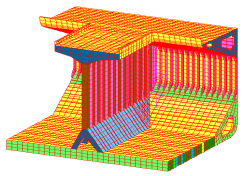
MARSTRUCT



Network of Excellence on Marine Structures

Project No.:	**FP6-PLT-506141**
Contract No.:	**TNE3-CT-2003-506141**

Document Name:	**MARSTRUCT Newsletter April 2008**
Document Status:	~~Confidential~~ / ~~Restricted~~ / **Public**
Document Identification Code:	
Document Date:	**21st April 2008**

Distribution List (*please tick where appropriate*):

European Commission	✓	Network Steering Committee	✓
WP Participants	✓	Task Participants	✓
All Network Participants	✓		

Document Status

Authors

Name	*Company*
Prof. P. K. Das	Universities of Glasgow & Strathclyde (UGS)

Reviewing/Approval of report

Name	*Company*	*Signature*	*Date*
Prof. P. K. Das	UGS		21st April 2008
		Approved	

Document History

Revision	*Date*	*Company*	*Initials*	*Revised pages*	*Short description of changes*

MARSTRUCT
Network of Excellence on Marine Structures

NEWSLETTER April 2008

Issue 4

MARSTRUCT Mission Statement

To improve the safety, effectiveness, reliability, environmental behaviour and comfort of ship structures through the application of advanced structural and reliability assessment within design, fabrication and operation, leading to increased public and commercial confidence in the competitiveness and use of waterborne transportation.

Introducing MARSTRUCT Network of Excellence in Marine Structures

As part of the 6th Framework Programme of Priority of the European Commission the MARSTRUCT Network of Excellence in Marine Structures Project started with the participation of 16 European Academic Institutions and 17 Industry and Research Organizations. Frame Programme 6 (FP6) is the frame for the EU activities in the field of science, research and innovation. With a budget of 17.5 billion euros for the years 2002 - 2006 it represents about 4 to 5 percent of the overall expenditure on Research and Technical Development in EU Member States. The main objective of FP6 is to contribute to the creation of the European Research Area (ERA) by improving integration and coordination of research in Europe which is so far largely fragmented. At the same time research will be targeted at strengthening the competitiveness of the European economy, solving major societal questions and supporting the formulation and implementation of other EU policies.

Aims and Objectives of MARSTRUCT

The overall objective of the Network, which has a duration of 5 years, is to improve the safety, effectiveness, reliability, environmental behaviour and comfort of ship structures through the application of advanced structural and reliability assessment within design, fabrication and operation, leading to increased public and commercial confidence in the competitiveness and the use of waterborne transportation.

This objective will be achieved by strengthening the European competitiveness aiming at a permanent organisation of the type of a virtual institute, which will ensure the integration of the various European groups in a European Centre of Competence for structural analysis of ships with improved safety environmental behaviour and comfort.

The objective will be achieved through a programme for jointly executed research in the area of structural analysis of ships, the creation of research facilities and platforms and a continuous programme of dissemination and communication of research results. The way in which the programme is designed contributes to the mutual specialisation and complementarily through building up of strengths and the shrinking of weaknesses of the participants. This programme will strengthen the scientific and technological excellence of the European Research Area by integrating at a European Level a critical mass of resources and expertise that will be able to provide European leadership in the design of efficient and safe ship structures.

The activities of the Network will cover the different areas related with advanced structural analysis such as:

- Specification of the loading appropriate for the various modes of structural response and strength.
- Methods and tools for the analysis both numerically and experimentally of the structural strength and performance, including aspects such as ultimate strength, fatigue, crashworthiness, fire and explosion, resistance, and noise and vibration.
- Influence of fabrication methods and new and advanced materials on the structural strength and performance of ships.
- Tools for design and optimisation of ship structures.
- Tools and methods of structural reliability, safety and environmental protection of ships.

The various assessment methods will be incorporated in the methods to design and optimise efficient ship structures as well as in the methods of structural

reliability to be used to ensure the safety and environmental behaviour of the ships.

The progress towards the overall objective will be managed by setting measurable intermediate objectives, such as:

• To document current practices and trends. Measurable by: Publication of state-of-the-art surveys and expert predictions; provision of a database to back up needs of Structural Reliability Analysis (including data on distribution shapes and cut-offs, assessment of quality and limitations of data, materials information, load states.

• To establish guidelines to best practices and generate case studies and benchmark test results wherever possible, after identification. Measurable by: Drafting best practice guidelines and standards proposals. Publish results of case studies and benchmark tests.

• To identify the research required by European universities and research institutes, in conjunction with industry. Measurable by: Results of survey of academic and industrial organisations in the marine field, with monitoring of progress by the Network in meeting those needs.

• To provide a forum where specific research and development issues can be discussed, including Modelling Process. Measurable by: Establishment of active network with opportunities for personal contacts, and associated online and paper publications, courses, workshops, seminars and conferences (including virtual conferencing), and provision of internal documents on methodologies and data.

• To ensure that reports of research projects are disseminated to industrial partners and policy-makers, and help industry to use these results in their design process. Measurable by: Publication and promotion to all involved in the industry, with guidance workshops provided to professional practitioners.

• The improvement in the advanced analysis and reliability techniques derived through the Network will be measurable by: Provision of reliability methodologies to the industry throughout Europe. Acknowledging that the provision of software tools is less likely to be practicable for many smaller companies, due to purchase and support costs, the network will aim to provide a methodology, with worked examples and comparisons from which designers can write their own computer code.

• To promote better understanding of industry's requirements in the application of reliability analysis techniques, incorporating advanced structural analysis. Measurable by: Networking activities to ensure industry has the opportunity to let researchers know their requirement.

• To enable a common basis for contracting within membership. Measurable by: Establishment of a common simplified form of contract agreed by members.

• To work in a cohesive manner within Europe. Measurable by: range and number of joint projects, reports and publications, the establishment of e-working and long-term virtual links.

The website of the project providing additional detailed information on the MARSTRUCT Network and its 6 Individual Work Packages, the participating members, published documents and scheduled meetings can be found at:
http://mar.ist.utl.pt/marstruct/index.aspx

Who's Who in MARSTRUCT

Network Coordinator: Carlos Guedes Soares (CGS)

Assistant Coordinator: Purnendu K. Das (PKD)

Work package Leaders:

WP1 Methods and Tools for Loads and Load Effects

Responsible:

Danish Technical University, Jórgen Juncher Jensen (JJJ)
Newcastle University, Jonathan Downes (JD)

WP2 Methods and Tools for Strength Assessment

Responsible:

Instituto Superior Técnico, José Gordo (JG)
University of Glasgow & Strathclyde, Atilla Incecik (AI)
Helsinki University of Technology, Petri Varsta (PV)

WP3 Experimental Analysis of Structures

Responsible:

TNO Centre for Maritime Constructions, S. Gielen (SG)
Hamburg University of Technology, Wolfgang Fricke (WF)

WP4 Materials and Fabrication of Structures:

Responsible:

Technical Univ. Szczecin, T. Jastrzebski (TJ)
Det Norske Veritas, Brian Hayman (BH)

WP5 Methods and Tools for Structural Design and Optimisation

Responsible:

Principia Marine, Nicolas Besnard (NB)
Cetena, Matteo Codda (MC)

WP6 Structural Reliability, Safety and Environmental Protection:

Responsible:

Universities of Glasgow & Strathclyde, P.K. Das (PKD)
Instituto Superior Técnico, Yordan Garbatov (YG)

WP7 Management, Integration, Dissemination and Exploitation

Responsible:

Instituto Superior Técnico M Ventura (MV)
Universities of Glasgow & Strathclyde, P.K. Das (PKD)

MARSTRUCT Participants

Instituto Superior Técnico, Portugal (IST)

Universities of Glasgow and Strathclyde, United Kingdom (UGS)

University of Liége, Belgium (ANAST)

Technical University of Varna, Bulgaria (TUV)

Technical University of Denmark, Denmark (DTU)

Helsinki University of Technology, Finland (HUT)

VTT Industrial Systems, Finland (VTT)

Kvaerner Masa-Yards, Finland (KMY)

Bureau Veritas, France (BV)

Principia Marine, France (PMA)

SIREHNA, France (SIR)

Germanischer Lloyd, Germany (GL)

Hamburg University of Technology, Germany (TUHH)

Flensburger Schiffbau Gesellschaft mbH & Co KG, Germany (FSG)

Center of Maritime Technologies e.V., Germany (CMT)

National Technical University of Athens, Greece (NTUA)

Centro Tecnico Navale, Italy (CET)

Università di Genova, Italy (DINAV)

Netherlands Institute for Applied Scientific Research, Netherlands (TNO)

Schelde Naval Shipbuilding, Netherlands (RS)

Norwegian University of Science and Technology, Norway (NTNU)

Det Norske Veritas, Norway (DNV)

Technical University of Szczecin, Poland (TUS)

Ship Design and Research Centre, Centrum Techniki Okretowej CTO, Poland (CTO)

Lisnave Estaleiros Navais SA, Portugal

Estaleiros Navais de Viana do Castelo, Portugal (LSN)

University "Dunarea de Jos" of Galati, Romania (UGAL)

IZAR Construcciones Navales S.A., Spain (IZAR)

Chalmers University of Technology, Sweden (CTH)

Technical University of Istanbul, Turkey (TUI)

Newcastle University (UNEW)

University of Southampton, United Kingdom (UoS)

The Welding Institute, United Kingdom (TWI)

MARSTRUCT MEETING

MARSTRUCT Sessions Meeting held in Varna, 2 – 9th September 2007

Fifth MARSTRUCT Meeting

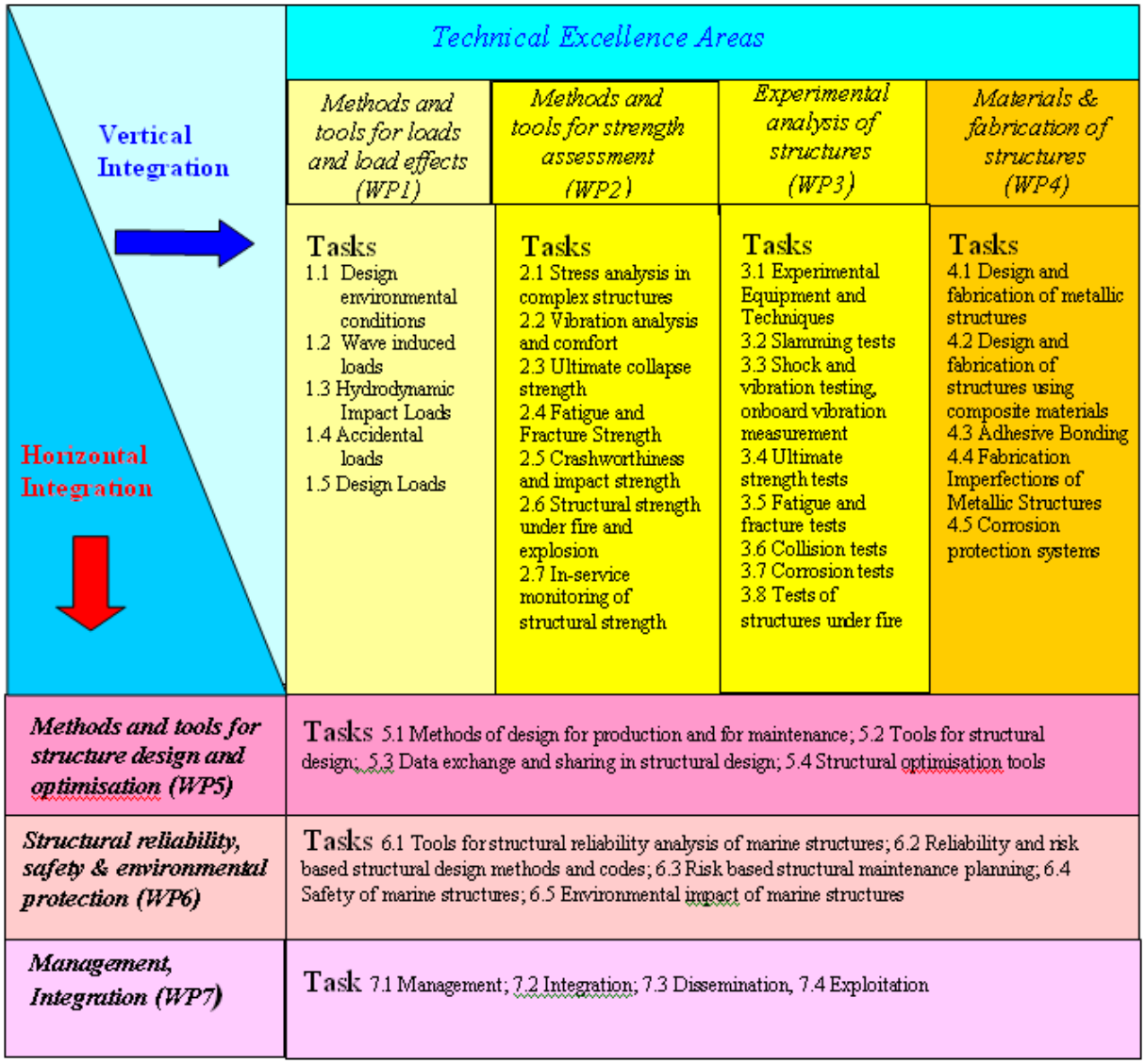
The fifth general MARSTRUCT meeting was held in Istanbul on 27 - 29th November 2006. The progresses in the different work-packages were discussed followed by queries and suggestions from the delegates. To draw the future plans every work packages and subtasks were given separate platform and time.

Sixth MARSTRUCT Meeting

The sixth general MARSTRUCT meeting was held in Varna on 2 - 9th September 2007. The chairman, co-chairman and WP leaders discussed various aspect of collaboration by the different work-packages and use each other's work to maximise the output. The progress and delivered reports were presented followed by queries and suggestion from the panel members.

Several research studies done under MARSTRUCT were presented in the International Conference on Advancements in Marine Structures (MARSTRUCT Conference), 12 – 14th March 2007, Glasgow, UK and also in the International Congress of Maritime Association of the Mediterranean Conference (IMAM), 2 - 9th September 2007, Varna and were well responded by queries and suggestions by the delegates present in the conference.

Overview of MARSTRUCT Work packages



Industrial Advisory Committee

An Industrial Advisory Committee (IAC) has been formed and it is fully operational. The IAC consists of six members and will be the standing group for the full term of the MARSTRUCT Network of Excellence.

Chairman:

Rob van der Graaf
Schelde Naval Shipbuilding

Members:

Sergio Fonseca
Estaleiros Navais de Viana do Castelo

Berend Bohlmann
Flensburger Schiffbau Gesellschaft

Avelino Martinez Cimadevila
Navantia S.A.

Mrs. Mervi Pitkänen
Aker FinnYards

Antonio Correia Rodrigues
Lisnave Estaleiros Navais SA.

Contact details of the IAC Chairman:

Rob van der Graaf
SCHELDE NAVAL SHIPBUILDING B.V.
Glacisstraat 165, P.O. Box 555
4380 AN Vlissingen, NETHERLANDS

Tel.: +31 118 482881
Fax: +31 118 482447
E-mail: rob.vdgraaf@schelde.com

Liaison with other Organisations

The Steering Committee has decided that the exchange information and generally interface with industry is of the utmost importance for the Network of Excellence, and should be one of its main objectives.

Contacts are to be made with various organisations such as EMSA, COREDES, and ACMARE - Technology Platform.

Training Activities

GL and TUHH organized a course on 'Local Approaches for Fatigue Assessment of Marine Structures' on 21st – 22nd January 2008 with approximately 50 attendees. The partners are involved in the development of the IIW Guideline on Notch Stress Analysis.

A course on 'Risk Analysis and Structural Reliability' was organized on 26 – 28th November 2007 in Paris, France, with 18 participants.

DTU in Copenhagen organized and hosted a summer school on the subject of 'Wave Loads on Ships' on 27 – 29th August 2007, under WP1, with several participants.

Integration / Exchange of Researchers

Short visits and exchange of researchers within MARSTRUCT can be done through the system on the official website.

Christian Berggreen (DTU) visited DNV for preparation of a joint paper and supervision of joint project students for 8 days (17 – 24th April 2007).

NTUA staffs (total of 3) visited DTU to take part in experimental plate testing for 5 days (21 – 25th May 2007).

Christian Berggreen (DTU) visited UoS for discussions concerning Task 4.3 for 3 days (31st Oct. – 2nd Nov. 2007)

Work package 1
Methods and tools for loads and load effects

The overall objectives of the WP1 are: to improve knowledge of environmental conditions encountered by vessels, to investigate and correlate load prediction methods for wave induced loads including non-linear and hydro-elastic effects, to investigate and correlate load prediction methods for slamming and green water impact loads, to increase the understanding of collision scenarios, and to investigate load prediction methods for design purposes including uncertainty in loading.

Development of realistic operational profiles and loading environments for Merchant Vessels

UNEW has undertaken the development of operational profiles of a containership and an oil tanker across the North Atlantic. This has lead to the estimation of global wave loads on a containership and oil tanker with/without operational restrictions and with/without weather routing. Within this work, this has also entailed the estimation of calm water resistances of merchant ships, Route selection for a containership and an oil tanker across the North Atlantic and the development of wave scatter diagrams for the selected routes.

DTU have considered general data for the North Atlantic. The analysis of almost 25000 observation of the wave height from ships in the North Atlantic shows that the encountered wave height distribution is significantly lower than the distribution provided by the classification societies for structural assessment. The joint probability distribution for the significant wave height, the relative speed, and the ship heading relative to the wave direction has been determined. The project is being extended with data obtained in 2007 from onboard ship measurements.

Estimation of sea state parameters from ship response measurements

The visit by DTU staff at DNV in Norway (July 2007) focused, in particular, on numerical generation of motion data. Different sets of RAOs were generated by Wasim (3-D panel code), and the influence of filtering due to the relative high inertia of a ship was later investigated. The objective was to see if estimations were improved by taking into account high-frequency sensitive responses such as relative motion. Some of the findings are reported in Conference proceedings.

Another study has tried to look into the possibility to predict about uncertainties in sea state estimations by the wave buoy analogy. In the study, the probabilistic software tool Proban has been linked into the estimation methodology based on the so-called parametric method.

Long-term distribution of Sea States

Based on recently available sea state data from satellite and numerical models, DTU is developing new probabilistic models for joint long term distributions and for prediction of extreme values to be used in design.

Dynamic Stability of Ships

Parametric roll occurrence and extreme roll angles are being investigated for the fine form ships. Surge motion coupled with roll in a stochastic model has been investigated and published. Longitudinal hydrodynamic force, representing added resistance in the model, has been compared to predictions by DNV and the full scale measurements for the similar ship are made available for the study.

Comparison of theoretical slamming models with model test results

The vertical and horizontal impact forces, due to symmetric and asymmetric impact of the bow section have been calculated lead by UoS and undertaken by a number of partners, and the findings are reported in MARSTRUCT document.

UGS focused on the issue of breaking waves. Breaking waves generated in the tank have been modelled using both CFD and a simplified model based on linear random wave theory with various non-linear corrections. Work is continuing in understanding the occurrence of these differences in the applicability of the simplified theory occur.

Prediction of green water loads

Work on breakwaters, carried out at UGS, was complimented by the FPSO research of the EU project SAFEFLOW together with research at IST and contributions from UNEW and DTU.

More validation data collected with reference to whaleback forecastle configuration and the porosity effect on breakwater design in relation to green water loading was investigated.

Prediction of sloshing loads

Three test cases with available experimental data (sloshing cases in a rolling tank with different tank fillings and different periods of roll) have been selected with other partners among a series which have been made available by ETSIN (University of Madrid, external contributor). In particular, two of the test cases present significant sloshing phenomena since they are in correspondence to resonant period for two different tank fillings, while the third is of interest because a beating phenomenon was recorded.

Calculations have been performed by participating partners using different codes:
DINAV with SPH (own-developed) and RANSE (commercial), PMA and BV with different RANSE methods (commercial), UoS with own developed RANSE method.

Preliminary results are reported, for comparisons between numerical and experimental sloshing pressures in partially filled tanks, in the deliverable document.

Wave Loading in Extreme Conditions including in damaged vessels

Some work has been developed where massive computations of wave loads performed by DINAV in cooperation with CETENA for ships in damaged conditions. The benchmark test, that has been proposed by DINAV and to which other partners have adhered, was designed in order to have a comparison with other computational procedures on various symmetric and asymmetric damage conditions. Activities performed were disseminated via a MARSTRUCT publication.

Work package 2
Methods and tools for Strength Assessment

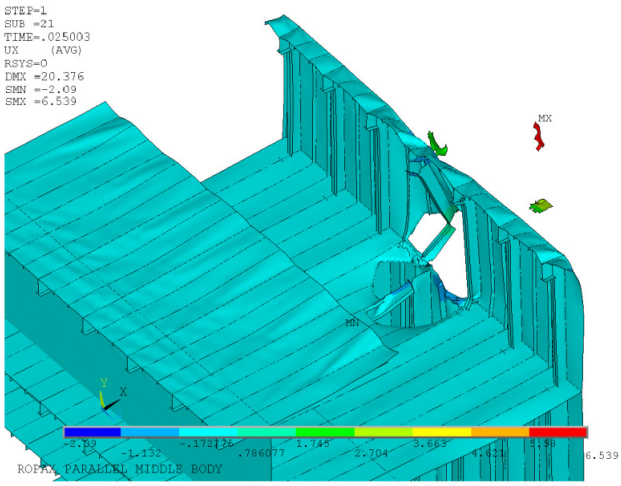
WP 2 discusses on Methods and Tools for Strength Assessment, in which the ongoing works are: stress analysis of complex structures, vibration and comfort assessment, ultimate strength, fatigue and fracture strength, crashworthiness and impact strength, structural strength under fire and explosion, in-service monitoring of structural strength.

Crashworthiness and Impact Strength

The necking behaviour of tensile specimens was studied with experiments and finite element method using shell elements. A series of tensile tests with full field strain measurements have been carried out to show the significance of the necking phenomena, respectively the failure behaviour. The usage of optical strain measuring system entails very satisfactory information of the whole testing process, respectively the deformation distribution. The precise determination of material characteristics improves the simulation accuracy and serves as a basis for metal deformation analysis. In addition, it was studied how the through thickness constraints can be replaced by increasing the in-plane resistance of the finite elements by stiffening the true stress-strain curve in post necking range. Findings of the study were reported in the MARSTRUCT Conference.

Structural Strength under Fire and Explosion

Activities carried out so far include successful modelling and characterisation of blast waves with CFD code; identification of failure modes with explicit FE code; reliability study of a blast-loaded stiffened panel; sensitivity analysis of blast loaded stiffened panels; damage assessment of ROPAX vessel from a VBIED; estimation of probability of yield-based failure that given charge weight and standoff distance; and current studies on an alternative, cost-effective geometry that will mitigate the blast effects. Findings of the study were reported in conference proceedings.



ROPAX Parallel Middle Body (FE model)

Work package 3
Experimental Analysis

WP3 deals exclusively with experimental analyses. Experimental work reviewed and performed in different tasks of the work package shall support the theoretical investigations in the other work packages. Furthermore, the techniques and procedures applied in experimental work are to be reviewed, shared within the network and improved by relevant guidelines.

Fatigue and Fracture Tests

A preliminary test was conducted in order to check the fatigue behaviour of doubler plates on plate strips with different weld throat thickness. For a relatively small weld, the primary crack occurred at the weld

toe as desired. The fabrication of the specimens for a total of four test series was started.

Collapse and fatigue tests on butt joints between bulb plate stiffeners were performed, which are or which are not partly reinforced by additional plates on top of the bulb (1+1 collapse test and 3+3 fatigue tests on specimens with 4 stiffeners joints each). The aim was to clarify the relevant structural hot-spot stress in case of relatively thick components, where stress extrapolation is difficult to be defined and the geometry is rather complex. Description of tests is reported in MARSTRUCT document.

Collision and Impact Tests

Within the framework of the EU-project CREATING, drop tests have been carried out on multi material panels. Moreover some theoretical investigation has been carried out into the effectiveness of a fracture criterion.

The drop test results showed that the specific energy absorbing capacity of steel can be increased by distributing the steel in several plies rather than just one solid panel. An increase of about 30% was found experimentally. Unfortunately this value is way below the factor 2.0, which was derived from theoretical considerations. Since the gain is too low it has been decided not to further pursue this idea.

Work package 4
Materials and Fabrication of Structures

This work-package discusses about "Material and Fabrications of Structures". The main tasks of the work-package are: Design and fabrication of metallic structures, Fabrication Imperfections of Metallic Structures, Design and fabrication of structures using composite materials, Adhesive bonding, and Corrosion protection systems

Design and fabrication of metallic structures

A MARSTRUCT document has been prepared on the 'Review of manufacturing technologies for metallic structures and problems related to introduction of innovative structural components'.

Work on the welding optimization of stainless steel AISI 316L plates has been performed, whereas at the same time work has started on the dissimilar welding of stainless steel AISI 316L plates with plates made of ordinary and high strength shipbuilding steel. Also relevant literature is being collected and studied. Similar work has also been performed on the welding of marine aluminium alloys. Conference papers have been contributed related to these works.

Fabrication imperfections of Metallic Structures

The main aim of this task is to identify the methods and tools for shrinkage and distortion prediction and their management in shipyard fabrication processes taking into consideration new manufacturing techniques for recommendations in shipbuilding practice.

A proposal on the 'study on distortion and residual stress prediction' is proposed by NTUA. To make progress in that field a benchmark study was also proposed. The benchmark will contain two parts: welding tests and numerical simulations (FEM). Revised version of the benchmark study as '*Proposal for a benchmark study on distortion and residual stress prediction'* has also been proposed.

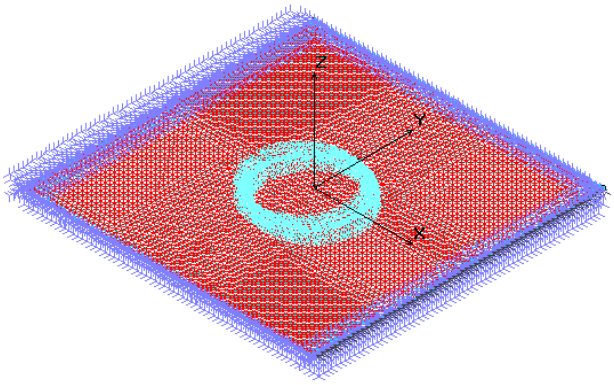
Design and fabrication of structures using composite materials

The main aim of this task is to investigate alternative methodologies, including probabilistic approaches, for predicting the strength of composite hull structures and for optimisation of such hulls, investigating both local and global strength and considering the effects of residual stresses, initial distortions, production defects and thickness variations.

The subtask '*Longitudinal strength of composite ship hulls*' aims to investigate various factors that affect the longitudinal strength performance of composite hulls, including residual stresses, initial distortions, defects and thickness variations. Methodologies will be proposed for predicting longitudinal strength by means of theoretical analysis, involving both simplified and more complex methods. The work also includes consideration of structural optimisation procedures.

For *Global Modelling* part, UNEW will investigate the collapse strength of a GRP hull section model for which experimental data is available for comparative purposes. Both FE and simplified modelling will be performed. UGAL has done work on preparation of a GRP model of a steel container vessel hull. This will be used to validate a thin-walled beam modelling method for such hulls under bending and torsion. The cross-section is partly closed and partly open. The shell and bulkheads are modelled. Stiffeners are not included directly in the physical model and are smeared in the analysis. The laminate layup is symmetric using balanced woven roving.

In the *Buckling of composite plates and columns in compression: Testing and analyses* part, panels have been manufactured and material testing has been carried out. Buckling tests on panels with geometrical imperfections have been carried out. Additionally, a FEA based progressive failure model has been developed and connected benchmark study carried out against the experimental results. Finally, a round-robin study has been carried out, determining mechanical properties of the applied materials in the panel specimens. A parametric study is planned to be carried out once the basic modelling approach using a progressive failure model has been validated against the panel tests. Also FEM study of plates with delaminations and geometric imperfections is going on.



FEM model of the delaminated plate

Studies on the buckling of slender composite plates are also going on and a completed work entitled "Compression Failure Analysis Application to Composite Yacht Masts" involved the experimental analysis of the influence of drilled holes on the critical buckling capacity of slender composite plates. In addition, delaminations due to impact were investigated and the knockdown effect on critical buckling load was investigated with respect to impact energy.

The subtask entitled '*Optimisation of structural components*' investigates methods to search for the optimal design using appropriate techniques for optimising stiffened and unstiffened single-skin and sandwich panels for ship hulls. Extensive optimisation analyses of a composite marine propeller blade for a large vessel have been carried out. Advanced FEA models has been developed integrating both strip-theory and optimisation methods. The results show that a considerable weight saving can be achieved compared to a similar metal propeller. The efficiency using a deformable composite propeller is noticeable compared to the undeformable metal counterpart. The study will continue aiming at simpler generic structural cases, however investigating and applying more advanced optimisation methods.

In the subtask '*Joints in composite structures*', analyses and tests are being performed on selected joints in composite structures with a view to establishing criteria that will ensure sufficient initial strength and also damage tolerance in the presence of production defects and in-service damage. An extensive test series on two types of sandwich X-joints in pure compression has carried out. The test results have been compared with numerical analysis using a standard foam model. Dynamic tests on T-joints and validated a newly developed 3D material model for closed cell foams used in the core of the sandwich have already been carried out. It is planned to model the tests in compression and tension using the newly developed material model. The numerical results will be compared with the test results.

In the subtask *'Damage tolerance of curved composite beams and panels'*, the effects of damage on curved composite beams and panels are being investigated using state of the art methods that involve the use of fracture mechanics. Application of the existing design and evaluation tools has until now been mainly confined to components without initial curvature. Curved sandwich plates exposed to in-plane compression with and without artificially implanted debonds have already been tested in a newly developed test rig for curved panels. All specimens have been manufactured. Further, numerical models have been developed exploiting sub-modelling techniques in order to include fracture mechanical routines to determine debond propagation and ultimate failure. The developed models have both been compared against existing experimental data for beams and the curved plate tests. The work is being monitored in order to implement the results in damage tolerance and production control procedures for naval ships.

The findings from these subtasks were contributed to journals and several conference proceedings.

Adhesive Bonding

The subtask '*Guidance for design and fabrication of adhesive joints in ship structures'* aims to provide an assessment of existing guidelines, and if necessary provide improved guidelines, for the modelling, design and production of single and/or double lap shear bonded joints relevant to ships. Specialised Digital Image Correlation (DIC) measurements on composite-composite and metal-composite joints are planned together with extensive numerical FEA modelling using various fracture analysis tools.

The aim of subtask *'Long-term performance of adhesive joints in ship environment'* is to do long-term testing based on the test programme developed and contribute to guidelines for long-term durability testing and for assessment of the degradation of adhesively bonded steel and composite joints. The durability test programme, which includes the fabrications of SLS steel/composite bonded specimens for accelerated environmental exposures, is under process. Additionally, long-term immersion testing in laboratory ambient conditions is progressing smoothly.

Work package 5
Methods and tools for Structural Design and Optimization

WP5 aims to find out the various optimisation techniques that can be used to improve the design process within the shipyard design offices. The main tasks of the work package are: Methods of design for production and for maintenance, Tools for structural design, Data exchange and sharing in structural design, Structural Optimisation Tools.

Methods of Design for Production and Maintenance

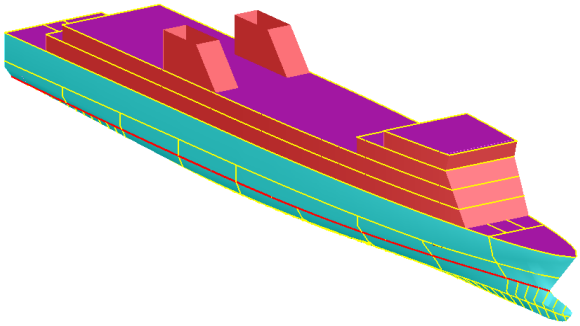
This task aims to set up innovative methods in order to improve the production and maintenance capabilities.

The subtask titled *'Guidelines, benchmarking'* concentrates on: identification of common test cases for benchmark activity; setup of a complete guideline concerning the implementation of design criteria for optimization of several types of ships. CETENA and ANAST issued a proposal for the simulation benchmark. The main issues are related to: the investigation of unitary times and budgets related to individual operations; the definition of simulation strategy and the selection of parameters to be compared; the up-date of the simulated structure following the agreement between CET and ANAST. ANAST completed the model of the workshop using em-Plant and CETENA started to model the workshop using ARENA system.

Tools for structural design

This task aims to identify simplified tools suitable for structural design at the early design stage and innovative tools suitable to support the designer in the detailed structural design phase.

The subtask *'Benchmarking'* deals with the definition of a benchmark on preliminary structural design tools and methods. A global optimisation study was specified by SIREHNA and PRINCIPIA including the implementation of several tools. The study consists in optimizing the global dimensions of a fast ferry with least structural weight and least hull resistance objectives, keeping the specified minimum garage capacity.



AVPRO model of the test case (fast ferry)

Three tools are implemented: AVPRO (an initial ship design tool developed by PRINCIPIA, based on a 3D model), LBR5 (a tool for the structural optimisation of ships) and ModeFrontier (the optimisation platform). The benchmark is based on two levels of optimisation: local structural optimisation with LBR5, and global optimisation of the ship dimensions with ModeFrontier, operating AVPRO automatically to generate the ship geometry and compute ship characteristics.

Structural optimisation tools

This task aims to identify various optimisation techniques related to the ship structural design.

The subtask '*Benchmark'* provides guidelines for good practices about the activity performed. It was decided in the WP5 meeting to build guidelines for the implementation of optimisation techniques for ship design, based on the results of the benchmark study performed during the two first periods. First, the work already performed will be valorised, with comprehensive comparisons between the methodologies and tools, and final conclusions on the benchmark study. Secondly, this work will be used to build recommendations to shipyards regarding the implementation of optimisation techniques for this type of study (midship section optimisation), and further on for any kind of design problem.

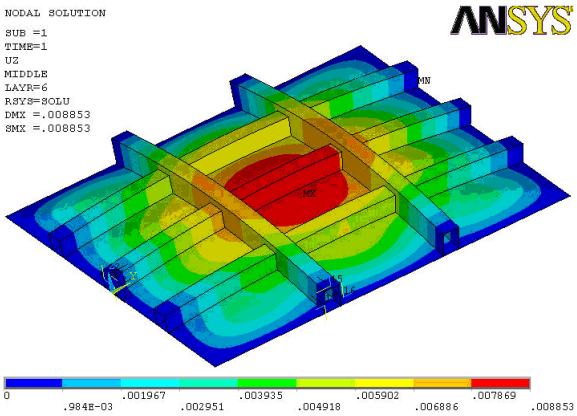
Work package 6
Structural Reliability Safety and Environmental Protection

The WP 6 has been developing different tools and procedures for structural reliability safety and environmental impact of marine structures. The main tasks of the work package are: Tools for structural reliability analysis of marine structures, Reliability and Risk-based structural design methods and codes, Risk-based structural maintenance planning, Safety of marine structures, Environmental impact of marine structures.

Tools for Structural Reliability Analysis of Marine Structures

At UGS, the work on FEM and response surface (RS) based reliability analysis of 2D transverse frame of a ship has been completed. Also, application of the FEA/RSM based reliability analysis methods on large 3D FE model of marine structure i.e. midship hold of a Bulk Carrier including single 3D frame and one complete hold of the vessel, is in progress.

UGS is also interested in the application of deterministic and reliability-based approaches in composite structure design. The deterministic analyses for laminated plates using classical laminated plate theory under transverse load are performed and the corresponding strength limit case is determined. The buckling analyses of laminated plate under uniaxial compression are performed as well.

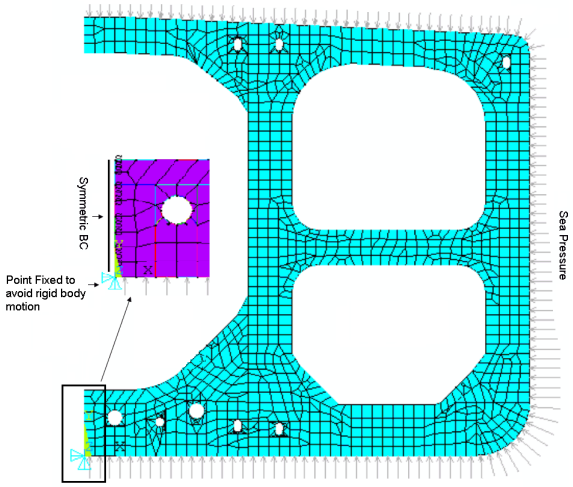


Stiffened Composite Panel (FE model)

The reliability analysis is performed to view the influence of each basic variable to the estimated reliability of laminated plate. General purpose FEA coupled with reliability models for stiffened plates

are used as well. That will interface the results from a FE program with a reliability analysis program through Response Surface Method (RSM). It has been observed that the response surface method can be used efficiently for the reliability analysis of laminated plate structures with reasonable accuracy.

Another study is the ultimate strength evaluation of a typical transverse frame of a Single Skinned Tanker structure using Finite Element nonlinear analysis in ANSYS. In order to simplify the analysis and reduce the computation effort, a 2D finite element model of the transverse frame taking into account the effective width of the attached plating is considered. The results from FE analysis were taken to the in-house computer program for the reliability estimation of this simplified 2D model using the Response Surface Method. Work on full 3D modelling and also the longitudinal strength evaluation of the mid-ship section is in progress.



Transverse frame (Simplified 2D FE Model)

IST has been studying the collapse strength of plates with non-uniform corrosion represented by random fields. The approach suggested to represent non-uniform corrosion was used to simulate inspections on ship plates with random corrosion patterns. This work has investigated how the number of thickness measurements and the location of each measurement influence, both the correct representation of the level of corrosion, and indirectly the correct assessment of the collapse strength of the corroded plates. For this propose, the corrosion patterns were represented by random fields, which were then discretized using the Expansion Optimal Linear Estimation method. This approach was used to simulate the present practice on thickness measurement patterns and to identify what would be the effect of other strategies of measurement patterns for representing the corrosion in terms of prediction of the average reduction of plate thickness. Also, the collapse strength of the plates with non-uniform corrosion was calculated by nonlinear finite element analysis and its correlation with the average reduction of plate thickness obtained from the different measurement patterns was assessed.

Reliability and Risk-based structural design methods and codes

Study on the impact of the new Common Structural Rules, which entered into force April 2006, on the ultimate strength and on the reliability of existing ships redesigned to comply with new IACS requirements has been done. First a program was developed to calculate the vertical ultimate bending moment using progressive collapse method and applying the formulas presented in the new IACS (CSR) rules. The program was used to calculate the ultimate strength of three tankers and two bulk carriers of different sizes based on net scantling, net scantlings with 50% and 100% corrosion addition. A reliability analysis of the two bulk carrier designs was carried out using a first order reliability method. The evaluation of the wave induced load effects that occur during long-term operation of the ship in the seaway was carried out and the stochastic model of the still water induced loads was defined based on information of vertical bending moment given in the loading manual.

Risk based structural maintenance planning

The tasks, which have been active, are: Probabilistic modelling of detection, Probabilistic modelling of the ultimate strength based on different deteriorations and Reliability assessment of ship structures based on inspection planning. As a result of these activities various papers have been published and others are submitted for publication in journals, conferences and as a chapter in books.

Safety of Marine Structures

The stochastic characterisation of static loads depending on a stochastic representation of the flood dimensions and locations (the aim is to assess the range of variation of this type of load for flooded ships) has been developed.

In post accidental strength analysis, criteria for selection of methodology, Calculation procedures and damaged strength analysis – methodology have been discussed. Generic methodologies applicable to various ship types and detailed description of chosen methodology have been done. In probability of Failure of a Damaged Vessel, Criteria for selection of methodology, different reliability methodologies, such as FORM (Time invariant), SORM (Time invariant), Monte Carlo (Crude & Variance Reduction), Response Surface, System Based Analysis Procedure have been described. Procedures for the development of Partial Safety Factors have been elaborated.

Environmental impact of marine structures

This task mainly concentrates on creating a methodology for holistically assessing the sustainability of ships. This includes the development of computing models that quantify the sustainability performance (environmental, economic and social performances) of several shipboard systems.

There has been a special emphasis on the social aspects of sustainability, due to their high level of

subjectivity. The participants are working on a model for quantifying social impacts in the most objective way possible. This will lead to establish a connection between the safety and sustainability assessment through the analysis of human factors. The assessment of environmental impacts of ferries for short sea shipping has also been investigated.

As part of this wider study, an evaluation of the operational phase of two Ro-Ro/Pax (SSS) differing in their design has been considered. One vessel is an existing design and the new one has been 'ad hoc' designed to limit pollutants. The geographical areas covered are the metropolitan areas around Genoa and Palermo. The environmental impact is based on the evaluation and analysis of the amount of pollutants produced by auxiliary machinery during harbour stops and the amount of pollutants produced by the combination of propulsion engines and the auxiliaries of a ship during the trip. The proposed design solution was found to have less environmental impact in important issues such as acidification, eutrophication and human toxicity, mainly due to its lower emissions of SOx and NOx; the mooring phase turned out to be an important phase contributing to diminish the environmental load mainly due to use of fuel cells as electric generators.

List of Publications

List of Journal publications acknowledged to MARSTRUCT are as follows:

Nielsen, U.D., (2007c), *Response-based Estimation of Sea State Parameters – Influence of Filtering*, Ocean Engineering, Vol. 34, Issue 13, pp. 1797-1810

Lewis, S.G., Hudson, D.A., Turnock, S.R., Blake, J.I.R. and Shenoi, R.A.S., 2007, *A comparison of experimental measurements of high speed RIB motions with nonlinear strip theory*, Australian Journal of Mechanical Engineering, 4, 165-182.

Varyani, K.S., Hodgson, T. and Pham, X.P., *'Effective and Efficient Breakwater Design for Trading Vessels and FPSO's*', Journal of OMAE, 2008(in press)

Varyani, K.S. Pham, X. *Whaleback Forecastle for Reducing Green water Loading on High Speed Container Vessels*', Journal of Ship and Offshore Structures, 2008 (accepted for publication and is under revision)

Rizzo C.M., Tedeschi R. (2007). Fatigue Strength of a Typical Ship Structural Detail: Tests and Calculation Methods, Fatigue & Fracture of Engineering Materials and Structures Vol. 30, pp. 653–663

Ehlers, S., Broekhuijsen, J., Alsos, H., Biehl, F. and Tabri, K., Simulating the Collision Response of Ship Side Structures; A Failure Criteria Benchmark Study, International Shipbuilding Progress, Special Issue on MARSTRUCT NoE. (accepted for Publication)

Berggreen, C., Branner, K., Jensen, J. F. and Schultz, J. P., Application and Analysis of Load Carrying Sandwich Elements in Large Wind Turbine Blades, *Journal of Sandwich Structures and Materials*, 9(6):525-552, 2007

Shahid, M. & Das P.K., Structural Reliability and Finite Element Methods, *International Shipbuilding Progress*, (*to be published*)

Ok, D., Pu Y. and Incecik, A., (2007), Computation of Ultimate Strength of Locally Corroded Unstiffened Plates under uniaxial Compression', *Journal of Marine Structures,* Vol. 20, pp.100-114

Ok, D., Pu Y. and Incecik, A., (2007), Artificial Neural networks and their application to assessment of ultimate strength of plates with pitting corrosion, *Ocean Engineering*, Vol. 34, 2007, pp. 2222-2230

Garbatov, Y. and Guedes Soares, C., 2008, Corrosion Wastage Modelling of Deteriorated Ship Structures, *International Shipbuilding Progress (to be published)*

Khan I.A., Das P. K., 2008, Random design variables and sensitivity factors applicable to ship structures considering combined bending moments. *Journal of Engineering for the Maritime Environment* (to be published)

Guedes Soares, C., Luís, R., Teixeira, A., Quesnel, T., Nikolov, P., Steen, E., Olaru, V., Khan, I, Toderan, C., Bollero A. and Taczala, M.,. 2008. Parametric Study on the Collapse Strength of Rectangular Plates with Localized Imperfections under In-plane Compression, *Journal of Ship Building Progress* (to be published)

Cabezas-Basurko, O., Mesbahi E. and Moloney, S.R., 2008, Methodology for Sustainability Analysis of Ships, *Journal of Ships and Offshore Structures* (to be published)

List of Some Past & Current EU Projects of Interest

ACMARE (CA) – Coordination action to implement an advisory council for maritime transport research in Europe
http://ec.europa.eu/research/transport/projects/article_4973_en.html

ALERT (CA) – Assessment of Life-Cycle Effects of Repairs on Tankers.
Web: http://alert.ncl.ac.uk

CREATING – Concepts to reduce environmental impact and attain optimal transport performance by inland navigation
Web: www.creating.nu

DEXTREMEL (FP4) – Design for structural safety under extreme loads
http://research.germanlloyd.org/Projects/DEXTREMEL/

DISCO (FP4) – Development of innovative structural concepts for advanced passenger vessels
http://cordis.europa.eu/data/PROJ_FP5/ACTIONeqDndSESSIONeq112242005919ndDOCeq611ndTBLeqEN_PROJ.htm

HULMON+ (FP5) – Intelligent hull monitoring systems for reduced risk of structural failures, spill to the sea, damage to cargo and for improved passenger safety and comfort

INMARE (FP6) – Technologies and methodologies for safe, environmental-friendly and efficient shipping operations of the future
http://www.ist-world.org/ProjectDetails.aspx?ProjectId=1828aa5227184c04875762d0e2818fcd

InterSHIP (IP) – Integrated collaborative design and production of cruise vessels, passenger ships and ropax
Web: www.intership-ip.com

MARNET – The Marnet Network, Proposal for an Inter-Regional Maritime Information Network
Web: https://pronet.wsatkins.co.uk/marnet/

POP&C (STREP) – Pollution prevention and control safe transportation of hazardous goods by tankers
Web: www.pop-c.org

SAFEDOR (IP) – Design, operation and regulation for safety
Web: www.safedor.org

SAFERELNET - Thematic Network on Safety and Reliability of Industrial Products, Systems and Structures
Web: www.mar.ist.utl.pt/saferelnet/

SHIPDISMANTL (STREP) – Cost effective and environmentally sound dismantling of obsolete vessels
Web: www.shipdismantl-project.org:81/

S@S-(FP5) - Safety at Speed

VISIONS (FP6) – Visionary concepts for vessels and floating structures
Web: http://www.maritime-visions.net/

Forthcoming Conferences of Interest

MARSTRUCT Events

MARSTRUCT 2008: Workshop on Corrosion Protection Systems, 14th May 2008, Chalmers, Göteborg
Web: www.mar.ist.utl.pt/marstruct

MARSTRUCT 2009: Short course on 'Risk Analysis and Structural Reliability', 21 – 23rd January 2009, Glasgow, UK
Web: www.mar.ist.utl.pt/marstruct

MARSTRUCT 2009: International Conference on 'Advancements in Marine Structures', 16 – 18th March 2009, Lisbon, Portugal
Web: www.mar.ist.utl.pt/marstruct

General Events

OTC 2008: Offshore Technology Conference, 5 – 8th May 2008, Houston, TX, USA
Web: www.otcnet.org/2008

US-JCCM 2008: 13th US-Japan Conference on Composite Materials, 6 – 7th June 2008, Tokyo, Japan
Web: www.smart.k.u-tokyo.ac.jp/usjapan2008

ISOPE 2008: 18th International Offshore and Polar Engineering Conference & Exhibition, 6 – 11th June 2008, Vancouver, Canada
Web: www.isope.org

OMAE 2008: The 27th International Conference on Offshore Mechanics and Arctic Engineering, 15 – 20th June 2008, Estoril, Portugal
Web: www.asmeconferences.org/omae08

SSC 2008: First European Shortsea Congress, 24 – 25th June 2008, Dublin, Ireland
Web: www.shortseacongress.com

ASRANet 2008: 4th International ASRANet Colloquium, 'Network for Integrating Structural Analysis, Risk & Reliability', 25 – 27th June 2008, Athens, Greece
Web: www.asranet.com

WCCM 2008: 8th World Congress on Computational Mechanics, 30th June – 4th July 2008, Venice, Italy
Web: www.iacm-eccomascongress2008.org

ICCM 2008: 16th International Conference on Composites, 8 – 13th July 2008, Kyoto, Japan
Web: www.jscm.gr.jp/iccm-16

SRT 2008: Ship Repair Technology: Life Cycle Effect of Ship Repairs, 1st – 2nd September 2008, Newcastle upon Tyne, UK.
Web: http://conferences.ncl.ac.uk/srtc

ESREL 2008: Safety and Reliability for Managing Risk, 22 – 25th September 2008, Valencia, Spain
Web: www.esrel2008.com

ICSOT 2008: International Conference on Ship & Offshore Technology, 16 – 17th October 2008, Busan, South Korea
Web: www.rina.org.uk/icsot2008

IAHR 2008: 16th Congress of Asia and Pacific Division of International Association of Hydraulic Engineering and Research and IAHR International Symposium on Hydraulic Structures, 20 – 23rd October 2008, Nanjing, China
Web: www.iahr2008nanjing.hhu.edu.cn

EURONAVAL 2008: 21st International Naval Defence and maritime Exhibition and Conference, 27 – 31st October 2008, Paris-Le-Bourget, France
Web: www.euronaval.fr

DOT 2008: 20th Deep Offshore Technology International Conference and Exhibition, 3 – 5th December 2008, Perth, Australia
Web: www.deepoffshoretechnology.com

ICOSSAR 2009: 10th International Conference on Structural Safety and Reliability, 13 – 17th September 2009, Osaka, Japan.
Web: www.sc.kutc.kansai-u.ac.jp/icossar2009

Contact MARSTRUCT

For more information contact the network:

Project Assistant

Fatima Pina, E-mail: fatima@mar.ist.utl.pt

Network Co-ordinator

Prof. Carlos Guedes Soares
Unit of Marine Technology and Engineering
Technical University of Lisbon
Instituto Superior Tecnico
Av. Rovisco Pais, 1049-001
Lisbon, Portugal.

Tel: +351-218-417607 or 218-417-957
Fax: +351-218-474015 or 218-473-868
E-mail:- guedess@alfa.ist.utl.pt