MARITIME INNOVATIONS FOR THE 21ST CENTURY

Success stories from EU Research

WATERBORNE TP

Maritime Europe Strategy Action

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Table of Contents

Introduction 3

Maritime Energy Efficiency 5

Safety 15

Production 19

e-Martime 23

Introduction

The Maritime Europe Strategy Action (MESA - FOSTER WATERBORNE) was launched in 2013 to support the activities of the WATERBORNE Technology Platform, primarily by updating the Strategic Research and Innovation Agenda, This will strengthen the effectiveness of the long-term research and innovation capacities of Europe's maritime industry.

Four major technology themes were identified for detailed study and Thematic Technology Groups were set up to analyse each: Energy Efficiency, Safety, Production, and E-Maritime. The groups performed an in-depth analysis and assessment of the current state of the art at EU and National level. In order to help improve the visibility of past and ongoing research activities, these Groups identified a number of exemplary projects that could be "showcased". Each showcase demonstrates the impacts made at an EU level, including commercial exploitation, resource efficiency, environmental benefits, and safety.

This publication focuses on the following EU Framework projects or project clusters and highlights the tangible benefits of EU support of the waterborne transport sector:

MARITIME ENERGY EFFICIENCY

GRIP (Green Retrofitting through Improved Propulsion) developed key technologies for CFD based design of Energy Saving devices, as well as production and installation.

STREAMLINE (Strategic research for innovative marine propulsion concepts) covered a large range of novel, alternative and optimised conventional propulsors.

HYMAR demonstrated that hybrid propulsion and power is an effective means of reducing energy consumption in small displacement vessels such as support vessels, workboats and recreational craft.

SAFETY

SAFEDOR was the first large scale project, worldwide, that developed a risk-based regulatory framework for the maritime industry and corresponding design tools.

PRODUCTION

A number of EU projects have supported European shipbuilders became world leaders in innovative laser welding technologies, including L-SHIP, TRANSLAS, SANDWICH, DOCKLASER, InterSHIP, and BESST.

E-MARITIME

i-Ship (Intelligent Ship Reporting) developed an innovative software application, enabling ship representatives to fulfil their reporting obligations to European and International maritime and custom authorities.

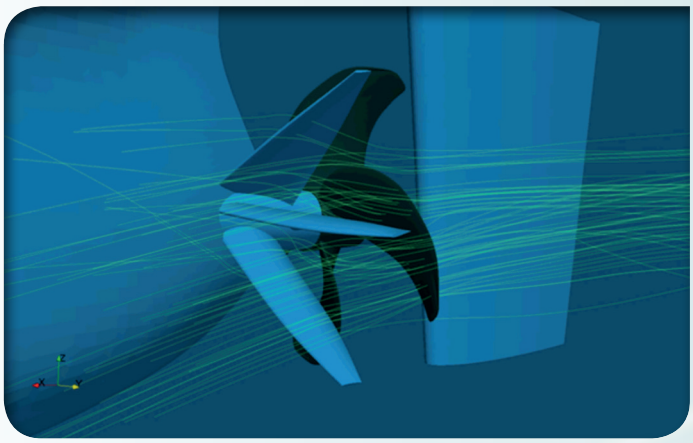
The DANAOS Collaboration Platform provides a place to publish and use software services related to shipping. It acts as a node in the e-Maritime Network and offers a directory of e-Maritime services that are already used by a number of shipping companies in their daily operations.

Maritime Energy Efficiency

EU Research propels Maritime Energy Efficiency

IMPROVED SHIP PROPULSION CONCEPTS IN EU FP7 PROJECTS GRIP AND STREAMLINE

Ship energy efficiency and emission reduction are key drivers for maritime operations worldwide. Even while fuel prices are at a record low, stricter emission rules call for a much more sensitive use of natural resources and higher efficiency. Ship propulsion is a decisive element determining the overall efficiency of a vessel. Besides reducing the resistance of a ship, increasing propulsive efficiency promises the largest gains in reducing fuel consumption of a cargo vessel. This is intrinsically linked with emission reductions.



The **EU FP7 project GRIP [Green Retrofitting through Improved Propulsion]** has developed key technologies for CFD based design of Energy Saving devices as well as production and installation / retrofitting of Energy Saving /Propulsion Improvement Devices. The concept is applicable to both new vessel designs as well as retrofits. It has been applied to a full scale demonstrator (54000 tdw bulk carrier) and demonstrated 6.8% power / fuel savings during consecutive sea trials.

GRIP – Demonstrated Impacts

Vessel fuel savings:	350 ts annually
CO_2 emission reduction:	1120 ts annually

Global Potential

World Bulk Carrier Fleet:	
Annual Fuel consumption:	55 Mio. ts.
Possible fuel Savings:	2.47 Mio. ts. [based on average savings of 4.5%]
Possible emission reductions:	7.9 Mio. ts.

The project opened up a large market for EU retrofit providers.

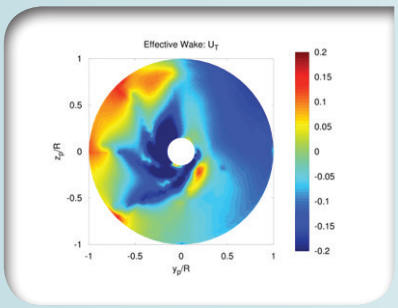
GRIP's starting point

The FP7 project GRIP (Green Retrofitting through Improved Propulsion) has been launched to address industry needs for improving on-board energy consumption and emission reduction by installing Energy Saving Devices (ESD) on existing ships. The high demand for retrofitting is largely driven by four factors: the reduction of CO_2 emissions, the fluctuating high fuel prices, effective regulations and the lifetime extension of existing ships. Although there is a remarkable market penetration already, it often remains highly uncertain whether these devices actually improve the performance of the complete hull-propeller system, and if so why. Some devices showed great promise in model tests, but failed in full-scale validations. For other devices, manufacturers claim proof of large improvements on real-size ships, but these claims cannot be verified by independent observers. Therefore, there is an urgent need for independent studies on the potential energy saving of such devices. The GRIP project addressed exactly this problem in a holistic approach.

GRID technologies: Development and Application

As explained above, a large variety of Energy saving – Propulsion Improvement Devices – already exist and practically all ships lend themselves to conversion / improvement by using an appropriate device. But not all of them are suitable to each type of ESD and even if a suitable generic device has been identified, a customisation of the design is required to adapt it to the individual vessel's characteristics, in particular the wake field and the propeller.

The Early Assessment Tool



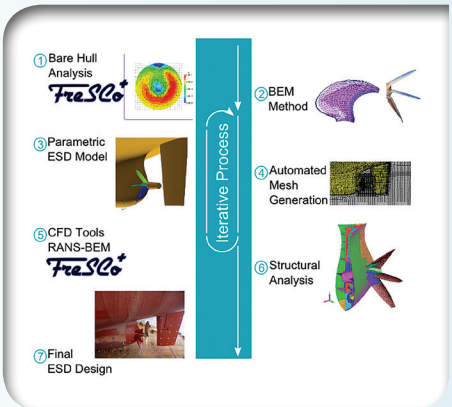
CFD prediction:
effective tangential wake with PSS

To circumvent the difficulties associated with the initial choice of the most suitable ESD, GRIP has developed in a first step an Early Assessment Tool (EAT) to provide guidance with the appropriate selection of ESDs. Therefore data from suppliers, literature, CFD calculations and trial measurements of earlier projects were collected to provide a sound basis. The EAT is the first major deliverable of the GRIP project. This web based tool for public use is aimed at technical staff of shipowners, consultants and others and gives guidance during a preliminary selection of ESDs. The tool gives a general overview of the field of application for a number of ESDs, based on characteristic ship data.

CFD based design procedure

One of the reasons for the reluctance of ship owners to invest in ESDs is the uncertainty in the performance gains at full scale which is caused by a number of factors. A chief factor is that the level of uncertainty associated with the theoretical predictions is often larger than the improvement itself. Therefore accurate model scale tests need to be extrapolated to full scale values which in turn have associated uncertainties. The GRIP project removed these uncertainties through the application and validation of computational tools applied to full scale conditions.

Advanced CFD and structural analysis techniques available were used to set up a design procedure including the analysis of the hull-propeller-ESD interaction. An example process is shown in the following figure. The GRIP procedure accounts for the interaction of hull, ESD and propeller by combining advanced CFD and structural prediction tools to assess the combined performance of propeller and ESD in the ship's wake. The CFD tools used vastly benefitted from prior developments in earlier EU funded projects, in particular the FP 6 project VIRTUE. They are now capable of capturing small deviations in the flow caused by the presence of ESDs and hence give an accurate result of the efficiency improvements to be expected from a new ESD.



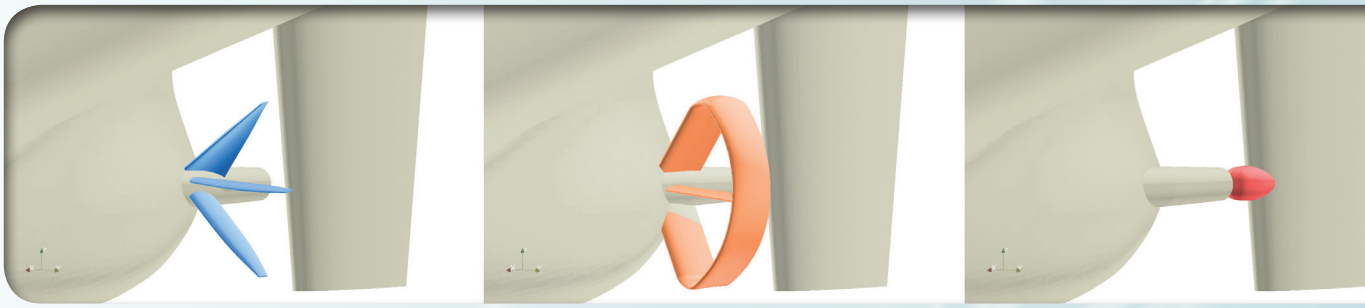
PSS design procedure

In addition, CFD also delivers the load inputs for the structural analysis. In GRIP a new methodology for the structural assessment of ESDs has been developed to enhance future classification regulations. These consider particularly dynamic loads including different causes of vibrations which are used to perform fatigue analysis.

Besides the actual hydrodynamic design process development in GRIP further comprised accurate geometry capturing of existing ships using 3d laser scan techniques and prototypical planning of ESD fabrication and installation to cover the entire loop from idea to the improved vessel.

Validation and Demonstration Case Study

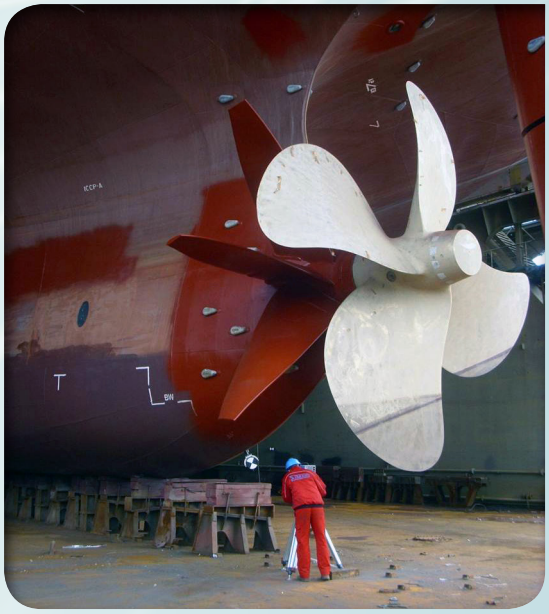
An actual ESD design case has been conducted for a reference ship. GRIP partners entered a contest to provide the most promising ESD solution for a new handymax bulk carrier built by partner Uljanik shipyard (ULJANIK BRODOGRADILISTE DD). The proposed solutions included a pre-swirl stator (PSS), a pre-duct and a rudder bulb.



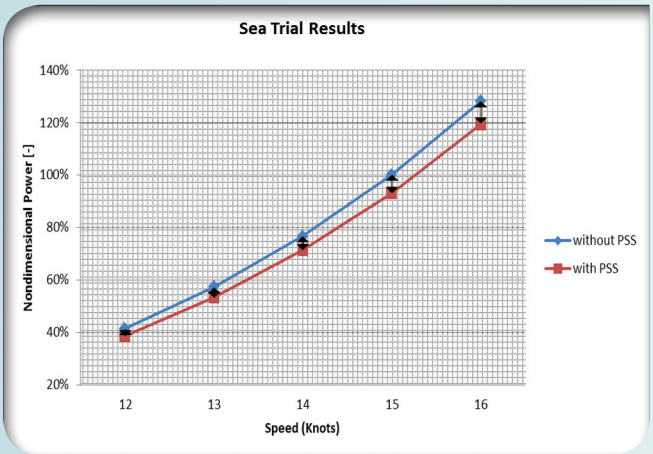
Contested ESD solutions for the GRIP reference ship

A thorough analysis cross-checking the three solutions revealed the PSS to be most promising. This device was further analysed and prepared for full scale testing. After hydrodynamic optimisation structural analysis of the selected design followed using the methodology developed in the project. The design wave and the corresponding maximum expected forces on the PSS fins have been predicted and Finite Element Analyses have been performed to validate the scantling. This was compared to class rules.

Once the design was completed the PSS was, manufactured and installed on the vessel (see pic. opposite) following careful alignment in situ and 3d scan measurements of the actual geometry were performed in the dry dock. With this configuration a second sea trial was performed repeating the first one only two weeks before in almost similar conditions.



Manufacturing and Installation of Pre-Swirl Stator at Uljanik Shipyard



The second sea trial with the PSS installed and otherwise unchanged conditions confirmed power savings of 6.8% and thus proved the validity of the GRIP design methodology.

Sea trial results, Power requirements with and without Energy Saving Device.

GRIP Project partners

Partner	Country	Role
MARIN	Netherlands	Model basin
BV	France	Classification
CMT	Germany	Research, material
FC	Italy	Ship yard
HSVA	Germany	Model basin
VICUS	Spain	Design
WPNL	Netherlands	Propulsion
ACC	Spain	Operator
IMAWIS	Germany	Research, production
ART	France	Management
ULJ	Croatia	Ship yard

Key facts

EU FP7 / 2011
Topic: SST 2011.1.1-1.

Grant agreement no: 284905

The total cost of the project were 4.162 M€ European supplied funding were 2.959 M€.

Further improved propulsion concepts have been developed in the FP7 project **STREAMLINE** [Strategic research for innovative marine propulsion concepts] which covered a large range of novel, alternative and optimised conventional propulsors. A very promising concept proved to be the contra rotating Pod (CRP) propulsor suggested by Rolls-Royce.

Planned CRP installation for a luxury yacht

The CRP features an aft mounted contra rotating Pod drive (AziPull thruster) which too regains rotational losses from the forward propeller. Both propellers are of controllable pitch type. The CRP concept is positioned as an alternative to conventional twin screw arrangements and promises significant increases in efficiency. In a design exercise which was validated through a thorough model test campaign, 4 different twin screw arrangements have been compared for a RoRo vessel. The CRP arrangement clearly marked the highest power savings at 15.6 % compared with the baseline (twin screw arrangement).

Rolls Royce are now adopting the concept for commercial use and will soon deliver the first such propulsion unit to be installed in a pioneering eco-friendly luxury yacht.

STREAMLINE CRP –Impact

Vessel fuel savings: ~ 1100 ts annually,
CO_2 emission reduction: ~ 3500 ts annually.

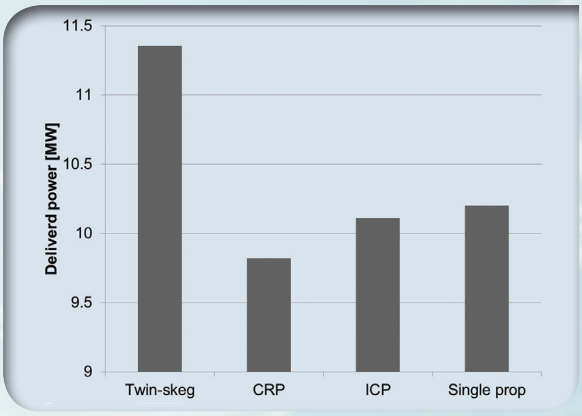
Global Potential

Based on a global fleet statistics (Psaraftis, Fairplay[1]) it was estimated that around 140 vessels between 15 – 25 (*1000) tdw would be suitable for a CRP propulsion unit. This would lead to the following savings:

Possible fuel savings: 151,500 ts.

Possible emission reductions: 80,000 ts.

The STREAMLINE project set out to develop, analyse and optimise a large range of ship propulsion alternatives, ranging from conventional propellers to radically new concepts such as biomechanical systems and the aft mounted Large Area Propeller. A very promising concept was the Contra rotating Pod Drive proposed by Rolls Royce. This was developed for a medium sized RoRo vessel and positioned against a standard design featuring a conventional twin screw arrangement.

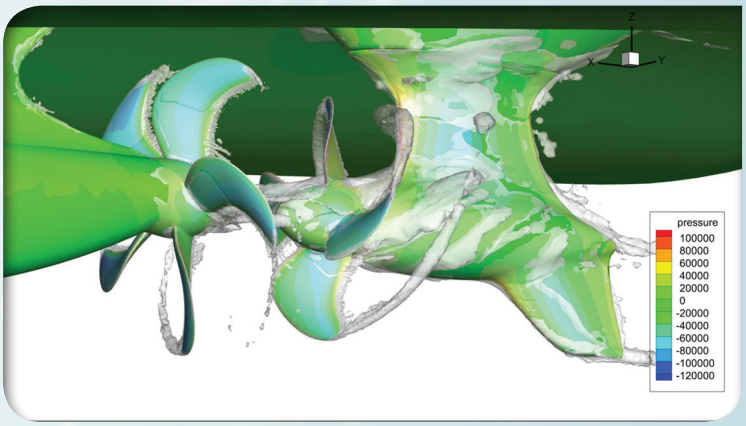


RoRo Power req. for 4 different propulsion concepts

The main objective of the Pod related work performed in STREAMLINE was to investigate new types and operational aspects of podded propulsion. Besides energy savings this related to the exploration of the effect of seakeeping conditions on the cavitation and ventilation behaviour of a podded propeller and the improvement of the reliability of full scale predictions.

The proposed CRP design proved to be superior to the conventional arrangement (twin screw) and other proposed design solutions. Model tests performed at SSPA confirmed the findings of earlier CFD analysis.

This convincing propulsion approach lead to a first order placed with Rolls Royce for a CRP installation with a total power of abt. 3000 kW.



The aft propeller regains rotational losses from the forward

1) Psaraftis, H., Kontovas, C., CO_2 Emission Statistics for theWorld Commercial Fleet, WMU Journal of Maritime Affairs, Vol. 8 (2009), No.1, 1–25

STREAMLINE Project partners

The STREAMLINE Project involved 22 partners and was organised in 3 main work packages dealing with different aspects of advanced propulsion.

Key Partners	Country	Role
RR	UK	Ind., Leader: New propulsion concepts
INSEAN	IT	Research, leader: Optimisation State-of-the-art Propulsors
MARIN	NL	Research: Leader: CFD Methods

Key facts

EU FP7 / 2008
Topic: SST-2008-RTD-1.

Grant agreement no: 233896

The total cost of the project were 10.9 M€, European supplied funding were 7.95 M€.

Hybrid power and propulsion for smaller vessels

The FP7 supported HYMAR project demonstrated that hybrid propulsion and power is an effective means of reducing energy consumption in small displacement vessels such as support vessels, workboats and recreational craft. A whole vessel approach was adopted, considering all aspects of the hybrid system from energy generation and storage through to propellers and data management. Fuel savings of 25% and more were demonstrated.

A number of new technologies were developed as a result of the project, including a dedicated marine hybrid controller, new power sensors, a load following propeller, new marine lithium ion batteries and a software tool for determining the commercial benefits of hybrid power and propulsion. A more comprehensive list appears on the final page.

A highly optimised load following propeller was developed based on the Bruntons Autoprop

The Hymar test boat "Armorel" was the guest vessel at the Southampton Boat Show in 2012

Target markets

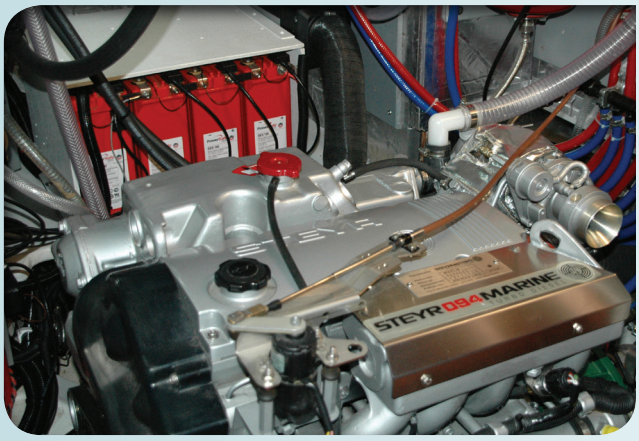
- Leisure marine
- Super yachts
- Pilot boats and other harbour working boats
- Offshore support vessels
- Small ferries
- Short sea shipping

Investments and outcomes

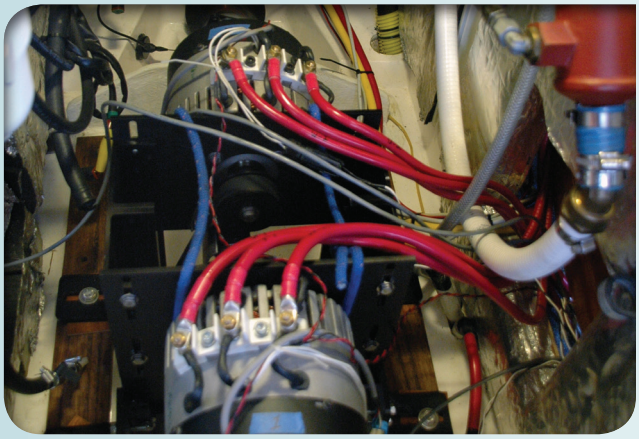
Following the EU FP7 investment in the HYMAR project, a further UK national grant was awarded from Innovate UK to refine the key findings and to take the enabling technology closer to market. Finally, in 2016, the principle technologies were licensed to a major engineering company for global exploitation, with a product launch expected by the end of the year.

EU funding (FP7)	€2.00M
UK funding (Innovate UK)	€1.26M
Industrial funding	€2.04M
Potential fuel savings	25% +
Potential HC & NO_x reduction (recreational craft)	10,000 tonnes p.a.

The HYMAR and HEME projects - from concept to product



The final HYMAR configuration was a parallel hybrid with the diesel engine and a motor/generator on the same shaft



An "automotive like" series hybrid system was initially tested and characterised using a variety of different electric motors

Using stored electrical energy to provide power and propulsion is a highly developed technique in the automotive industry with many hybrid architectures and options available on the market. This energy efficient technique is less widely used in the maritime sector, which typically has much higher power requirements and very different operating profiles.

HYMAR undertook pioneering research work to understand how to optimise the use of hybrid technologies for vessels which operate at varying speed and load. Both propulsion and electrical generation were considered and a whole vessel view was adopted. This included extensive modelling of the interactions between all elements of the electrical and propulsion systems, including the propeller.

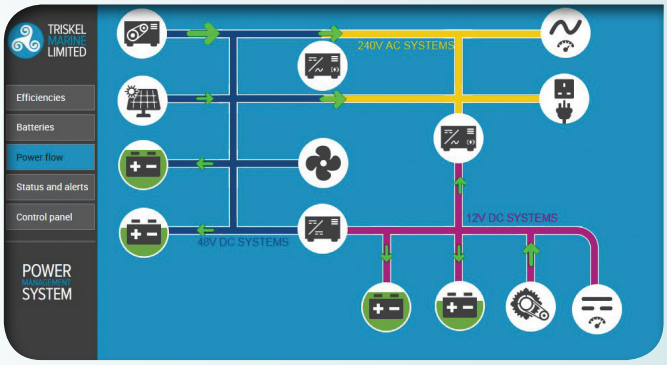
The project initially built and tested a "series hybrid" configuration, which is equivalent to an all electric car with a range extending generator. Technology transfer from the automotive sector was viewed as a potentially rapid route to success but the very different operational constraints and duty cycles meant that this was not practical. This automotive-like configuration quickly proved to be less efficient than conventional diesel propulsion and had insufficient power to handle heavy seas and strong winds. As a result, this line of research was dropped in favour of a parallel hybrid architecture which uses both a diesel engine and an electric motor on the same propeller shaft. The motor can also act as a generator so that when the main engine is running a variable electrical load can be added to the propulsion load.

Electric motors have different power characteristics than a diesel engine, including high torque at low revs. In practical terms this means that an electric motor can turn a much bigger propeller at lower revs than a diesel, promising further efficiency gains. Electric propulsion at low speed and diesel propulsion at higher speed were the objective but to achieve this meant developing a variable pitch propeller suited to small craft. One of the major results from the HYMAR project was the modelling and optimisation of a self pitching propeller, in which the angle of the blades changes with rotational speed and hydrodynamic load.

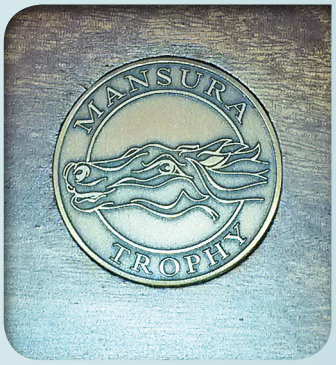
The key to efficient operation was to keep the internal combustion engine – whether the generator or main engine - operating at its most fuel efficient point by managing the interaction between the electrical and propulsion loads, and by the use of stored energy when appropriate.

In 2012, the HYMAR test vessel Armorel, was awarded the Mansura trophy for having made the greatest technical advances in marine hybrid propulsion over the previous two years. The competition involves a global review of marine hybrid technologies.

At the end of the HYMAR project in 2012, better than expected efficiency gains had been demonstrated by using electric drive at manoeuvring and other low speed operations and then switching to diesel propulsion at higher speeds and loads. Further gains were evident when a variable electrical load was added to the propulsion load under diesel power.



A real time power flow diagram shows the flow of electrical power around the test vessel



In 2012, Armorel won the global Mansura technology trophy for the most advanced hybrid vessel

In order to develop these concepts further, a second grant was awarded under the UK government's Vessel Efficiency programme. Project HEME (High Efficiency Marine Energy) used the same test vessel and two of the same partners but the main focus was on the interaction between hybrid propulsion and electrical power generation.

HYMAR showed that the greatest energy savings were to be made in electrical generation and HEME developed that theme. Most small vessels have a generator based electrical system with very little stored energy, which means that a generator has to be running at all times, regardless of the electrical load. This is energy inefficient, produces unwanted and unnecessary emissions and results in high maintenance costs, noise and vibration.

By optimising on board battery storage and manipulating engine load using a controllable pitch propeller and a shaft generator, both fuel and maintenance costs were reduced. A marine equivalent of the automotive engine management system was developed to handle the large amounts of data and to provide the user with an intuitive interface.

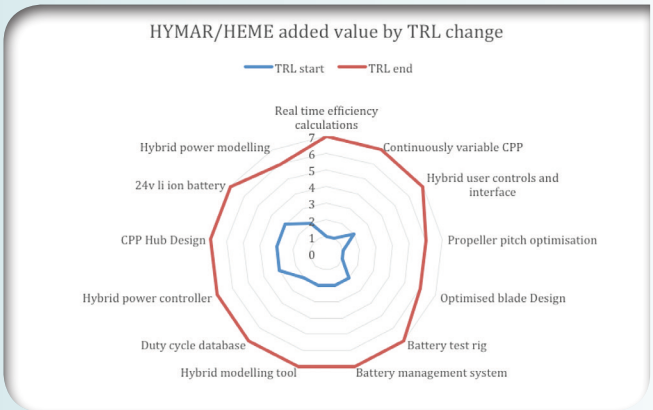
Despite the higher initial cost, the projects demonstrated that through life costs are reduced substantially. Depending on the way in which the vessel is operated, the unit cost of power on board can be reduced by up to 30%, from about €1.50 per kWh to €1.00 per kWh. In addition, overall fuel consumption for electrical generation was reduced by approaching 30% and for propulsion by around 25%.

Other benefits demonstrated include:

- Reduced operational costs – both fuel and maintenance
- Silent and emission free operations in port
- Extended vessel autonomy
- Modelling of commercial benefits of hybrid power and propulsion

Technical outputs

The key technical outputs from the projects are shown in the graph below together with a measure of added value as indicated by the increase in technology readiness level.



Project partners

International Council of Marine Industries (BE) – HYMAR lead partner; Pendennis Shipyard Ltd (UK) – HEME lead partner; Steyr Motors (AT); Triskel Marine Ltd (UK); Malo Yachts (SE); Bruntons Propellers Ltd (UK); Mastervolt (NL); Enersys Ltd (UK); Energy Solutions Ltd (UK); INSEAN (IT); ESP Ltd (UK)

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Safety

SAFEDOR (2005-2009) is the first known large scale project worldwide that developed a risk-based regulatory framework for the maritime industry and corresponding design tools to facilitate first principle approaches to safety, addressing the complexity of a fully comprehensive system.

The conducted research work, which was completed in 2009, focused on strategies and technologies to improve maritime safety and, at the same time, the competitiveness of the involved stakeholders.

Three major achievements have been accomplished in SAFEDOR Project:

1. SAFEDOR partners created a framework for risk-based design which is now documented in a handbook for naval architects and marine engineers.

2. SAFEDOR has led to the development of an approval process for risk-based ships which is been submitted to IMO.

3. A series of innovative ship and system designs were generated that show the practicability of the SAFEDOR approach. To document the current risk level, five formal safety assessment studies for major ship types were conducted and also submitted to IMO.

A systematic and all-embracing approach to ship safety has been developed that leads to optimising of safety and an effective use of both critical technologies and the wealth of information amassed over years in ship design. Gained knowledge has been applied to innovative ship design and approval, as well as improved safety-critical technologies.

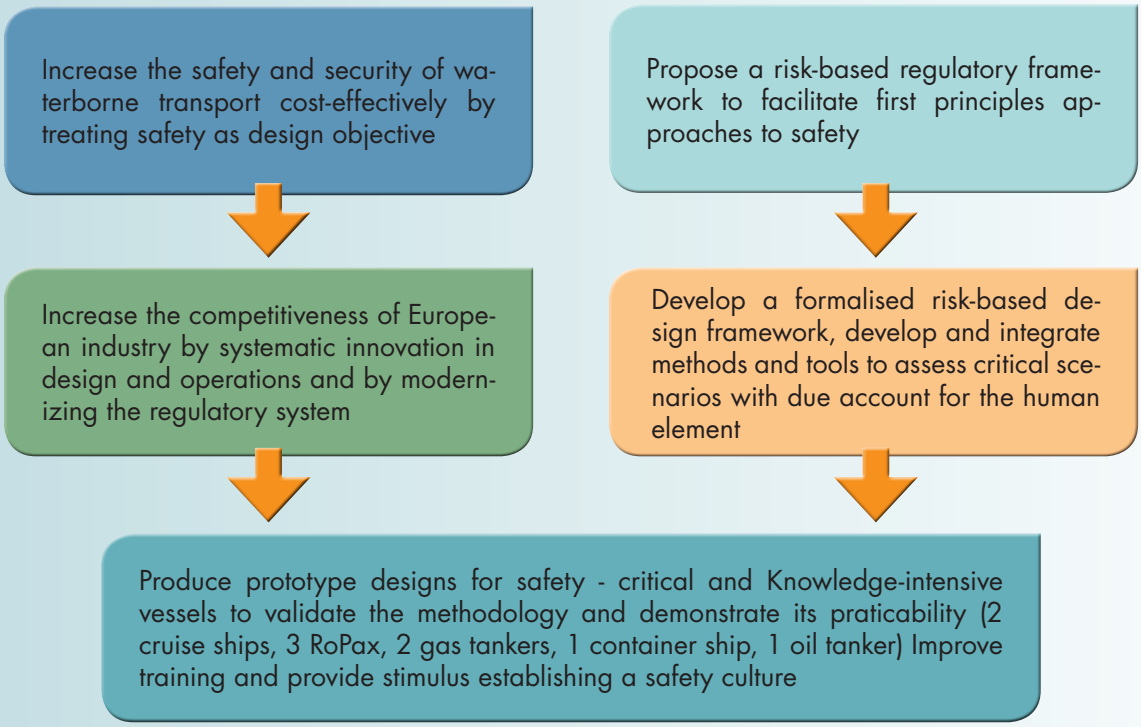
The SAFEDOR approach is a novel approach to a transparent and consistent methodology for Risk-based Ship Design and Approval.

Safe design - that effectively minimizes the likelihood of accidents and mitigates their consequences - has long been a priority in many industries; to mention but a few, such as Civil, Offshore, Aeronautics, Nuclear, Systems, Hydraulic, Water Resources & Environmental Engineering. Risks cannot be completely eliminated but at least be consistently reduced to a level that can be tolerated by all concerned - by facility staff, company management, surrounding communities, the public at large, industry and government agencies.

Therefore, methods of risk and reliability analysis in various engineering disciplines, developed during the last decades, are becoming more and more important as decision support tools in engineering applications.

Presently core technical elements governing the operation of seagoing ships are established by regulations of the International Maritime Organization (IMO). In addition, rules governing the construction of ships are established by Classification Societies. As a consequence, ship design is significantly constrained by these rules and regulations.

SAFEDOR has had the aim to provide additional design freedom for ship and systems and an appropriate approval process that introduces safety as additional objective – additional to standard performance requirements like speed, capacity, endurance etc. - and by proposing a modernised regulatory framework to facilitate risk analysis as additional element of the approval process. This way, the regulator imposes boundary conditions directly on the targeted safety performance of the ship with quantified risk acceptance criteria and the ship designer decides how to achieve the prescribed level of safety cost effectively. Thus, a path to approve novel ships beyond the current regulatory constraints is offered.



SAFEDOR objectives and the approach are summarised in Figure on the side showing the two development tracks – one related to risk-based ship design and one related to risk-based ship approval – and the validation and application activities.

SAFEDOR researchers developed new safety-performance prediction tools related to flooding, structural integrity, intact stability, collision and grounding, and fire, system failures, as well as ship type specific risk-cost-earning models. These new tools became the building blocks of an integrated design environment, a first prototype of which was developed and elaborated in co-operation with shipyards and design offices.

SAFEDOR also developed a series of novel ship systems and new designs for cruise vessels, ropax vessels, gas tankers, oil tankers and container vessels. Innovative features include large fire safety zones, lightweight super structures, and new damage stability arrangements aimed at balancing cargo space with grounding risks, reducing oil outflow and increasing operational flexibility.

The novel systems focused on navigation, power distribution and life saving, selected with the knowledge that in particular these ship functions contribute to ship's safety performance.

SAFEDOR results can benefit all maritime players across Europe. Innovation has been a driving factor for both profitability and safety in many industries, he explains. But in the maritime industry, the particular regulatory approach has left little leeway to exploit it. SAFEDOR has made new avenues for shipping innovation available for European industry with respect to both economy and safety.

With risk-based approaches firmly established in the maritime industry, ship owners can be able to realise innovative ships and maritime transport solutions which cannot be approved today, relating to, e.g., new layouts challenging damage stability regulations or use of new materials and systems challenging current SOLAS regulations.

Shipyards can benefit from the introduction of risk-based approaches through enabling novel and optimised ships incorporating new layouts, functions and materials. The benefits arise from the fact that yards acquainted with risk-based approaches are among the first to respond to the increasing demand from ship owners to realise novel and innovative ships - which may challenge current prescriptive rules. In addition, production costs may be reduced through application of risk-based approaches. Thus, understanding and applying risk-based approaches now may be a competitive advantage.

Marine equipment manufacturers can benefit from the introduction of risk-based approaches through enabling new and optimised systems incorporating new functions and materials.

Engineering service providers and software producers for simulation tools can also benefit from SAFEDOR's novel approach to "design for safety".

Ultimately, risk-based ship design and approval processes can go a long way towards satisfying European society's demands for safer and more cost-effective maritime transport. With the new risk-based approaches becoming progressively accepted at IMO (e.g. the document MEPC 58/INF.2, in fact, this document provides information on the Formal Safety Assessment (FSA) study on crude oil tanker carried out within the research project SAFEDOR) and, therefore, at national flag-state level, industry may be able to capitalise on the design freedom becoming available. Introducing safety as a design objective opens the door to innovative ship designs. Thus, SAFEDOR can eventually succeed to enhance safety through innovation and, at the same time, to strengthen the competitiveness of the European maritime industry.

The Commission's primary aim remains to enhance the quality and competitiveness of the European shipping sector through enhanced ship safety, and this is what SAFEDOR has sought to achieve. The project has resulted in a coherent means by which innovative ship design can be encouraged, recognised and approved under the auspices of the International Maritime Organisation, while maintaining ship safety as its basic premise.

Organization	Town	
Germanischer Lloyd AG	Hamburg	DE
Carnival plc	London	UK
Danish Maritime Authority	Copenhagen	DK
Det Norske Veritas AS	Høvik	NO
Navantia, S.A.	Madrid	ES
SAM Electronics GmbH	Hamburg	DE
University of Strathclyde	Glasgow	UK
Technical University of Denmark	Kgs. Lyngby	DK
National Technical University of Athens-Ship Design Laboratory	Athens	GR
Instituto Superior Tecnico	LISBON	PT
Maritime Research Institute Netherlands	Wageningen	NL
D'Appolonia S.p.A.	Genoa	IT
SSPA Sweden AB	Göteborg	SE
Safety at Sea Limited	Glasgow	UK
Deltamarin Ltd	Raisio	FI
FINCANTIERI - Cantieri Navali Italiani S.p.A.	TRIESTE	IT
Alpha Ship Design ApS	Hellerup	DK
Flensburger Schiffbau-Gesellschaft mbH & Co. KG	Flensburg	DE
Lund, Mohr and Giaever-Enger Marin AS	Bergen	NO
Wadan Yards MTW GmbH	Wismar	DE
GKSS Forschungszentrum Geesthacht GmbH	Geesthacht	DE
STC B.V.	Rotterdam	NL
ANSYS Europe Ltd.	Reading	UK
DFDS A/S	Copenhagen	DK
RFD Beaufort Limited	Belfast	UK
Umoe Schat Harding AS	Rosendal	NO
Martec S. p. A.	Vignate (MI)	IT
ITI Gesellschaft fuer ingenieurtechnische Informationsverarbeitung mbH	Dresden	DE
University of Hull	Hull	UK
British Maritime Technology Ltd	Teddington	UK
Color Line Marine AS	Sandefjord	NO
Peter Döhle Schiffahrts-KG	Hamburg	DE
Centro per gli Studi di Tecnica Navale	Genova	IT
Aveva AB	Malmoe	SE
Leif Hoegh & Co. AS	Oslo	NO
Columbus Shipmanagement GmbH	Hamburg	DE
Harland & Wolff Heavy Industries Ltd	Belfast	UK
Stena Rederi AB	Gothenburg	SE
Brodrene AA AS	HYEN	NO
FiReCo AS	Fredrikstad	NO
Snecma	Paris	FR
Napa Ltd	Helsinki	FI
NAVALIMPIANTI S.p.a.	MONFALCONE (GO)	IT
Fr. Fassmer GmbH und Co. KG	Berne	DE
Lloyd' s Register	London	UK
Rina SPA	Genova	IT
Royal Caribbean Cruise Line	Weybridge, Surrey	UK
V. Ships	London	UK
Sirehna	Nantes	FR
ASME	PIRAEUS	GR
FRESTI-Sociedade de Formação e Gestão de Navios, Lda.	CAPARICA	PT
STX France Cruise SA	SAINT-NAZAIRE	FR
Meyer Werft GmbH	Papenburg	DE

12 million EUR sponsorship by the EU

More than 50 partners from the European maritime industry

More then 100 participants

Project management by Germanischer Lloyd

Source: www.safedor.org/index.htma

Production

Ships made of Light – Lighter Ships

This show case tells how European shipbuilders became world leaders in innovative laser welding technologies and which benefits this offers to shipyards and their customers, to other industries and to the European society. The still ongoing development commenced as early as 1992 with a series of EU research projects, e.g. L-SHIP, TRANSLAS, SANDWICH, DOCKLASER, InterSHIP, BESST. Exploitation results include modern production installations like the one shown in the picture below.

One of the largest laser welding installation in the world: Panel line (30m x 30m) for butt and fillet welding with disc & CO_2 laser, operating at Meyer Werft, Papenburg since ~2010 , Source: Meyer Werft

The most relevant impacts that have been yielded by laser welding in shipbuilding are summarised in the table below. Hence, laser welding in the shipbuilding industry considerably contributes to several of the exploitation outcomes (EOs) in the implementation plan of the European Technology Platform Waterborne[TP], especially EO8 Leading shipbuilding, EO2 The low energy, low emission ship, EO6 The European Cruise Ship.

IMPROVED PRODUCTION	Shipyards applying laser welding have improved their productivity by 100% and more. This is mainly due to high welding speed, stable and robust processes that lead to improved reliability and efficiency, and less heat input which reduces distortion and rework dramatically. Also, working at shipyards has become much safer, and lots of attractive jobs have been created.
LOW MAINTENANCE	It has been shown that laser welded structures provide better fatigue properties than conventional ones. Therefore, less maintenance and repair is required over a vessel's lifetime, and ships' safety is increased as well.
IMPROVED DESIGN **LESS FUEL**	Metallurgy related and other benefits of laser welded joints have enabled a wider and more flexible use of thin sheet designs in ship structures, for instance in large cruise vessels. The increased payload to weight ratio also reduces emissions from shipping and the consumption of raw materials, such as steel, welding consumables and gas per transport unit.
IMPROVED PRODUCTION	In consequence, the abovementioned benefits bear economic advantages both for shipbuilders and for ship operators.

Selected aspects of impact yielded by laser welding in shipbuilding

Laser welding helps maintaining Europe's leadership in shipbuilding

Meyer Werft in Papenburg, Germany, is one of the early adopters of laser welding, and has become world leader in production of large cruise vessels since. The explanations below predominantly follow the developments taken by Meyer Werft, thus serving as an example on how beneficial strategic production technology innovation can be for European manufacturers of highly specialised vessels. It has to be noted however that there are more European shipyards than Meyer Werft which use laser welding technology successfully.

First steps into laser welding applications

In the early 1990s, the knowledge about the potential for material processing supported by laser had achieved a critical level and evoked interest in realising concepts for laser based manufacturing in shipbuilding. A few years later, the first laser cutting machines for shipbuilding appeared on the market, but shipyards also realised the potential of laser welding to provide competitive advantages. In a nationally funded project from 1994-1998, Meyer Werft did comprehensive research and development on laser welding.

Laser welded I-Core sandwich panels. The charac-teristic girders are joined to the facing sheets by means of hidden Tee joints. Source: Meyer Werft

The work did not only comprise the realisation of a prototype welding facility and the qualification of novel welding processes, but also product innovation. Hence, the entirely new lightweight I-core panel was introduced thanks to the newly developed laser welded hidden Tee joint (pic. above). In the aftermath of the project, Meyer Werft installed a productive laser facility, successfully produced structures for vessels, and delivered panels to customers outside shipbuilding for several years.

A radical step towards breakthrough of laser application

The I-Core technology proved to be very suitable for several structural members of cruise ships (e. g. stair case landings, walls). However, existing rules and other obstacles prevented I-Core from replacing the conventional design of major parts of a cruise vessel's structure. To make much wider use of the merits of laser, a way had to be found to produce conventional ship structures.

At the end of the 1990s, this goal became achievable by means of laser hybrid welding, i. e. by creating a process that combines laser with conventional arc welding. Meyer Werft took a radical step in 2000, removing the conventional panel line completely and replacing it with a laser hybrid welding facility both for butt and fillet welds. No doubt, this was one of the largest laser welding installations worldwide, both in terms of installed power and the size of the panels produced. An integrated design approach combining laser welding, new clamping devices and a novel edge preparation based on milling ensured reliability and productivity. More than 300km welds – corresponding to more than half of the weld length of a cruise vessel of the time – were now welded in extremely high quality with lasers.

The investment paid off within a few years, and the facilities became too small to keep pace with Meyer Werft's increasing order book and with the size of the ships built. Based on the success of the first installation, in 2010 Meyer Werft invested in a second production line of flat sections sized 30m by 25m, equipped with disc and CO_2 lasers for butt and fillet welding.

Little but important steps - Continuous research for further enhancement of applications

Further to what has been described above, a wealth of research activities for laser processing in shipbuilding were undertaken. In this story, only a selection of the achievements can be mentioned in note form:

- **EDGE PREPARATION** - Equipment that allows for melting the edges of metal sheets with a defocused laser beam to produce a rounded shape prior to applying anticorrosive coatings;
- **MOBILE LASER** - More flexible, modular and mobile equipment for assembly and outfitting work in the later production stages and for repair;
- **FATIGUE** - Evidence of improved long term dynamic strength of laser welded structures, and approval of introducing such lightweight structures in passenger vessels.

How big is the success?

Meyer Werft's and other shipyards' research efforts with respect to laser technology received considerable fundings from EU and national programs. It is assumed that the magnitude of private investments that were made subsequently to exploit the gained knowledge is about five times as high. This leverage factor already gives an idea of the usefulness of the initial fundings. As for the numerable technical merits of applying laser technology, production technology experts at Meyer Werft sum up: "Due to the lower energy input per unit length offered by laser hybrid welding, the quality of joints has improved significantly. This pays off by ca. 30% reduction of efforts for straightening of distorted welds. At the same time, the lead time in panel production was reduced dramatically. This applies particularly for fillet welds, since this is the joint with the highest share. We have doubled or tripled our welding speeds compared to conventional techniques." The results in competitiveness Meyer Werft has gained become obvious when comparing some of the company's key figures of 2000 and today: While increasing the work force by some 50 %, the number of vessels delivered per year has doubled and their size has increased by ca. 50 % This is, not solely but to a very large extent, the result of innovation in manufacturing technology.

Beyond the figures above that indicate the production performance, using laser in shipbuilding bears a number of additional advantages. Ship weight reductions for instance have been achieved due to the use of thinner metal sheets and due to the reduced amount of levelling compound that needs to be added thanks to the improved accuracy. This helps saving energy and avoiding emissions in the production process and over a ship's operational life. Several recent research projects develop and apply Life Cycle Performance Assessment methodologies, thus addressing the challenging task to systematically assess and quantify new technologies' economical, environmental and societal impact.

Cruise vessel Ovation of the Seas, being outfitted in Meyer Werft's drydock. Source: Meyer Werft

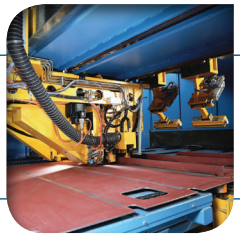
Next steps

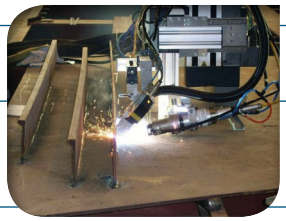
Meyer Werft is ready to face the next challenges. 3D laser welding, robotics, Industrie 4.0, additive manufacturing by laser are keywords for paving the way towards using laser in assembly stages subsequent to the panel lines and to relieve workers from the heaviest physical work processes. Besides the Mobility for Growth funding program, the program under the contractual Public-Private Partnership Factories of the Future will gain importance for Meyer Werft.

Additional information

While the story on the preceding two pages focused on the developments experienced by one single company, the table below provides an overview of important laser applications that have been realised by several European shipyards. More detailed information including technical aspects of laser and laser welding technology and their application in shipbuilding can be found in the Public Report Innovation Show Cases, which has been issued by the Thematic Technology Group Production and Materials within the MESA project.

LEGEND: R - Application in Research and Prototype Production; C - Commercial Production Application





~ 1995	Meyer Werft, DE	R / C
Test and Production Facility for Laser Welded Sandwich Panels with CO_2 Laser ▸ First commercial use of laser welding in shipbuilding		
~ 1997	Odense Steel Shipyard, DK	R
Flexible Manufacturing Cell for Cutting, Welding and Marking of Components		
~ 1997	Fincantieri - Monfalcone, IT	R / C
Laser Butt Welding Station up to 16m with CO_2 Laser		
~ 1999	Blohm & Voss Shipyard, DE	C
Laser Cutting and Welding Shop for Flat Micro-Panels with CO_2 Laser ▸ First industrial application for main ship structures fully relying on laser		
~ 2001	Meyer Werft, DE	C
Large Panel Line (20m x 20m) and Micro Panel Lines with Stationary Butt and Fillet Welding with CO_2 Laser ▸ First commercial application of laser hybrid welding - largest laser center in the world		
~ 2006	Aker Yards Turku, FI	R / C
Refitting a 6kW Fibre Laser into an existing Gantry System		
~ 2006	Meyer Werft, DE and NAVANTIA, SP	R
Successful tests of mobile laser system in production environment		
~ 2007	Fincantieri - Monfalcone, IT	C
Panel line with laser butt welding using a fibre laser ▸ First commercial application of high power fibre laser		
~ 2010	Meyer Werft, DE	C
Additional Panel Line (30m x 30m) for Butt and Fillet Welding with Disc and CO_2 Lasers		

Overview of industrial prototype installations and commercial installations of laser welding in European shipyards. Sources: Meyer Werft, Fincantieri, Blohm & Voss, Schuler-Held, Aker Turku, Navantia"

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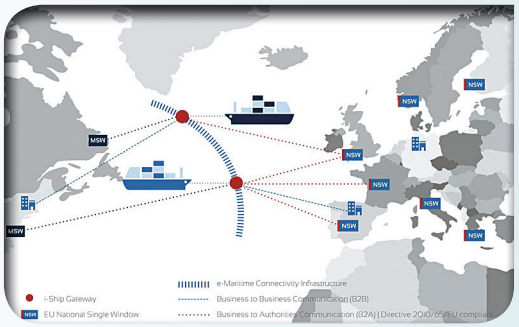
e-Maritime

i-Ship (Intelligent Ship Reporting)

EMAR – e-Maritime Strategic Framework and Simulation based Validation



i-Ship interconnects ships with operational stakeholders and reporting authorities

Principal outcome

The intelligent Ship Reporting Gateway (i-Ship) is an innovative software application, enabling ship representatives to fulfil their reporting obligations to European and International maritime and custom authorities. i-Ship can be used to automate reporting formalities in a timely and correct manner taking into account the type of ship and the voyage.

Principal impacts at EU level

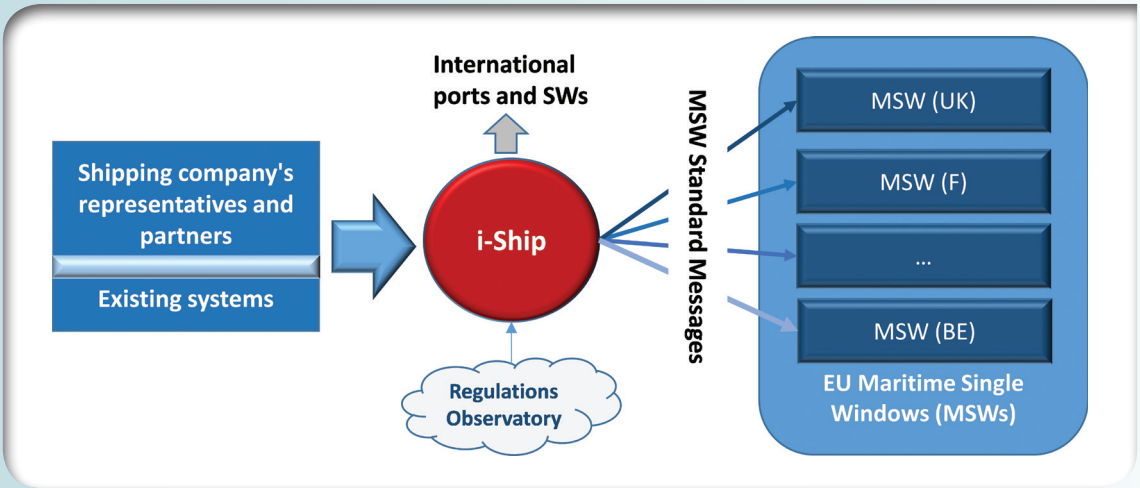
- EMAR received funding from the EC's 7th Framework Programme DG Mobility and Transport. Consortium: 28 Participants
- Reduction of the overall cost of reporting by eliminating non-adding value activities.
- Reduction of the reporting burden -from hours to minutes- allowing ship personnel to focus on efficiency and safety of operations.
- Synchronisation for optimised berthing times.
- Reduced clearance uncertainties leading to improved planning.
- Shorter lead times
- As European member states prepare National Single Windows in accordance with the Directive 2010/65/EU, i-Ship ensures full compliance with the EU legal requirements on ship and cargo reporting, taking into account exceptions for regular shipping.

Future developments envisaged

- i-Ship is offered as a SAAS (software as service), but can also be available on private clouds or on premise.
- Currently it is deployed in Microsoft's Azure WebSites infrastructure. It is monitored and can be auto-scaled to meet demand and SLA terms.
- The application is configured to use SSL and RSA encryption for securing data exchange.
- The service can be hosted by a ship operator or a service broker providing services to several shipping actors (managers or agents).

Applications of the new technologies

- **Ship Managers**: Ship managers introduce voyage information directly using the i-ship web application or via connection to the company's applications. The data introduced may include cargo information.
- **Cargo Consignors**: Cargo consignors introduce cargo consignment data being aware -or not- of the specific cargo movements, which are decided by the ship operator. Example of the application of the new technologies/processes based on a real case study, quoting users' reactions if possible and with multiple pictures.
- **Ship Representatives**: Ship masters, agents at a specific port or other authorised users submit port clearance related formalities to maritime Single Windows or related authority systems.
- **Cargo Representatives**: Cargo representatives submit cargo clearance formalities to maritime Single Windows such as ENS, eManifest etc., to Port Systems or to Custom Authorities (e.g. ICS, ECS).



i-Ship: a complete solution for ship formalities and compliance management

The i-Ship dashboard facilitates choice of actions in three areas: ships, voyages and notifications:

Ships: The "ships" area presents a list of all the vessels that the user is authorised to handle; mostly used for creating future voyages.

Voyages: The "voyages" area presents a list of all voyages that the logged-in user can manage. This list may be filtered through text search or by a specific ship name. Users may choose to update the details of a specific voyage or create a notification.

Notifications: The "notifications" area presents a list of the reporting obligations and their status (pending submission, having been submitted or authorized, etc.). Users can produce and submit notifications.

Users configure time thresholds and applicable formalities according to national legislation, as well as modify these settings to accommodate port level requirements. The set of formalities from which a ship is exempted are specified.

EU Ship reporting requirements fulfilled by i-Ship

Reporting requirement	Legal Basis	Potential Submission Formats
Pre-arrival notice	According to EU legal Acts (Article 4 of Directive 2002/59/EC) and similar regulations adopted by Norway and Iceland, a notification for ships arriving in ports of the Member States is required (submitted at least 24 hours before arrival and including ETA and person on board information).	National regulations may require the electronic submission of berth allocation
Passenger and crew list	According to EU legal Acts (Article 7 of Regulation (EC) No 562/2006) passenger and crew and stowaways information for border checks on persons, is notified to border control Authorities.	
Notification of dangerous or polluting goods carried on board	According to EU legal Acts (Article 13 of Directive 2002/59/EC) and similar regulations adopted by Norway and Iceland, a notification of dangerous or polluting goods carried on board is required.	
Notification of waste and residues	According to EU legal Acts (Article 6 of Directive 2000/59/EC) and similar regulations adopted by Norway and Iceland a notification of waste and residues are required (submitted at least 24 hours before arrival).	
Information on ship security level & on last 10 calls at port facilities	According to EU legal Acts (Article 6 of Regulation (EC) No 725/2004) and similar regulations adopted by Norway and Iceland a notification of security information (including e.g. the information on ship security level and on last 10 calls at port facilities)is required (submitted at least 24 hours before arrival).	

Entry summary declaration (ENS)	According to EU Custom regulations an Entry summary declaration (ENS) for cargo consignments loaded at non Union ports has to be lodged at the Custom Office of first entry in the Union or at an ENS office of lodgement at least 24h before the departure of the ship from the port where the consignment was originally loaded.	XML-based (ISO 28005/ EMSA epc xsd edition) XML-based (WCO-based AnNA format) XML-based (eMAR CRS) XML-based DDNIA format (DG TAXUD)
Cargo Manifest	According to specific Customs regulations applicable in European countries a cargo manifest is to be lodged for ships arriving and/or leaving EU ports. Furthermore a declaration of goods unloaded for temporary storage might be required.	
FAL Forms	National regulations may require the submission of individual FAL forms for ships arriving or departing.	EDIFACT XML-based (ISO 28005) XML-based (eMAR CRS)
Berth Requests	National regulations may require the electronic submission of berth allocation.	EDIFACT (BERMAN) XML-based (eMAR CRS)

i-Ship innovation Technological advantages

Utilising research outputs from key FP7 projects

- **eFreight:** Deliverables related to CRS (work related to cargo data elements); prototype intermodal Next Generation Single Window and e-freight platform.
- **COMCIS:** Integration of ENS messages to ICS Customs systems using CRS.
- **SUPPORT, CONTAIN** and iCargo: Connectivity infrastructure, semantic integration technologies, cloud and smart systems.
- **eCompliance:** Rules Engine

Related work:

- **DG TAXUD** on ENS-related messages.
- **eMS Group** on data elements definition/business rules and specifically on data mapping-related reports.
- **AnNA project** on data elements/messages definition and specifically on B2MSW reports and relevant messages.
- **EMSA** on IMP demonstrator project and SSN (documents published on the EMSA web site).
- **Testing programme** by masters and shipping

Project partners

Inlecom, with partners including BMT, CLMS, DANAOS, EBOS and MarineTraffic

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The i-Ship prototype has been developed as part of the eMAR project, building on FP7 projects in the period 2008-2014

i-Ship is Directive 2010/65/ EU compliant; it ensures full compliance with the EU legal requirements on ship and cargo reporting, taking into account exceptions for regular shipping

This eMAR project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 265851.

The DANAOS Collaboration Platform

EMAR – e-Maritime Strategic Framework and Simulation based Validation

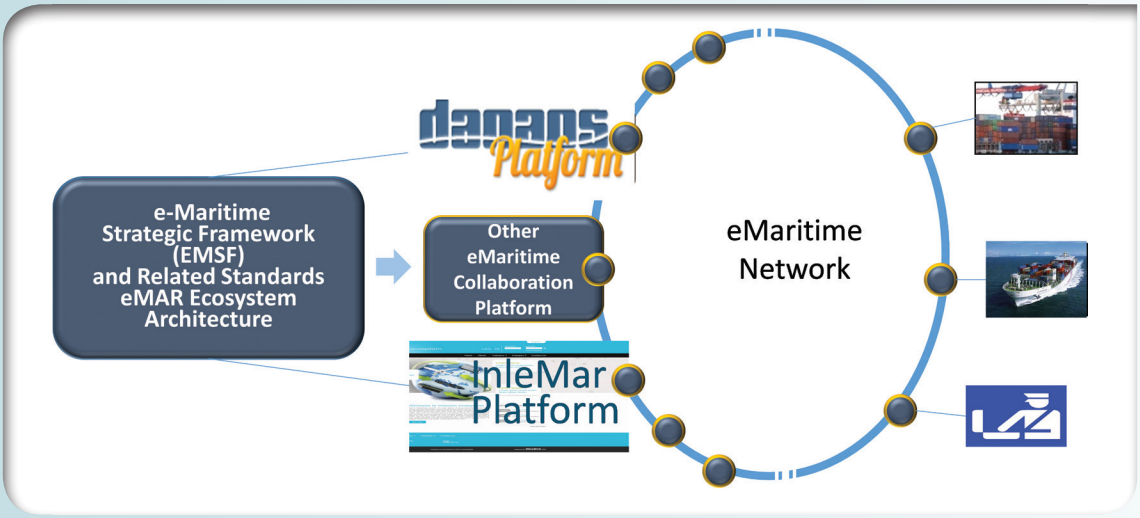
Principal outcome:

The DANAOS platform provides a place to publish and use software services related to shipping. It acts as a node in the e-Maritime Network and offers a directory of e-Maritime services that are already used by a number of shipping companies in their day to day operations.

Principal impacts at EU level:

- EMAR received funding from the EC's 7th Framework Programme DG Mobility and Transport. Consortium: 28 Participants
- Promotes collaboration among shipping companies
- Enables integration between the various in-house systems that shipping companies currently use
- Links business activities with other business partners and third parties, live, through an active shipping directory

- Significantly reduces IT complexities and costs
- Accelerates wider adoption of advanced information and communication technologies by different users in the maritime and supply chain sectors
- Facilitates professional socialising via messages, forum postings, conferencing, etc.



The DANAOS Collaboration Platform was developed within the EMAR project, which aimed to empower the European maritime sector by offering efficient quality shipping services fully integrated in the overall European transport system.

The e-Maritime ecosystem developed within the EMAR project enables advanced business applications for the maritime and port sectors to be made available to potential users over an upgraded information management infrastructure. It facilitates information exchanges which give a user full control over interaction, and allows participants to choose the right mixture of cloud-based, or office-based tasks, in order to tailor their processes according to their needs.

The DANAOS Collaboration Platform is a fully interoperable solution for enhanced collaboration in maritime transport that has been driven by market needs, and is in line with the overall e-Maritime objective of making maritime transport safer, more secure, more competitive and more environmentally friendly.

Future developments envisaged:

The DANAOS Platform will allow companies in the maritime sector to progress faster into the new era of shipping, where teamwork, outsourcing, transparency, and visibility drive improvements in performance, quality, and profitability.

The DANAOS Collaboration Platform is already being used by a number of shipping companies in their day to day operations, and already features published information services, such as:

- Port arrival and departure reporting
- Class Status information services
- Manifest related services
- e-crewing, e-Statement of Fact (Electronic version of the SoF and a standard data model for communicating statement of fact information)
- Energy Efficiency Operational Indicator service requirements
- Port formalities reporting and CO_2 calculations

DanaosONE™ is the first complete e-servicing platform for the shipping industry, based on the European Maritime Strategic Framework (EMSF). It is a professional B2B versatile e-servicing Platform that seamlessly integrates a company's internal operational, safety systems and compliance policies, securely.

The DanaosONE™ Platform is also based on the principle of Single Window, a One-Stop-Shop for all shipping and oil and gas industries. This provides a Portal where diffusion of e-services leverages team work, outsourcing, and transparency, as well as visibility whilst enhancing performance, quality, and profitability.

Either in an Intranet Network, shared within a Company's personnel or in an Extranet Network, operated between each Company's trusted partners (e.g. suppliers, agents, brokers and affiliates), DanaosONE™ saves time and money whilst assuring high Quality of Service (QoS) by transforming traditional transactions to securely offered e-services.

DanaosONE™ uses web plugins that bridge existing in-house back office systems with the platform, without retaining any sensitive corporate information locally, providing advanced security and real-time interoperability.

A quantum leap to collaborative adaptive e-servicing

The DANAOS Collaboration Platform (DanaosONE™) offers a suite of services and can "bridge" any functionality provided by users' in-house back office systems within a network of trusted stakeholders of their selection.

Users can start exchanging information accurately and securely with their suppliers, partners, agents, brokers and affiliates, while avoiding the cumbersome drawbacks of traditional information exchange.

Offered services include:

- Crew Management
- e-Sourcing
- RFQ
- Invoice Reconciliation
- Protocol/Registrar
- e-Drawings

The platform also enables users to launch and make available on demand certain in-house system functionalities as services to their internal users (intranet). This set of services can facilitate two-way secure remote access to corporate information and assure compliance with regulatory and statutory operational and safety processes.

Examples of these services and functionalities are:

- Task Management
- Project Management
- Leave/holiday Management
- Support Tickets
- Collaboration
- Communication

DanaosONE™ provides a set of bundled services that facilitate the Shipping Industry's essential everyday activities, whilst allowing exposure of products and services, creating new business opportunities. Members gain international exposure and endless possibilities to connect with other trusted members.

Examples of these products and services are:

- Directory Services
- Information for Ports
- Formalities for Ports
- e-Sea Weather
- e-Currencies
- Maritime News
- Classifieds
- Virtual Exhibitions
- Forums

DanaosONE™ Technology advantages

Utilising research outputs from key FP7 projects

- **eFreight**: Deliverables related to CRS (work related to cargo data elements); prototype intermodal Next Generation Single Window and e-freight platform.
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Project partners

DANAOS, with partners including BMT, CLMS, Inlecom, EBOS and MarineTraffic.

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The Danaos collaboration platform has been developed as part of the eMAR project, building on FP7 projects in the period 2008-2014. The Danaos platform provides a place to publish and use software services related to shipping

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NOTES

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