukawa, A. Matsuda, D. Terada and H. Abyn

Ship Design 3
Navegadores Room

Chairs: N. Ventikos, D. Konovessis

Human Centred Design of a mooring winch control station
J. Gaspar, A.P. Teixeira, A.M.P. Santos, C. Guedes Soares, P. Golyshev 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. Pruyn and J.J. Hopman

A new concept design solution for pleasure sailing yachts
V. Bucci, F. Mauro and A. Marino

Renewable Energy 1
Galeão Room

Chairs: L. Castro-Santos, J. M. Rodrigues

Time domain analysis of circular array of heaving point absorbers
A. Sinha, D. Karmakar, J.F. Gaspar, M. Calvário and C. Guedes Soares

Trajectory generation for automatic emersion/immersion manoeuvers of first generation TEC
J.A. Somolinos, M.P. Portilla, E. Segura, M. Espin, L.R. Nuñez and A. López

Power Take-Off concept with flow proportional valves based rectification
J. Gaspar, A. Sinha, M. Calvário and C. Guedes Soares

Modeling of the western Iberian oceanic currents with ROMS
L.T. Pereira, T.C. Costa, M. Marta-Almeida and C. Guedes Soares

Time: 16:00 to 17:30 h

Shipyard Technology
Açores Room

Chairs: Y. Garbatov, J. M. Gordo

Shipbuilding: from traditional naval construction to offshore wind
L. Carral-Couce, L. Castro-Santos, C. Alvarez-Feal, M. J. Rodriguez-Guerreiro and TJ. 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. Benjamin, E.S.P. Loureiro, H.B. Moraes, N.M. Figueiredo and T.L. Porto

Ship Hydrodynamics 6
Porto Santo Room

Chairs: E. Begovic, J. Prpić-Oršić

An hybrid RANSE - strip theory method for prediction of ship motions
L. Bonfiglio, G. Vernengo, S. Brizzolara and D. Bruzzone

On the estimations of ship motions during maneuvering tasks in irregular seas
M. Acanfora and J. Matusiak

Non-parametric estimation of directional wave spectra using two hyperparameters
M.A. Hinostroza and C. Guedes Soares

Hydroelastic vibration of bottom platting subjected to wave impact
S. Wang and C. Guedes Soares

Ships in Ports
Navegadores Room

Chairs: J. A. Santos, S. Sutulo

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. Diaz, 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

Renewable Energy 2
Galeão Room

Chairs: L. R. Nuñez, J. F. Gaspar

Evaluation of the wave energy potential in some locations where European offshore wind farms operate
F. Onea, A. Raileanu and E. Rusu

Long-term assessment of the wave load acting on semi-submersible wind turbine support structure
K. Raed, D. Karmakar and C. Guedes Soares

Semi-taut mooring line damping
Sheng Xu, Chunyan Ji and C. Guedes Soares

Influence of the electric tariff on a floating offshore wind farm
L. Castro-Santos, L. Carral-Couce, A. Filgueira-Vizoso, I. Lamas Galdo and J. I. Fraguela Formoso

Wednesday, 6th July 2016

Time: 9:00 to 10:30 h

Safety and Reliability 1
Porto Santo Room

Chairs: N. Ventikos, S. Haugen

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
Galeão Room

Chairs: S. F. Estefan, T. A. Santos

Design methodology for modifying a MODU into a FPU
A. Martin Moe and M. Laranjinha

A wind heeling moment curve for ship-shaped MODU early design stability considerations
J. Mendonça Santos and C. Alves

A mixed integer formulation for the offshore rig scheduling problem
L.M.R. Silva, A.M.P. Santos and C. Guedes Soares

An offshore oil industry inventory routing problem with weather windows
A. M. P. Santos and C. Guedes Soares

Study of the risk to export crude oil in pipeline systems
L.M.R. Silva and C. Guedes Soares

Time: 11:00 to 12:30 h

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 Christino 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

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

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

Time: 14:00 to 15:30 h

Oil and Gas Workshop 2
Açores Room

Chairs: R. Baptista, C. Guedes Soares

Advances in FPSO Technology
Umberto Viviani (SBM)

Drillship Design Innovations
João Mendonça Santos (Gusto MSC)

The CLOV Hybrid Riser Tower
Jérémy de Barbarin (Subsea7)

Synthetic fibre ropes: new applications
Sérgio Leite (Lankhorst)

Safety and Reliability 3
Porto Santo Room

Chairs: X. Yan, N. Ventikos

Review of statistical data on ship accidents
B. Bužančić Primorac and J. Parunov

A data envelopment analysis based FMECA method for prioritization of maritime accidents failures in Yangtze River
B. Wu, X.P. Yan and Y. Wang

Assessment of the contributing factors of accidents in the Tiete-Parana Waterway
M.S. Saito, A. de A. Prado, G.P.Salvador and M.R. Martins

Control charts limits flexibility based on the equipment conditions
S. Lampreia, V. Vairinhos, V Lobo, R. Parreira and J. G. Requeijo

Energy Efficiency 1
Navegadores Room

Chairs: M. Figari, J. Prpić-Oršić

TOPSIS method implementation on Slow steaming alternatives evaluation
I. Dagkinis and N. Nikitakos

Development of intelligent ship fuel consumption algorithms
K. Ramesh, D. Konovessis, S.K. Thong and X. You

Machine intelligence for energy efficient ships: a big data solution
L.P. Perera and B. Mo

Route planning of a fishing vessel in coastal waters with fuel consumption restraint
R. Vettor, M. Tadros, M. Ventura and C. Guedes Soares

Data Requirements in Fisheries Science 1
Galeão Room

Chairs: A. Campos, P. Fonseca

Fisheries-related activities in seamounts
A. Campos, P. Lopes, P. Fonseca, I. Figueiredo, J. Delgado, N. Gouveia, T. Morato, V. Henriques, T. Drago and A. dos Santos

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

Chairs: R. Baptista, C. Guedes Soares

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

Chairs: M. R. Martins, X. Yan

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
N.P. Ventikos, D.I. Stavrou and Z.L. Yang.

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

EEG-based human factors evaluation for maritime simulator-aided assessment
Yisi Liu, Xiyuan 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

Chairs: M. Figari, S. Sutulo

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

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

Chairs: J. Sousa, L. Pessoa

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
A. Rocha, R. Amorim, J. Castro, C. Almeida, D. Benevides, G. David, C. Ribeiro, A. dos Santos, A. Campos, M. Guerra and I. Farias

IMPORTANT CONTACTS:

Congress Location	**CENTEC**	**Congress Dinner**
Holiday Inn Lisboa Hotel Av. Antonio Jose de Almeida, 28-A 1000-044 Lisboa Tel: +351 21 004 4000 Web: http://www.holiday-inn.com/lisbonprt	Centre for Marine Technology and Ocean Engineering Instituto Superior Técnico Avenida Rovisco Pais Lisboa 1049 – 001 Tel: +351 218 417 468	**Casino Estoril** Av. Dr. Stanley Ho Edifício do Casino Estoril 2765-190 Estoril **Telefone:** 214 667 700 **Email:** Info.cestoril@estoril-sol.com
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PLAN OF THE ROOMS

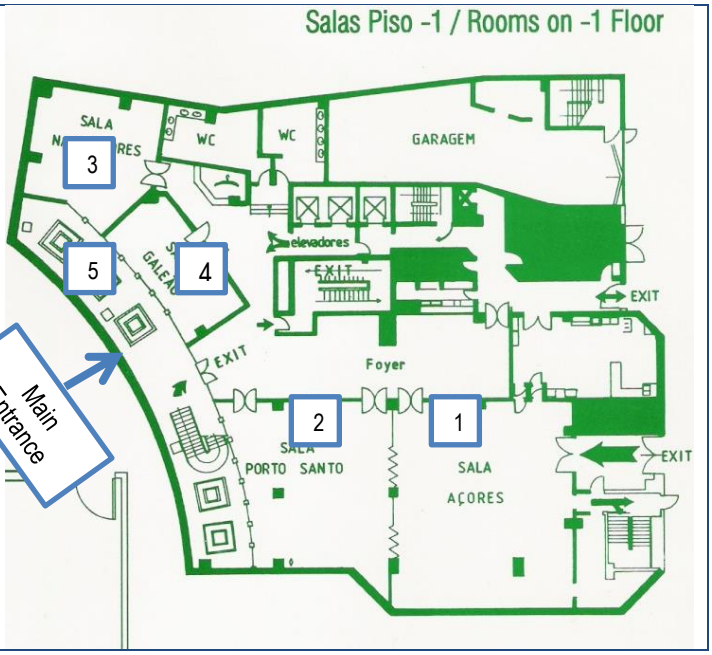
1 – Room Açores

2 – Room Porto Santo

3 – Room Navegadores

4 – Room Galeão

5 - Secretariat



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Shipbuilding: From traditional naval construction to offshore wind

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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 minority, 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

Figure 1. Cumulative installations of offshore wind energy in Europe (MW) (European Wind Energy Association (EWEA) 2013).

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.

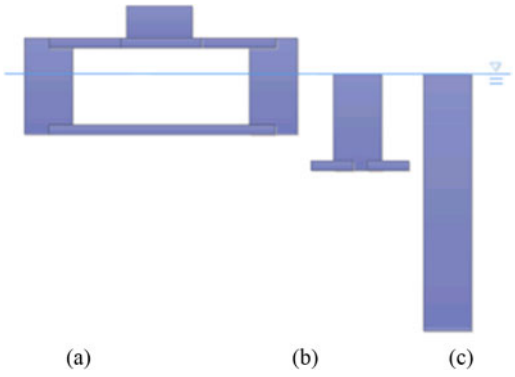

Figure 2. Floating offshore wind platforms: (a) semisubmersible, (b) TLP and (c) spar (Castro-Santos and Diaz-Casas 2014).

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

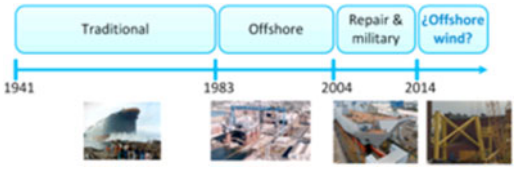

Figure 3. Evolution of ASTANO shipyard.

Figure 4. Facilities of ASTANO shipyard. 1. Prefabrication area 2, 2. Building slip 2, 3. Modules workshop, 4. Prefabrication and assembly area Z1, 5. Prefabrication and assembly area Z2, 6. Flat blocks workshop, 7. Curved Blocks workshop (1), 8. Curved Blocks workshop (2), 9 Building slip l, 10. Prefabrication area l, 11. Prefabrication area 3. (Fundación Ferrol Metrópoli et al, 2009).

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 1. Options considered for manufacturing, assembly and erection of offshore wind substructures.

Option (t/year)	Manufacturing/ Prefabrication/ Assembly (m^2) Indoor	Outdoor	Erection – Building berth	Total (m^2)
10,000	14,300	40,600	2	54,900
20,000	62,100	72,310	1 and 2	134,410

Figure 5. Construction step.

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.

Weight (t)	<40	40–180	180–750	750–3,000
Road or railway	X			
Port cranes	X	X		
Gantry cranes	X	X	X	
Load-out (Roll on system and special mobile cranes)			X	X

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

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

Concept	Dock 2	Dock 4	Dock 10
Minimum draft (m)	5.5	7.5	7
Maximum draft (m)	9.8	11.8	11.13
Tidal path (m)	4.3	4.3	4.13
Cranes (t)	1 × 25	1 × 25	1 × 100 1 × 80

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.

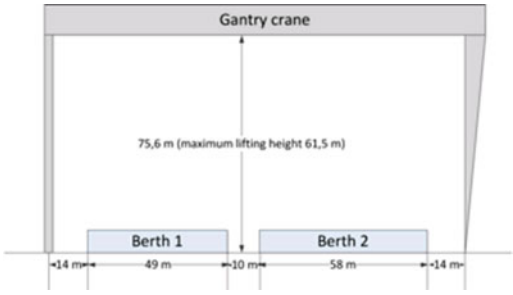

Figure 7. Main dimensions of gantry crane.

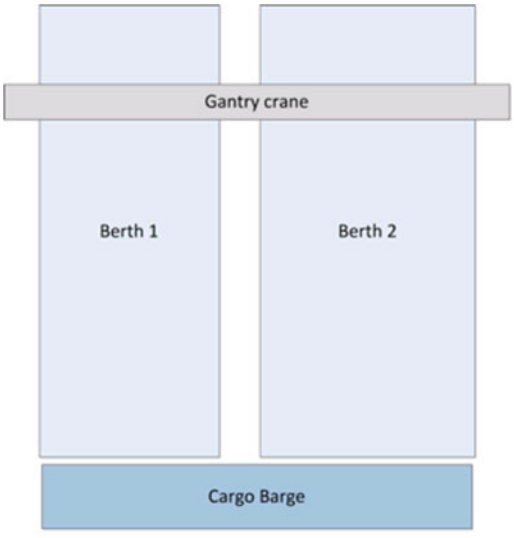

Figure 8. Schematic position of the cargo barge considering the load-out up to 750 t.

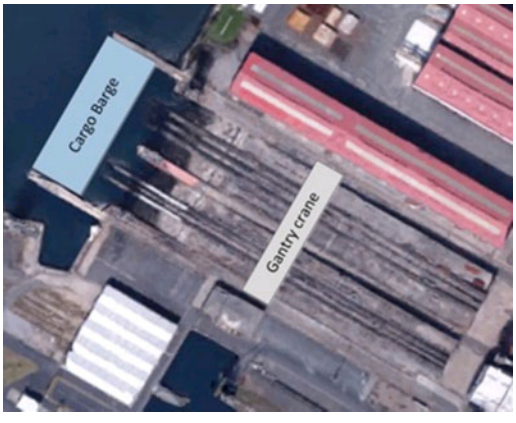

Figure 9. Real position of the cargo barge considering the load-out up to 750 t.

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

Ashuri, T., Zaaijer, M.B., Martins, J.R.R. a., van Bussel, G.J.W., and van Kuik, G. a. M., 2014. Multidisciplinary design optimization of offshore wind turbines for minimum levelized cost of energy. *Renewable Energy*, 68, 893–905.

Bussel, G. Van and Henderson, A., 2001. State of the art and technology trends for offshore wind energy: operation and maintenance issues. *In*: *OWEC 2001*. 1–4.

Castro-Santos, L. and Diaz-Casas, V., 2014. Life-cycle cost analysis of floating offshore wind farms. *Renewable Energy*, 66, 41–48.

Collu, M., Kolios, A.J., Chabardehi, A., and Brennan, F., 2010. A comparison between the preliminary design studies of a fixed and a floating support structure for a 5 MW offshore wind turbine in the North Sea. *In*: *Marine Renewable and Offshore Wind Energy*. London, UK, 63–74.

ECN, MARIN, Windmaster, L. the, TNO, TUD, and MSC, 2002. *Study to feasibility of boundary conditions for floating offshore wind turbines*. Delft.

European Wind Energy Association (EWEA), 2013. *Deep water. The next step for offshore wind energy*.

Fornahl, D., 2011. From the Old Path of Shipbuilding onto the New Path of Offshore Wind Energy? The Case of Northern Germany. *In*: *Innovation, strategy and structure – Organizations, institutions, systems and regions*. 835–855.

Global Wind Energy Council (GWEC), 2014. *Global Wind Report*.

Greenacre, P., Gross, R., and Heptonstall, P., 2010. *Great expectations: The cost of offshore wind in UK waters – understanding the past and projecting the future*.

Guedes Soares, C., Bhattacharjee, J., and Karmakar, D., 2014. Overview and prospects for development of wave and offshore wind energy. *Brodogradnja*, 65 (2), 87–109.

INCITEFO, Fundación Ferrol Metrópoli, Ministerio de Industria Turismo y Comercio, IGAPE, and Colegio Oficial de Ingenieros Navales de España, 2009. *Estudio de reutilización global de instalaciones de Navantia Fene para promover la creación de empleo sostenible, en base a la complementariedad de las instalaciones existentes. Plan de usos de instalaciones de baja actividad en la Ría de Ferrol – 1ª part*.

Jonkman, J. and Buhl, M.L., 2007. Development and Verification of a Fully Coupled Simulator for Offshore Wind Turbines Preprint. *In*: *45th AIAA Aerospace Sciences Meeting and Exhibit, Wind Energy Symposium*. Reno, Nevada.

Jonkman, J., Butterfield, S., Musial, W., and Scott, G., 2009. *Definition of a 5-MW Reference Wind Turbine for Offshore System Development*.

Jonkman, J. and Matha, D., 2010. *A quantitative comparison of the responses of three floating platforms*. Proceedings of the European Offshore Wind 2009 Conference and Exhibition. Stockholm (Sweden): National Renewable Energy Laboratory (NREL).

Stopford, M., 2009. *Maritime economics*. Routledge.

Organisation for Economic Co-operation and Development, 2015. *Shipbuilding and the offshore industry*.

Sclavounos, P.D., Lee, S., and DiPietro, J., 2010. Floating Offshore Wind Turbines: tension leg platform and taught leg buoy concepts suppoting 3 – 5 MW wind turbines. *In*: *Proceedings of the European Wind Energy Conference (EWEC) 2010*. Warsaw, Poland.