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FINAL REPORT 1/2014

FIMECC
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Innovations & Network

2009-2013

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PROJECT HIGHLIGHTS | FACTS AND FIGURES

CONTENTS

PREFACE

FIMECC pioneers created a platform for implementing the 4th Industrial Revolution

In the days when we started FIMECC's first-ever research programme, Innovation and Network (I&N), in 2009, we were a start-up company, with just a vision of what a co-creation and innovation platform could be. We had a solid basis in the strategic research agenda created by Finnish manufacturing, mechanical engineering, marine, and metals industries. We had a good research plan, oriented towards public-private partnership and written by a huge and enthusiastic FIMECC I&N consortium. But what we did not have was tested leadership, decision-making, and management practices. Everybody – companies, universities, research institutions, Tekes, and FIMECC shareholders – was convinced we would get more out of research and development by joining forces and pooling competence. Thank you to all who believed in us and invested in research through FIMECC!

After six years of operation, and a track record in creating results that has been noticed positively all around Europe, we have reached a significant position within European manufacturing R&D&I decision-making. Five years of running and performing FIMECC I&N has taken the consortium far down the academic path and created many new technology openings and applications almost ready to market. According to the feedback, FIMECC I&N participants have reached many of the goals they set in 2009. A more important phenomenon was the excellent performance of the participants in new openings not on the FIMECC I&N agenda at all! This might be the most valuable reason for using FIMECC as a platform in R&D&I work: within a good group a lot of new input arrives for processing, even where it has not been asked for.

The years of FIMECC I&N have included crisis, in the maritime industry and shipyards, but also renewal in the way in which industry and leading research institutes can work together to develop products and services, allowing customers to increase their profitability and environmental achievements. As examples of this, the FIMECC Factory was opened in Turku, and the new FIMECC REBUS programme launched in 2013 to boost the competitiveness of the marine and logistics industries. Innovations & Network programme was the pioneering programme in creating FIMECC's management systems and practices. As leader responsible for the programme, I would like to thank all who contributed to the process and to its success.

The key global discussion in manufacturing in 2013 was the 4th Industrial Revolution. In Germany, this is called "Industrie 4.0", referring to the total digitalisation and connectedness to the Internet of products, services, and processes. This revolution is the first in technology ever to be announced in advance. FIMECC implements the revolution through a wide variety of activities. Our strong presence in Germany through the FIMECC Factory in Aachen, and strategic partnerships with German research and industry networks, help our programme participants to identify new opportunities with the world's technology leaders.

I now invite you to enjoy reading these highlights of the excellent results achieved!

Harri Kulmala
CEO
FIMECC Ltd

Developing a Research Engine

A 48-million-euro research programme has reached its end. The Innovations and Network programme involved the participation of a total of 46 companies and research institutes, and around 200 people. This book will give an idea of what has been achieved. To mention some tangible results, so far 85 scientific peer reviewed publications have been published in international forums. The programme has generated 20 doctoral dissertations and 40 Master's theses, and there have been 4 patent applications, of which 3 have been approved.

Even though international co-operation was not the main issue when it started, the programme has realised more than 150 man-months of international researcher exchange. Worth mentioning is that one researcher spent the entire duration of the programme at Berkeley Haas Business School.

Innovations and Network was the first research programme initiated by FIMECC, a combination of originally separate industry and science-driven initiatives harmonised into one programme, something that is evident in the programme's structure. The success of the programme, however, stems from its bringing together pragmatic engineers and systematic scientists to discuss with each other.

As the first to start, the programme was the forerunner of all the practices within FIMECC. This naturally created challenges for the participants and the programme manager. The commitment and flexibility of the participants has been admirable. Development of the Innovations and Network research engine transformed something looking like a somewhat jerky, unbalanced boxer motor into a smooth running Stirling engine!

It would be unfair to raise any individual result above others. I prefer to point to the FIMECC slogan: 'We boost strategic research – together'.

I would like to thank TEKES, and especially Rauli Hulkkonen, for excellent and patient co-operation, as well as the FIMECC office for its tremendous support. My programme manager colleagues have also given me remarkable support and inspiration. I sincerely hope that the Innovations and Network programme has boosted understanding of the importance of co-operation, and that the scientists and engineers will continue the discussions that have germinated during the programme.

Matti Nallikari
Programme Manager

STAKEHOLDERS PERSPECTIVES

Aalto University

The Innovations and Network (I&N) programme has served as an excellent platform for thematic research bringing together top university research and practical applications by firms. One of the great achievements in FIMECC I&N is the development of different business models and their selection processes for project-based firms. This development – which has led to significant improvements in the practical applications of participating firms – is built on well-integrated and vivid research work across Finnish universities, headed by Professors Karlos Artto (Aalto University), Kim Wikström (Åbo Akademi University), and Jaakko Kujala (University of Oulu). These three professors have co-authored several top-level journal articles in the FIMECC I&N programme on business models, project-based firms and solutions business. These articles have mainly been published in the International Journal of Project Management, the leading journal in its field. Another research area with significant accomplishments in the Innovations & Network programme is sustainable safety research, led by Professor Pentti Kujala. This research has resulted in world-class breakthrough results in two distinctive areas: application of ultra high strength steels in cruise ships, and analysis of the flooding process of damaged ships in extreme weather conditions. These FIMECC I&N results have been published in scientific top-level marine journals, with high impact and appreciative feedback from marine community scholars worldwide. The FIMECC I&N research area of product and service design, led by Professor Turkka Keinonen, has produced novel knowledge for the field of art and science. This design research area has also contributed in an excellent manner to the broad cross-disciplinary foundation in FIMECC I&N.

International scholarly activities in the FIMECC I&N programme include several months of visits by researchers and professors to and from international universities. Collaboration with Professor Raymond Levitt's Global Projects Center at Stanford University, in particular, has been close, concrete, and significant, leading to researcher visits from the Innovations & Network programme's well-integrated Finnish project business professors' team (Artto & Wikström & Kujala) being mainly directed there. In connection with the Innovations & Network programme's international activities, this same Finnish professors' team joined with Stanford's Global Projects Center in organising a successful joint seminar in 2010 on the Stanford University campus with the theme: Global Projects, Business Networks and Project Business. Another seminar on the project business theme was arranged on the Aalto University campus in October 2011, targeted primarily at Finnish firms and focused on the implementation of FIMECC I&N research results in practice. Finnish professors participating in the Innovations & Network programme have also collaborated to a significant extent with professors at the University of California, Berkeley.

FIMECC's I&N programme has been extremely well-coordinated, and has therefore enhanced both domestic and international cross-university research activity, as well as collaboration between the universities and firms participating in the programme. As a platform for new knowledge creation, the Innovations & Network programme has allowed enough flexibility and freedom for highly ambitious professors to use their international scholarly network, and make FIMECC I&N research visible in international arenas by publishing in international journal outlets and co-authoring with international professor colleagues, as well as by using other means for inviting international colleagues to share the attention on cases involving Finnish firms.

International academic visibility – and the potential appreciation a Finnish professor might enjoy in the competitive international scholars' market – requires articles to be publishing in international top journals. Without this visibility and appreciation, development of the advanced management practices of Finnish firms cannot be linked to understanding at the global level of how competitor firms are managed. The FIMECC I&N programme has enabled the creation of just such visibility and appreciation for Finnish professors in its focused theme areas. It has been an excellent example of the successful cross-disci-

plinary collaboration that is a central objective on both the Aalto University and the FIMECC agenda. The Innovations & Network programme can be used as a prime example for future programmes when selecting good cross-firm and cross-university co-ordination practices. I am very much looking forward to continuing the well-established collaboration between FIMECC and Aalto University in forthcoming FIMECC's research programmes.

Karlos Artto
Professor, Aalto University

STX Finland Oy

The FIMECC I&N research programme offered the Finnish maritime industry and STX Finland an excellent forum for improving the competitiveness of the shipbuilding industry, and for increasing co-operation within the large maritime network responsible for its innovative products. The FIMECC I&N targets were well aligned with STX Finland's strategic goals, and the project offered an interesting opportunity to combine the knowledge and competence of various industrial partners, research institutions and universities in developing the industry and its products for the dynamic global markets.

More than 50 companies and institutions were brought together by the FIMECC I&N programme to work for a single, common target – to secure the viability of the Finnish maritime industry for the foreseeable future. While a clear demonstration of the cluster's commitment, the large number of participants also illustrates the great necessity and importance of this type of multi-disciplinary research and development programme: a forum for shared knowledge and experience, for shared innovation of business opportunities and the products of the future; a forum open to all from the smallest domestic company to the largest global enterprise. The Innovations & Network programme has simply excelled in supporting this unique, Finnish style of research co-operation.

STX Finland has found the FIMECC I&N programme to be very important for its business and product development. Many of its strategic research and developed tasks scheduled over the past five years were undertaken within the programme, and developed together with the best resources of the maritime cluster. The total investment in the Finnish maritime industry of over 50 million euros significantly improved the competitiveness of this branch of industry, with a crucial impact on the realisation of the latest ship orders. This will certainly help in securing future orders for Finnish shipyards and the maritime industry.

STX Finland is very grateful for the opportunity offered by the FIMECC I&N programme to co-operate with domestic and international maritime industry, research institutions and universities, and to share in innovating and developing the future of the Finnish maritime industry. We also owe sincere thanks to the Finnish Research Funding Agency for Technology and Innovation (Tekes) and FIMECC Oy for their invaluable contribution, for without their support the programme could not have reached its successful conclusion.

STX Finland Oy

Jari Anttila
Deputy Chief Executive Officer

Platform and Product Management Development

Advanced design reuse requires systematic development and management of applied technologies

Platform management methods, tools processes and established organisations developed in WP 1 tasks 1 and 2 will enable efficient design reuse. Furthermore, product technologies can be developed consistently according to customer needs. This will increase customer value, enhance quality and reduce overall costs as the need for project-specific management is decreased.

In shipbuilding, as well as in any projective businesses, design reuse has typically exploited reference project processes, design libraries or a combination of these methods. In the reference project model, old projects are used as templates for new customer projects (figure 1). In the design library model, new customer projects are based on a collection of technical solutions that have been identified as feasible (figure 2). Both these methods, although promoting design reuse, have significant disadvantages. First of all, the copying of old projects works against elimination of design errors as there is typically no systematic evaluation of "good" and "bad" templates. Over time, continuous copying and modifying tend to result in a huge variety of technical solutions for similar purposes, creating problems from a production point of view. Collection and the use of design libraries embody similar problems. Design libraries tend to build up without control and eventually also contain multiple solutions for similar purposes. Furthermore, use of design libraries is often up to the individual designer; there is no guarantee or control, therefore, regarding the actual reuse of solutions.

Figure 1.
Reference project model: old projects are used as templates to new ones

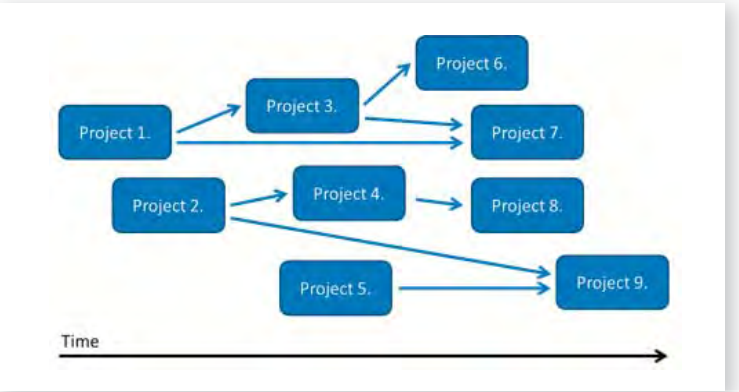
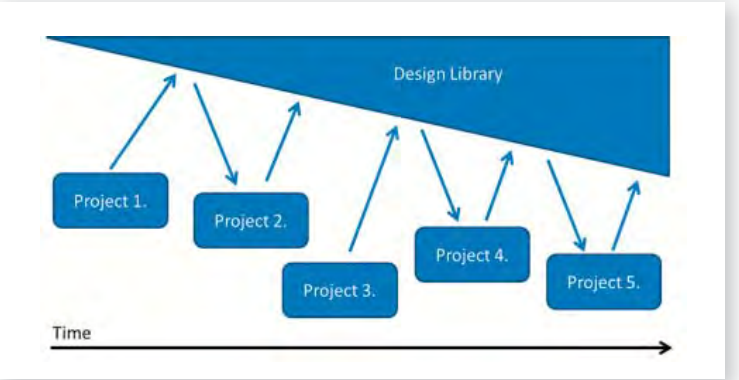
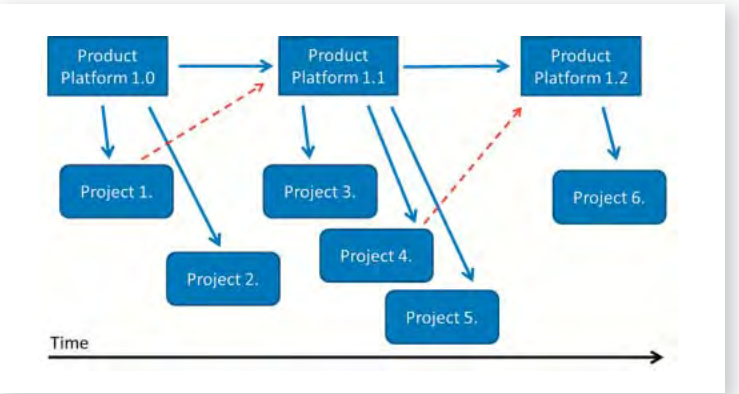


Figure 2.
Design library model: collection and re-use of feasible solutions



The more advanced method for overcoming these problems is the development and use of product platforms. In an applied product platform method, customer projects are based on a product platform, and the new technical solutions are implemented via platform versions. Where there is a need to add customer-specific elements or make modifications at project level, these are implemented through a systematic evaluation process, rather than automatically in the product platform as new features.

Figure 3.
Product platform method: customer projects are based on platform solutions



PROJECT NAME

WP 1 Product management processes and tools

Task 1–2

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
HENRI PAUKKU CARGOTEC FINLAND OY	**CARGOTEC FINLAND OY** **STX FINLAND OY** **VARIANTUM OY**	**2009 – 2011**	**1.004 MILLION**

Platform and Product Management Development

Main targets & motivation

Shipbuilding is a typical example of project-based business, where daily business is driven primarily by individual customer projects; these customer-specific projects are nevertheless typically based on modifications of previous deliveries. This approach has its effect on the management of technological solutions. In project-based businesses, management of product technologies (from applied solutions to detailed component designs) has traditionally been seen as an integrated part of the customer projects. The main challenge that arises is uncontrolled variation between individual projects and the lack of top-level, well-defined solutions (e.g. product platforms). The target within this project was to develop platform management methods, tools, processes and organisations for the shipbuilding business environment – namely for cruise ships and merchant ship hatch covers. This development was carried out in parallel with the development of product architectures (WP 2) and design processes tools (WP 3).

Novelty & added value brought by this work vs. state-of-the-art

Major differences at company level make it hard to define the precise situation regarding platform management in the shipbuilding and marine technology businesses. Product platform management in this sector is generally not at a particularly high level when compared with many other industries facing a similar complexity (e.g. the automotive and aviation industries). Although

platform management in itself is no novelty, the same cannot be said with regard to its successful application in the shipbuilding business environment.

Research problems solved

How do we manage product platforms in shipbuilding and other projective marine technology businesses?

Results

(Cargotec) This project developed a new process and organisation for the management of merchant ship hatch cover platforms. Previously, nearly all management related to product and technology was carried out in parallel with individual customer projects. As a result of this project, hatch cover product platforms can now be managed consistently and efficiently with nominated people and resources.

(Variantum) A literature review was conducted to forecast the problems in implementing platform technology. This also included material from previous related projects. The message of this review was clear: (1) platform technology is exploited extensively in the automotive and electronics industries, (2) effective use of the technology requires organisational support, (3) project industry processes supporting platform technology are still in their infancy.

A framework to support platform documentation was developed as a derivative of Variantum's PDM and configurator systems, with the configurator part piloted using Cargotec's new hatch platform.

In shipbuilding, as well as in any projective businesses, design reuse has typically exploited reference project processes, design libraries or a combination of these methods. In the reference project model, old projects are used as templates for new customer projects (figure 1). In the design library model, new customer projects are based on a collection of technical solutions that have been identified as feasible (figure 2). Both these methods, although promoting design reuse, have significant disadvantages. First of all, the copying of old projects works against the elimination of design errors as there is typically no systematic evaluation of "good" and "bad" templates. Over time, continuous copying and modifying tend to result in a huge variety of technical solutions for similar purposes, creating problems from a production point of view. Collection and the use of design libraries embody similar problems. Design libraries tend to build up without control and eventually also contain multiple solutions for similar purposes. Furthermore, use of design libraries is often up to the individual designer; there

is no guarantee or control, therefore, regarding the actual reuse of solutions.

The more advanced method for overcoming these problems is the development and use of product platforms. In an applied product platform method, customer projects are based on a product platform, and the new technical solutions are implemented via platform versions. Where there is a need to add customer-specific elements or make modifications at project level, these are implemented through a systematic evaluation process, rather than automatically in the product platform as new features.

Networks and international co-operation

Tampere University of Technology, Department of Production Technology

Applications & impact

Developed platform management methods, tools processes and established organisations will ensure that product technologies are developed consistently according to customer needs. This will increase customer value, enhance quality and reduce overall costs as the need for project-specific management is decreased.

Configurable Machinery Arrangement

Cost efficiency with configurable modules

The FIMECC I&N programme has produced a remarkable rise in the prefabrication of machinery systems. In the machinery outfitting of MS Viking Grace, the degree of prefabricated outfitting was increased from 15–20% to 50%. This is expected to reach 70% in forthcoming projects.

Figure 1. **Functional machinery module**

Modern shipbuilding is an assembly-type industry, where the major share of design and production is located outside the shipyard, and widely – almost globally – spread abroad. The vital challenge for cost-efficient operation is to create common practices for all participants.

Improvement was needed in the following items:

- submitting the lessons learnt from previous projects to the global network of subcontractors and designers
- information transfer between the participants
- scheduling of various design and production phases
- standardisation of subcontracted modular production.

Arrangement standardisation was decided upon to increase the machinery outfitting level. The long-term target is to develop a configurable modularised production structure where the interfaces to other participants are clearly determined. Modularised units should be created from a combination of standardised and tailored parts, with interfaces set so that the standardised part is as large as possible. Using this approach, modular units form functional systems that can be built and tested in the workshop. Standard parts are available for the designer right at the start, so that all design effort can be focused on the parts to be tailored. Savings were achieved because of reduced design error, shortened production schedule, and increased prefabrication.

Figure 2. **Prefabricated piping modules assembled in a workshop**

PROJECT NAME
WP 2
Platform Solutions

Task 1

CONTACT PERSON
RISTO RANTANEN
STX FINLAND OY

PARTICIPANTS (ORGANISATIONS)
STX FINLAND OY
TECHNOLOGY DESIGN AND ENGINEERING ENGn'D OY
ARCTECH HELSINKI SHIPYARD OY

PROJECT DURATION
2009 – 2011

PROJECT VALUE (EUR)
0.431 MILLION

Configurable Machinery Arrangement

Main targets & motivation

The shipyard was previously an independent production plant: almost everything was made by the yard, and know-how retained within the shipyard gates. Today the shipyard is an assembly site, where production is widely spread beyond the gates. Characteristic of today's activities is the outsourcing of design, with different designers for each project prohibiting the learning process. Information flow among the numerous participants is a challenge, and schedules are tight. Outsourcing also extends to the production of modules, creating difficulty with standardisation. All this leads to erroneous design and high quality costs.

To overcome these difficulties, standardisation was introduced to increase the outfitting ratio, with tailor-made solutions minimised. The long-term target is to develop a configurative modularised production structure where the interfaces are clearly determined. Another target is to define common work practices for all the participants.

While the modularised units should be built up from both standardised and tailored parts, the goal is for the standardised parts to be as large as possible. Modular units will form functional systems that can be built and tested in the workshops. The standard parts are ready for the designer, so that the entire design effort is reserved for the parts to be tailored. Savings can thus be achieved through a shortened production schedule and increased prefabrication level.

Results

It was understood at the start of the work that the original plan of attempting to design 1–2 standardised machine rooms for cruise vessels was impractical, and that effort should be put into more moderate modularisation and the standardising of smaller sub-assemblies. Certain rooms may be standardised, at least with a few variations, and it is also possible to design more standardised machine units. The potential for monetary benefit is lower in machine units than in whole areas, but the likelihood of success is greater.

Several objects for modularisation were discovered: these included separator rooms, fuel stations, air conditioning and refrigerator compressor rooms, fuel feed units, lubrication oil units, cooling units, ballast water units, starting air units and service and control air units.

Research remained at a more conceptual level than anticipated. The problem is often not modularisation itself, but the lack of awareness among designers of how it should work. A situation where the professionalism of the designer cannot be relied upon requires a general change of mind set. At the outset, a designer should be equipped with rules of thumb and the principles of modularisation.

Key publications

Number of Master's Theses: 1

Applications & impact

The results are used in vessels in both the contemporary and future order book. Although not entirely due to enhanced modularisation, the outfitting ratio at launching event has been raised from 15–20% to 50–60%, with future projects expected to reach as high as 70%. This is a significant increase.

Configurable Solutions

Configurable architecture eliminates idle time

Existing lead time for customer projects has been reduced up to 90%. At the same time the adaptability to fulfill customer specific needs is maintained.

The resulting structures can be summarised as standardised and optimised but still flexible for customer-specific solutions. **The most important modularity feature relates to interchangeability of drive, stopper and steel structure modules. This reduces the need for redesign in cases where customer requirements change during the project. Furthermore, interchangeability enables the use of pre-analysed steel structure modules, as steel structure can be defined according to size and loading parameters only.**

Hatch covers are used in merchant marine ships to enable opening and closing of cargo holds, carry possible deck cargo and keep water out of the ship's holds. Hatch covers are weight-sensitive products determined by various requirements from shipyards and ship owners. Variation in ship's particulars leads to project-specific solutions despite products look alike on the face of it. Variations occur typically in hold opening dimensions, ship's main dimensions, location of structural components, drive types, steel materials and scope of delivery.

Within this project new product architectures for hatch covers were developed. Architecture is fully configurable. All design variables are standardised, parameterised or modularised. The hatch cover product architecture is introduced for large and medium-sized bulk carriers, side rolling and folding type covers.

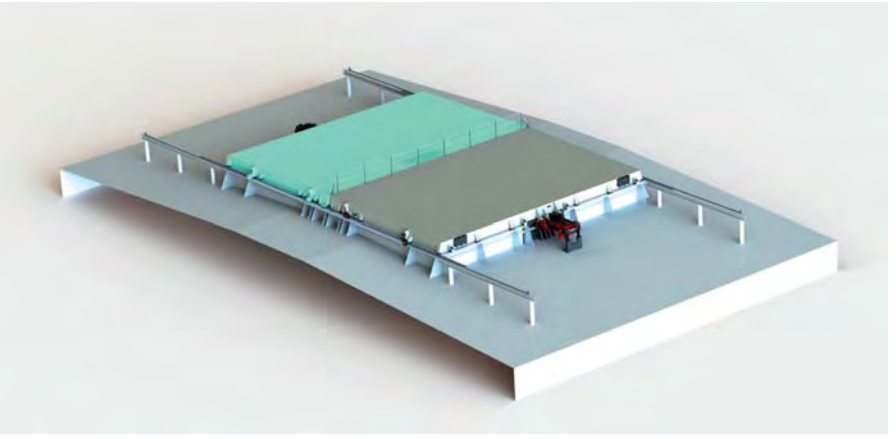


Figure 1. **Modular and configurable hatch cover architectures**

PROJECT NAME
WP 2
Platform Solutions

Task 2

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
HENRI PAUKKU	**CARGOTEC FINLAND OY**	**2010 – 2013**	**3.231 MILLION**

Configurable Solutions

Main targets & motivation

During the past ten to fifteen years, configurable product architectures have become increasingly popular in industrial and maritime equipment manufacturing industry. Hatch covers, used in various types of cargo ships to keep water out of cargo spaces, shelter the cargo below decks and support cargo on deck, are weight-sensitive and design-intensive products. Variation in ship's particulars, component locations, drive types, steel materials and scope of delivery leads to very distinct solutions, despite products appearing to look alike. This variation often leads to 8 weeks of design lead-time. The requirement for 150 to 200 design drawings and documents creates a significant amount of work that is largely repeated from project to project. The main target for this project was to **develop configurable product architectures** for existing hatch cover types to bring about a radical shortening of existing design lead-times and to automate repetitive design and documentation tasks.

Novelty & added value brought by this work vs. state-of-the-art

Existing design practices in the hatch cover industry are based on the engineered-to-order process paradigm (ETO), meaning that a considerable amount of engineering design is required for each customer project. Configurable product architectures will reduce design lead-times radically, thus creating value both internally and externally. Use of configurable product architectures also enables radical developments in the sales, purchasing, logistics, manufacturing and service functions compared to existing state-of-the-art.

Research problems solved

How to develop configurable product architectures for industrial products with considerable variations in design parameters, interfaces and customer preferences.

Results

World's first fully configurable (all design variables standardised, parameterised or modularised) hatch cover product architectures introduced for large and medium-sized bulk carriers (side-rolling and folding-type covers). With these product architectures it is possible to reduce existing design lead times by up to 90%, while at the same time maintaining the adaptability to fulfil customer specific needs. Development of a third type of hatch cover, lift-away covers for container ships, was started and will continue.

These hatch cover architectures consist of parametric main steel structure with either pre-defined loading capacities or automated strength analysis process, together with modular operation system options and standardised components. Along with new design tools and processes, configurable product architectures will enable the transition from ETO to configured-to-order paradigm (CTO).

Networks and international co-operation

Research and development work was done in co-operation with Tampere University of Technology, Department of Production Technology.

Applications & impact

Developed side-rolling hatch cover architecture has been applied in the following shipyards and vessels.

SungDong Shipbuilding and Marine Engineering:
S1194-5 / Quintana / 1355773

Hyundai Mipo Dockyard:
6116-9 / Novoship / 1355582
6146 / LS-Nikko / 1355683

Zhejiang Zhenghe Shipyard:
70058-9 / Zhejiang Province Zoushan Bishenglong Ship Co. / 1115890

Jinling Shipyard:
8100423-4 / Chios Navigation / 1115738

Jiangsu Yangzijiang Shipbuilding Co:
YZJ2013-1055-6 / Pegasus Shipping Pte. / 1116168

Yangzhou Dayang Shipbuilding Co:
DY6001 / Franco Compania Naviera S.A. / 1116136

Shanghai Waigaoqiao Shipbuilding Co:
H1312-3,39-9 / Oceanbulk Maritime S.A. / 1116181

Dalian Shipbuilding Industries Co:
4344-45 / Frontline Management AS / 1116135

Developed bulk folding hatch cover architecture has been applied in the following shipyards and vessels.

Hyundai Mipo Dockyard:
088-9 / HI-Invest / 1355775

PROJECT NAME
WP 2
Platform Solutions

Task 3

Cabin Area Platform

Innovative materials meet systemised project execution throughout the cabin area

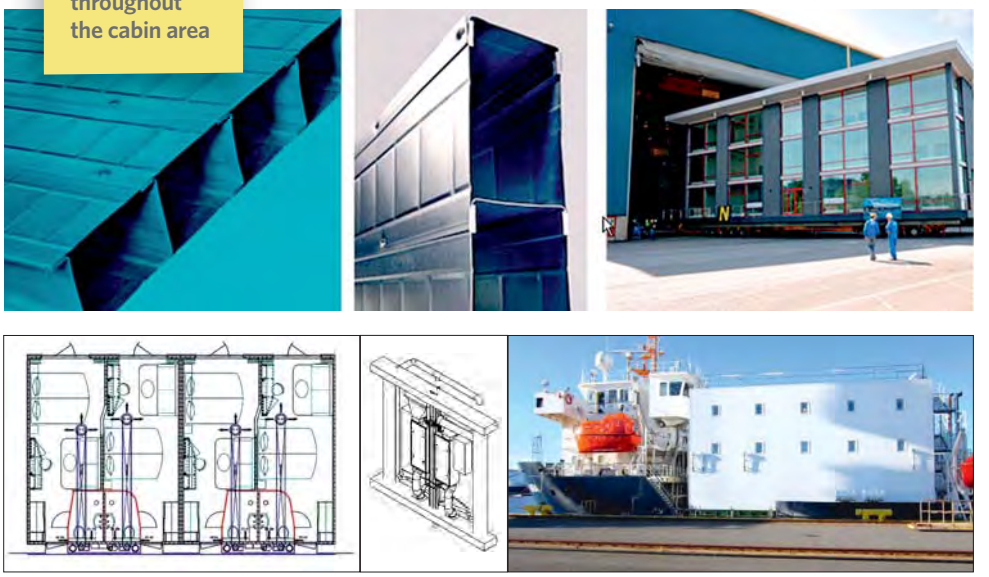


Figure 1. **Steel sandwich panel and its path to the full scale marine product**

The feasibility of using steel sandwich structure in large passenger vessel cabin areas has now been proved by means of extensive FEM calculation. A sandwich structure enables more cabins and a bigger earning capacity compared with a traditional steel structure. To facilitate its use, major emphasis was put on the detail design of connection between the sandwich and traditional structures. Shippax has developed manufacturing techniques and preliminary building processes for the new innovative sandwich-type building material. This material has the potential to allow integration

of multidisciplinary building blocks, including HVAC, electrical systems, piping and the final surface materials for both exterior and interior use. Besides system integration, the structure possesses the crucial ability to form part of the ship's load-carrying hull girder. The structure has already found successful use in house building and in floating structures.

A comprehensive study of current building practices for cabin areas revealed the possibility of a reduction of up to 50 per cent in parts for the various HVAC and pipe systems. The Product Structure Domains, or Design Structure Matrix method, is a procedure for specifying potential modular concepts. The most common HVAC systems in a typical cabin area were the main objective, which involved the design of HVAC routing modules for cabin areas.

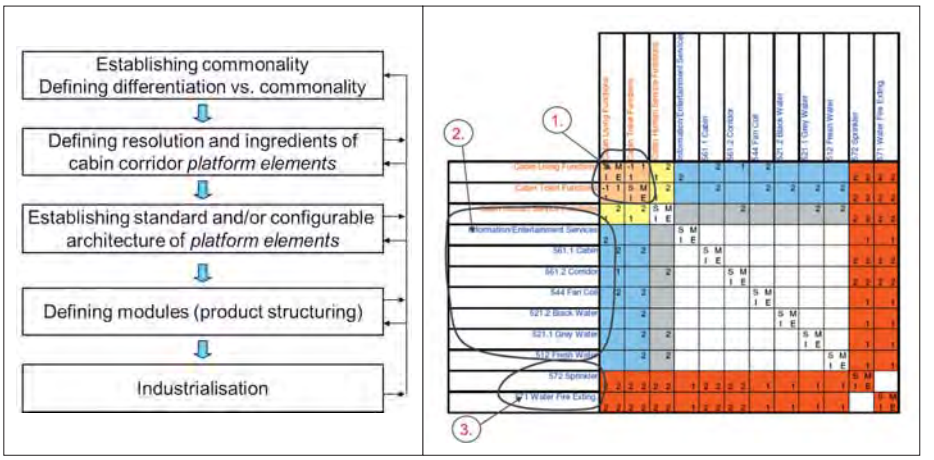


Figure 2. **Procedure of differentiation and association for specifying potential modular concepts**

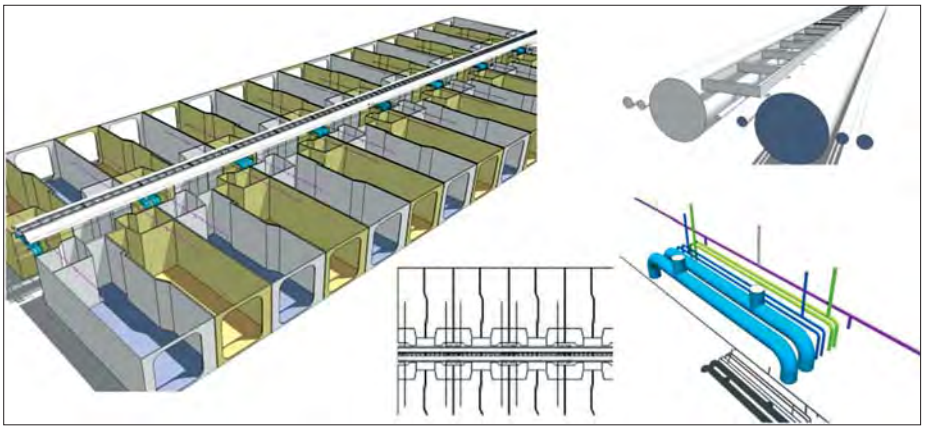


Figure 3. **Routing modules**

PROJECT NAME
WP 2
Platform Solutions

Task 3

CONTACT PERSON
JUHA KÄRKÄS
STX FINLAND OY

PARTICIPANTS (ORGANISATIONS)
STX FINLAND OY
STX CABINS FINLAND OY
OY SHIPPAX LTD
EUROPLAN ENGINEEERING OY
JUKOVA OY
LAIVASÄHKÖTYÖ OY

PROJECT DURATION
2009 – 2011

PROJECT VALUE (EUR)
2.851 MILLION

Cabin Area Platform

Main targets & motivation

Cabin areas generally cover more than a quarter of all deck area in a passenger ship. The cabin areas of a large modern cruise liner will often contain more than a thousand instances of potentially repeatable design. The potential for standardisation to rise with increase in volume is common knowledge in other industries. Standardised design and modularity promises several benefits: reuse of design, scale economics, improved control and quality, reliability, reduction of waste, reduction of production cost and mass customisation. Development of the building method has failed to keep up with the speed of growth in ship size.

Cabin areas are built through collaboration involving shipyard, cabin manufacturer and the contractor responsible for the area in question. Contractors carry a major burden because of the vast scope of their work. All three parties are dependent on each other's decisions, which means that work productivity is also interdependent. This task brought all the main parties together to develop building methods and processes. The companies taking part in this development were STX Cabins Finland, Shippax, Europlan, Jukova and Laivasähkötyö.

A separate target was to enhance the use of innovative structures in the cabin areas. The motivation for using innovative structures is to save weight and space. The Fixcel steel sandwich structure developed by Shippax Ltd particularly fell within the scope. The challenge of innovative structures lies in how to integrate them with the conventional structure and the integrity of the hull girder.

Results The items with most potential for development were first identified. Careful redesign was carried out on the typical re-usable technical cabin concept, and a mock-up installed on board to assess savings potential. Further theoretical study was performed for all the most common HVAC systems in a typical cabin area. Studying techniques were based on the product structure domains method.

Conclusions of the variant-reduction study were:

- modularity can be significantly increased in the cabin area
- concept phase decisions are the key to obtaining maximal benefit of design reuse of larger modular structures
- variations are better controlled in early basic design phases, especially in the ship's concept phase
- advanced technical modular solutions can be brought into practice.

It was also noted that the size of the modular units studied had multiple effects on the other desired characteristics. Uniform, highly repeatable design is more difficult to find, for example, where the modular structure increases in size.

A considerable part of the work was dedicated to arriving at the bigger picture regarding the potential for sandwich structures in shipbuilding. The sandwich structure's ability to participate in the global ship strength was studied by means of selected FEM analyses in which a traditional structure was replaced by a sandwich structure. The analysis revealed that, with some restrictions, the use of sandwich structures in large scale is feasible.

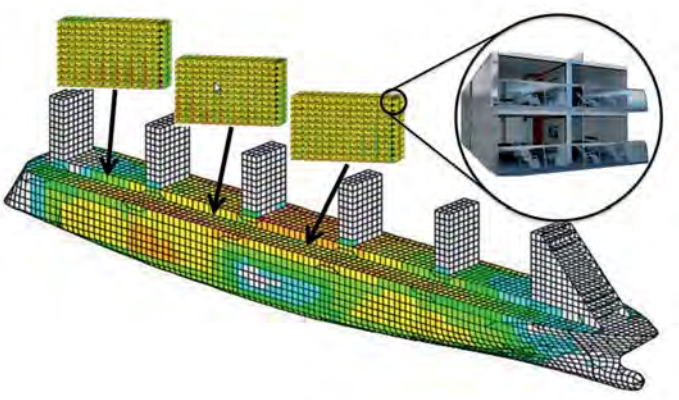


Figure 1. **Use of sandwich structures in a large passenger vessel**

Various studies and development work were carried out as alternative ship concepts alongside that of the ship itself. These subtasks included the sandwich cabin concept and the technical module concept for HVAC supplies of the cabin area. Major emphasis was also placed on detailing how the traditional steel and the sandwich meet, as these are totally new interfaces in the sandwich cabin area concept.

Applications & impact

A standard solution for cabin supply systems has been introduced. Use of parts in various HVAC and pipe systems for cabin supply can be reduced by up to 50 per cent.

HVAC routing modules for cabin areas are in the first implementation phase.

A ship concept, designed for massive use of sandwich structure, has been introduced to selected clients.

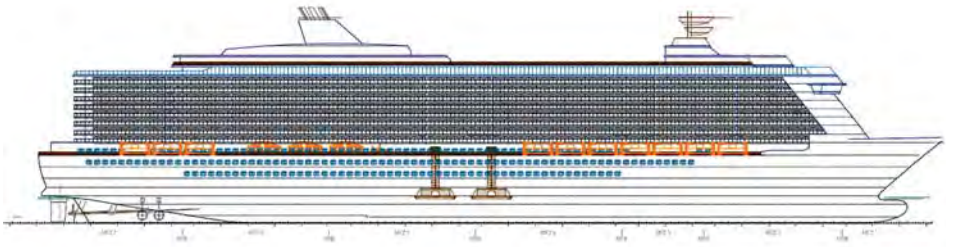


Figure 2. **Passenger ship concept with cabin area of sandwich structure**

HVAC Solutions

Superb modularity

The construction of a ship typically comprises a multitude of different operations, including various types of modular solutions for a range of facilities and applications. Such modules are typically prefabricated and fitted out separately from the ship hull building process, and delivered to the shipyard at an appropriate time for installation. Ship cabins are one example of modules typically installed on board a ship.

Use of a modular structure, however, especially for structurally heavier projects, has frequently resulted in considerable problems from the shipbuilding standpoint, such as the substantial weight of the modular framework, more problematic final connections and maintenance operations, and a considerable increase in hot work and installation hours in the process of fixing the module in place. A particular difficulty arises over the modularisation of aggregates and equipment in which the module extends vertically over two or more decks, typically the case with air conditioning units to be installed in ships' fan rooms.

STX therefore began improving the AC-room building method, and the solution that has been developed and patented provides a capability, notably in the case of prior-known, heavy entities, for complete elimination – or at least substantial mitigation – of the modularisation problems described above.

The developed solution modularises the machine, aggregate or other type of equipment entity in such a way that it can be attached to the module frame during prefabrication. The module is a self-supporting structure, typically including horizontal as well as vertical brace members. Its construction also allows the vertically extending frame components, including any diagonal braces, to be removed after onboard installation.

Figure 1. **3D design model of a 4-deck-high AC room module**

In an anchored module, this enables the space occupied by the module frame to be minimised, providing room around a securely installed equipment unit for necessary retrofitting operations and equipment maintenance. The removable frame components also minimise the module's burden on the ship's total weight.

The modular solution developed resulted in significant savings in production hours, provided more comfortable working conditions, improved safety and better quality.

Figure 2. **One of the AC room modules ready to be lifted on board newbuilding 1383, Mein Schiff 3**

PROJECT NAME
WP 2
Platform Solutions

Task 4

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
OLLI SALVI	**STX FINLAND OY**	**2009 – 2011**	**0.150 MILLION**

HVAC Solutions

Main targets & motivation

- More productive building method
  - Less work in the ship, earlier production in better conditions with better efficiency
  - Solid station indoors with lifting facilities enables more productivity
  - Better HSE
- Shorter production period
  - Modules can be built earlier
    - Shorter lead time
  - Earlier commissioning of AC units
    - Plug-in and start commissioning much earlier compared to normal building method

Results

- Appr. 30% saving in production hours
  - Better building conditions
  - Better logistics
  - Better follow-up with better storage arrangement
  - Shorter lead time
  - Better HSE
  - Better quality
- Patent is now valid.

Key publications Number of patent applications/patents: 1

Networks and international co-operation

Development work was carried out in co-operation with suppliers, ship owners and classification societies.

Applications & impact The developed modular solution resulted in significant savings in production hours, provided more comfortable working conditions, improved safety and better quality.

Figure 1. **AC room module installed on board the ship in the dry dock, and the grand block is lifted over it**

PROJECT NAME
WP 2
Platform Solutions

Task 5

Platform Conversion for Lifecycle Improvement

Double cabin solution for ferry refit

The target was to convert an existing car ferry into a passenger vessel by fitting cabins on the trailer decks.
The arrangement should fulfil all requirements of

- rules and regulations regarding fire safety
- technical issues regarding systems
- easy installation.

With the achieved solution in a ferry of 30,000 GT the cabin capacity can be increased from 200 to 1,000 in an economically feasible way.

Figure 1. **Double cabin unit**

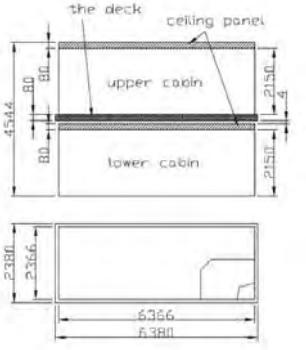


Figure 2. **Double cabin unit transverse section**

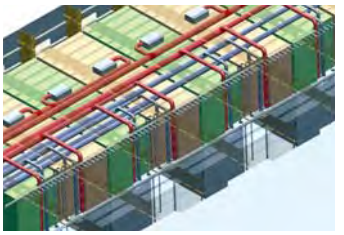


Figure 3. **Pipes routing**

Figure 4. **Units installed in ship's hull construction**

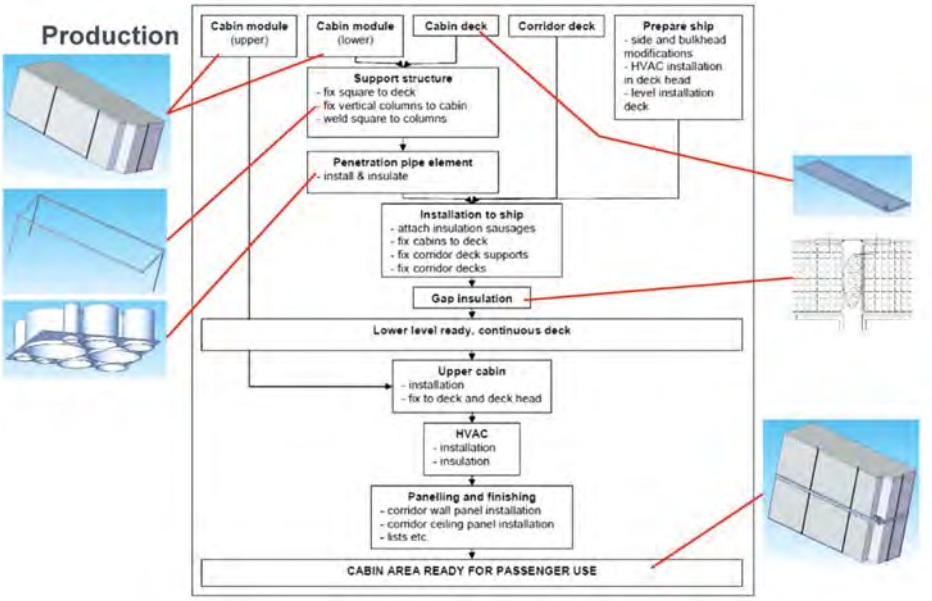


Figure 5. **Assembly flow chart**

Key points of the concept:

- Two cabins mounted on top of each other in a double cabin unit, to fit into a traditional trailer deck
- Lightweight support structure built around lower cabin modules
- Intermediate sandwich deck installed between the cabins to fulfil SOLAS A-15 fire category
- Each tower self standing, attached to floor and ceiling
- Minor connections fitted to side shell and cabins next to the unit
- Separate intermediate corridor and deck elements installed
- Required steel deck height per cabin unit 300 mm lower than normally required in a traditional construction
- Weight of the intermediate sandwich deck lower than in a traditional construction (43.5 kg/m^2 versus 60 kg/m^2)
- Size of double cabin unit – width 2380 mm, height 4544 mm and length 6380 mm
- Weight of a double cabin unit ca. 4785 kg
- HVAC systems enter cabins vertically; pipes routed through the second cabin level deckhead
- Simple integrated pipe elements installed for quick installation of penetrations.

PROJECT NAME
WP 2
Platform Solutions

Task 5

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
DAN WESTERLUND STX FINLAND OY	**STX FINLAND OY** **STX FINLAND CABINS OY** **ALVARS OY**	**2009 – 2011**	**0.131 MILLION**

Platform Conversion for Lifecycle Improvement

Main targets & motivation

The target was to convert an existing car ferry into a passenger vessel by retrofitting cabins on the trailer decks. The arrangement should fulfil all requirements of

- rules and regulations regarding fire safety
- technical issues regarding systems
- easy installation

The research questions were how to

- fit two cabin decks in a car deck height that is normally 5.4–5.6m
- arrange routing of pipes and cables
- arrange passive fire suppression.

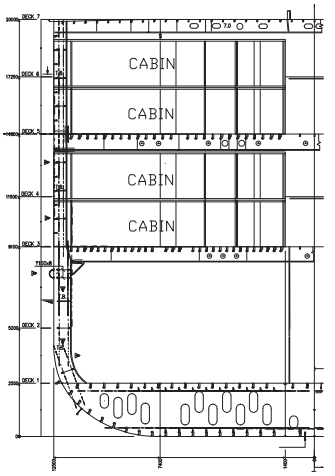


Figure 1. **Cabin position in the ship's cross section**

Results

It was obvious that a normal steel tween deck construction is excluded because of insufficient deck height on trailer decks. The cabins should be modular and stacked on top of each other in two layers with a sandwich plate construction in between.

A typical existing vessel was chosen as basis for the research – MS Superfast, built in STX Turku shipyard. A 3D model was created to enable exact determination of geometry and routing.

Materials were chosen for the tween deck and seals between the cabins and ship constructions.

Support structural calculations were made, and concept drawings produced for the developed cabin module and for routing of cables and pipes.

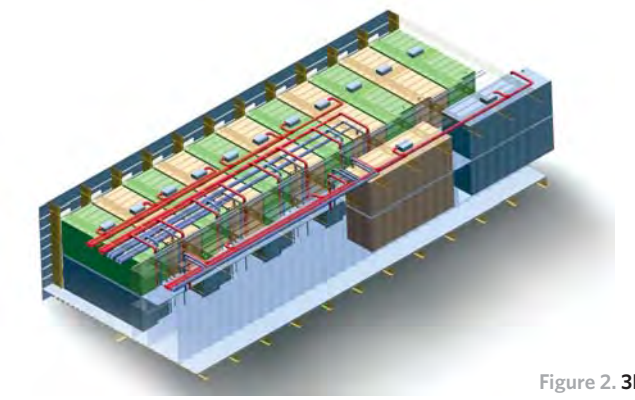


Figure 2. **3D model of a trailer deck layout**

Co-operation partners

STX Cabins Finland contributed with modular cabin technology and choice of materials.

Alvars Oy, Raisio Finland, made a 3D model of the spaces and outfitting.

Targets and markets

There is a substantial second-hand global market for reasonably priced ferries. Ship owners can convert a ferry into a passenger ship in an economical way.

The short building time is an important feature. The work can even be done at quayside without the need for docking.

There are also some ice strengthened ferries on the market which can be converted easily into expedition cruise ships for a growing Arctic market.

Implementation

The results have not yet been implemented. A fire test must be performed. Few concept design proposals have been indicated to ship owners.

Configurable vessel platform and standardised processes

Configurable Ship Systems

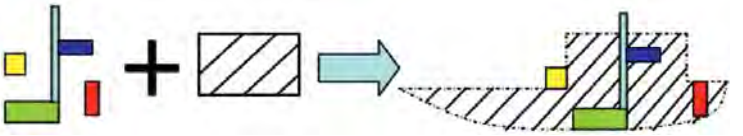


Figure 1. **A vessel platform from configurable solutions**

Configurable solutions, modularisation and standardisation have been top issues for technology industries for quite some time. The aim of the project was to apply these ideas to shipbuilding. New regulations were also launched during the project, such as the SOLAS rule Safe Return to Port, published by the International Maritime Organization's Marine Safety Committee, specifying the safety performance requirements for securing safe return to harbour after an accident. With safety being the top priority for STX Finland, implementation of the new regulations formed the other main activity in the project. STX Finland also conducted studies on its vessels' performance in several areas.

The scope of the project was extended during the period, with further knowledge being achieved on building special vessels. The standardised processes defined in the development project were implemented in these newbuilding projects, which enabled Finnish shipbuilding to include a new competitive product segment in the portfolio. There was also a relevant increase in knowledge of the requirements in demanding Arctic conditions, which is highly significant as Finland has recognised Arctic know-how as one of the key strategic knowledge areas for the Finnish marine industry.

Result 1: Flooding simulations

STX Finland Oy created a process offering the latest technology and know-how in passenger ship safety simulations. Numerical flooding simulation is an efficient and state-of-the-art method for optimising the internal watertight integrity of a passenger ship, and for increasing passenger ship safety in flooding scenarios. Previously, such services were only offered to passenger ship operators by a few universities in Europe.

STX Finland Oy, together with NAPA Oy, created the necessary software modules for NAPA software and a simulation process. Results were used to create operational instructions for damage cases and training of the crew. The results also provided abundant new information for rule development on the behaviour of ships in damage scenarios.

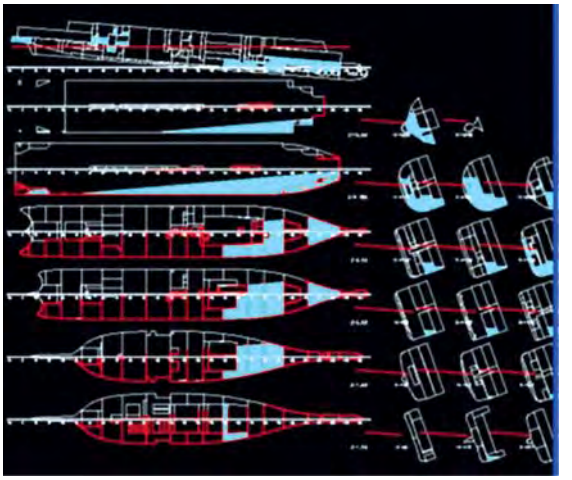


Figure 2. **Some very long damage cases resulted in capsizing**

Result 2: Seakeeping calculations

Good seakeeping characteristics are of utmost importance for a research ship. The enhanced seakeeping calculation package was used in the concept for South Africa's logistics and support vessel S. A. Agulhas II. The enhanced software makes it possible to handle rolling, which is a non-linear phenomenon, by means of linearising for each significant wave height to be studied. This process would be too time-consuming without the improvements made to the programme.

Seakeeping characteristics of the proposed concept were good for this size of vessel, and the seakeeping package development project played an important role in winning Finland the contract. Testing and development of the calculation process was carried out together with Flume Stabilization Systems, New Jersey, USA.

Criteria for Hydrographic Survey (example)

1. **Significant vertical motion amplitude of the echosounder/sonar < 2.0 m for heave compensation**
2. **Average of highest 1/500th of roll angle at echosounder/sonar and for launching and retrieving RIB < 5°**
3. **Criteria for security / operability of the crew**
   - Significant pitch amplitude < 3.5°
   - At the location of the RIB / sloop, measurement analysis work spaces, deck spaces for launch ant retrieval of buoys and the bridge:
     - Significant amplitude of vertical accelerations < 2 m/s^2
     - Significant amplitude of lateral accelerations < 1.5 m/s^2 (on the bridge < 2 m/s^2)
4. **General criteria**
   - Green water over the bow < 30 times/hour, on the aft deck < 1 time/hour
   - Slamming < 20 times/hour

Result 3: Hull Form Optimisation

Many passenger ferries in Northern Europe operate in shallow water. Hull form optimisation of such ships is problematic because of a lack of efficient and reliable resistance and propulsion power estimation methods. The situation has changed thanks to the latest computational fluid dynamics (CFD) software that takes viscous and turbulence effects into account. Such software packages, commonly based on Reynolds-averaged Navier-Stokes (RANS) equations, are commonly available, and computer time with them is becoming acceptable for practical optimisations.

STX Finland Oy tested accuracy of the new RANS codes in speed/power prediction of a passenger ferry concept designed for operation in the English Channel. The RANS code calculations were conducted by Deltamarin in Finland and Force Technology in Denmark. Potential theory-based calculations were performed by STX Finland.

Hull geometry optimised with RANS codes was tested in a model basin in shallow water. Results of the model tests and the numerical simulations were compared, with good correlation. The case ship

obtained her contractual speed in shallow water conditions and was able to maintain her schedule with engine power lower than estimated. The results obtained with the RANS method also proved reliable for shallow water conditions, and so promising, in fact, that since then the speed/power predictions for all shallow-water ferries have been made by RANS calculation. This has improved STX Finland Oy's competitiveness in the European shallow-water ferry markets. The developed process also brings a significant reduction in the risks related to contractual speed.

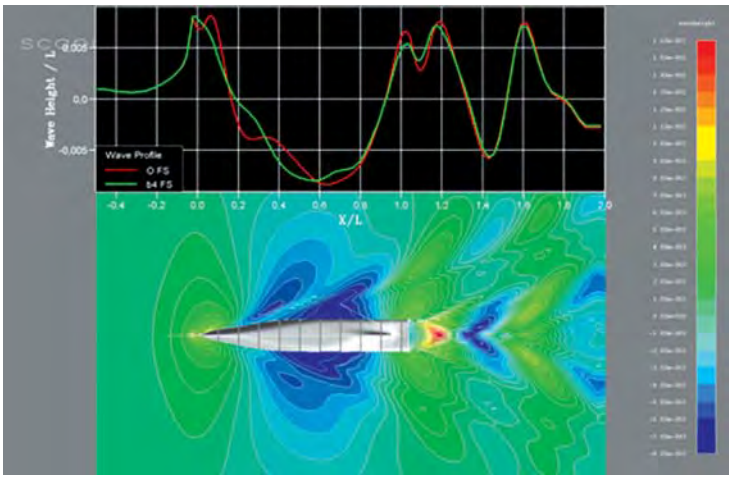


Figure 4. **Generated wave pattern**

PROJECT NAME
WP 2
Platform Solutions

Task 6

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
ERKKI STRENGELL STX FINLAND OY	**STX FINLAND OY** **TECHNOLOGY DESIGN AND ENGINEERING ENG'nD OY**	**2009 – 2011**	**1.337 MILLION**

Configurable Ship Systems

Main targets & motivation

The original aim of this task was to develop a common ferry platform with configurable systems and modules based on standard components or materials. A specific area of platform development was to develop new design processes and technical solutions for fulfilling forthcoming requirements in safety, energy saving or the environmental field, in order to achieve leading technical and competitive status in ferry building. One major need was to develop the execution of Safe Return to Port (SRtP) analysis. Other goals were to create standardised procedures, further develop the tools and create module libraries.

The research questions were:

What are the best solutions for creating a cost-effective concept with best practices and quality, and with short time to market?

What are the criteria for a configurable ship platform?

How would it be possible to reuse previous designs, components and materials?

How should the processes be standardised?

What is STX Finland's current ship performance?

How do the coming regulations effect the design solutions, and how can they be implemented?

How could the design tools be used more efficiently?

Results

The first research question was answered by defining platform criteria and planning implementation. Platform solutions were also developed for various designs, so that the reuse of previous designs would be maximised. A plan for engine casing modules was made and studies on machinery area standardisation reviewed. Definition of a 3D Basic Design Model in Tribon/AVEVA was accompanied by the writing of 3D studies for hull platforms in Autocad and a manual for 3D hull design. FEM links between Aveva and Ansys were also tested, and a FEM calculation method defined for ice class rudder arrangements.

New work standards for design brought standardisation to design processes, and new basic fabrication design guidelines were composed. The new challenge that arose during the research was the need to apply the solutions to new vessel types and to Arctic conditions. Studies were conducted on deck heating for Antarctic vessels and on a standardised and power-optimised structure for a heating system, while a study on winterisation sought the best materials for outfitting exterior decks when sailing in cold conditions. Solutions were also sought for handling research equipment in Arctic conditions, and function descriptions composed for research equipment. Simulations were also made of moon pool water flow.

STX Finland's ship performance was measured by making flooding scenarios, evacuation simulations, hull form analysis and seakeeping calculations for STX Finland vessels. The most significant new regulation to comply with was SRtP. An execution plan for SRtP was formed and a significantly improved SRtP analysis process achieved for the STX Finland Rauma shipyard. An SRtP macro was also developed. The results were implemented through successful SRtP analyses for the vessel "S. A. Agulhas II".

Key publications

1. Kopo, I.(2013), Laivan ulkokansivarustelun materiaalivalinnat arktisiin olosuhteisiin, Bachelor's Thesis, SAMK.
2. Jalava, T. (2011), Tutkimuslaivan työkannen laitteiden toiminnan kuvaukset, Bachelor's Thesis, SAMK.
3. Niinikorpi, P. (2010), Automatkustajalauttojen vesijärjestelmien virtausteknisten laskelmien yhtenäistäminen ja järjestelmien modulointi, Master's Thesis, TTY.

Number of publications: 3
Number of Master's Theses: 1

Networks and international co-operation

Safety at Sea (SAS), England, participated in evaluation of and commenting on the flooding simulations. Force Technology, Marin, Netherlands co-operated with the shipyard in testing and development of the Hull Form Optimisation calculation process. RANS calculations in the testing phase were performed by Deltamarin, Finland and Force Technology, Denmark. Model tests of the vessels were carried out in a model basis by Marin, Netherlands and Force Technology. The RANS software package licensed for STX Finland is developed in France. Flume Stabilization Systems, New Jersey, USA participated in testing and development of the seakeeping calculation process.

Applications & impact

The results have been put to immediate use. The standardisation efforts, advanced use of tools and new introductions have streamlined the design processes and improved quality. The new safety requirements, especially SRtP in RoPax vessels, differed substantially from earlier requirements, and their implementation required a significant amount of development of new technical solutions. Globally, these requirements were established for the first time in this very project, gaining the shipyard a significant competitive advantage. The Antarctic vessel's ship type was technically challenging, and additional development needs were discovered in areas related to research functions and operations. One of the most challenging tasks was to modify the SRtP concept to cover the needs of a special vessel type that was not an ordinary passenger vessel, as well as to standardise the procedure. The results of the project have been highly significant for STX Finland. Through the project, the yard readied itself for technical negotiations concerning various new types of research vessels, and for building them efficiently. The completed development work relating to the Antarctic vessel developed the shipyard's know-how and helped it penetrate into new markets. The new technical solutions developed for harsh conditions were used in many research or ice-going ship sales projects. The new knowledge gained during the project netted the shipbuilding contract for the Namibian fishery research vessel "Mirabilis". The results also had an immediate effect on the pricing of new sales projects.

The work on developing flexible design solutions could also be applied in other industries. The designing of a vessel is a complex project that other industries could benchmark. The achievements in developing systems for research vessels were significant, granting new skills to the entire maritime industry and the benefits of the work on Arctic conditions. The projects increased the ability of Finnish marine industry to compete internationally in these markets.

PROJECT NAME
WP 2
Platform Solutions

Task 7

Configurable Product Architecture

Maximisation of mass production benefits in the prototype product!

Methods for how to find potential repeatable, modular items and their mutual dependences were developed in order to maximise the mass production benefits. The summary of the suggested development method is presented in the figure below, which represents the method's phases. Decisions made in each phase also affect other phases, especially the industrialisation phase where building processes are developed and advantages of modularity realised.

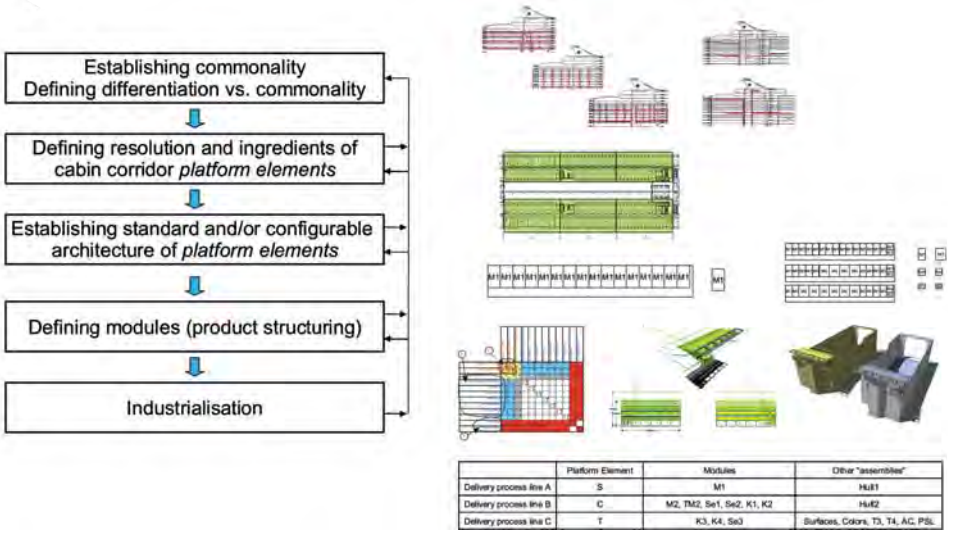


Figure 1. **Platform-based modularity development method**

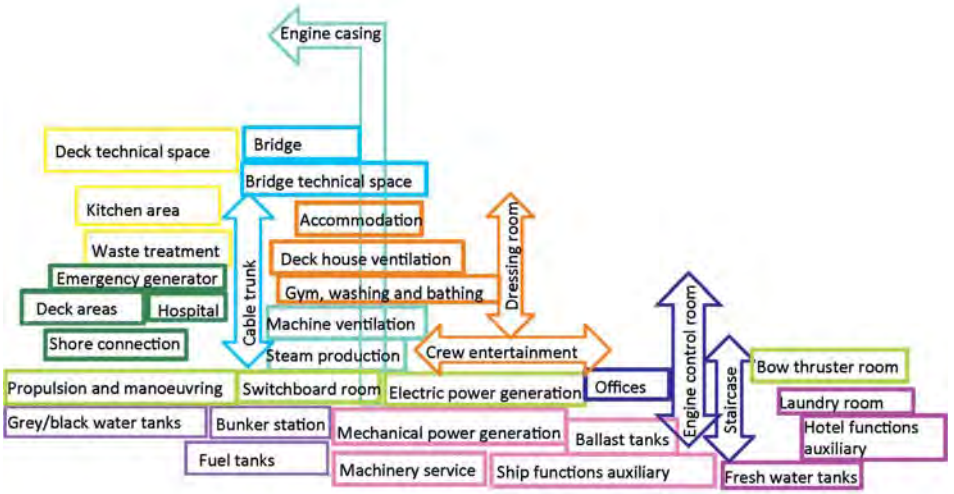


Figure 2. **Clustering model according to the design structure matrix**

PROJECT NAME
WP 2
Platform Solutions

Task 7

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
KARI SILLANPÄÄ STX FINLAND OY	**STX FINLAND OY** **ARCTECH HELSINKI SHIPYARD OY**	**2009 – 2011**	**0.198 MILLION**

Configurable Product Architecture

Main targets & motivation

Efforts have been made by the shipbuilding industry to lower the cost of a ship by discovering repeatable items inside the ship and building them in an onshore industrial building environment. On the other hand, ship owners want to be distinguished from each other, or have different needs to fulfil. The shipbuilder would need to know the parts of the ship that could be developed as common from ship to ship, the parts that require differentiation, and the most efficient way of combining these. The aim of the task was therefore to develop a modular and configurable product architecture for combining innovative solutions with repeating platform solutions.

Results

Methods were developed for finding potential repeatable, modular items and their mutual dependences. Certain technical and economic analyses of the ship concept need to be assessed comprehensively, and the results incorporated into existing design and building methods. Further research was also found to be necessary in order to clarify the content of guidelines which would increase commonality and help to establish a functioning configurable product architecture system.

Key publications

1. Korpela, V. (2010), Utilization of a Modular Ship Concept in a Shipyard's Order Book, Aalto University.
2. Kiuru, H. (2012), Systematization of Ships' General Arrangement Designs with Design Structure Matrices, Aalto University.

Number of master's theses: 2

Networks and international co-operation

- Aalto University, Department Applied Mechanics, Master's Theses
- ENG'nD Oy, Development of platform-based modularity

Smart Standardisation

Where there is no standard, there can be no kaizen (improvement)

CEN, CENELEC and ETSI, the European Standardisation Organisations (ESOs), firmly believe that standardisation is an integral part of R&D activities, and thus critical to innovation. This development project was started on the strength of such encouragement. One project highlight that can be considered an achieved target is standardised, state-of-the-art, three-dimensional (3D) parametric modelling of ladders. A feast of information and know-how was exchanged during the development, with results already in use in several projects and bringing positive feedback from customers.

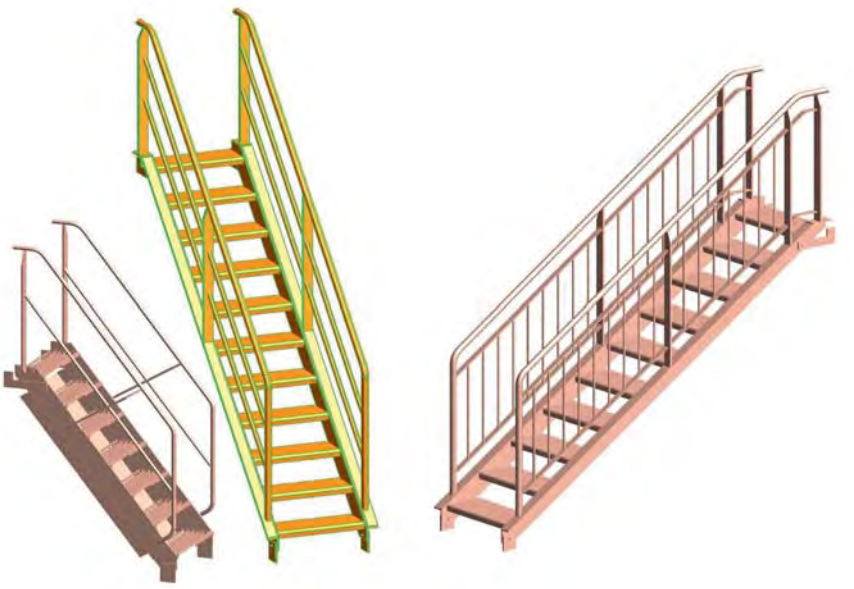


Figure 1. **Parametric 3D ladders for use on board commercial ships**

Improving the quality of processes and increasing productivity, standardised 3D parametric modelling has demonstrated its potential for replacing the age-old paradigm of 2D drawings as the main medium of design and communication for construction projects.

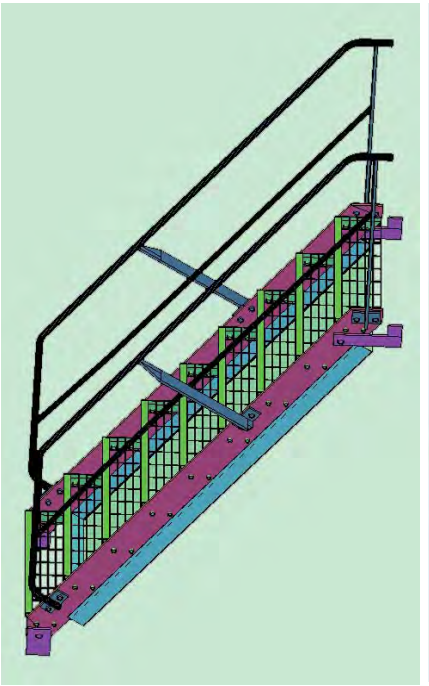


Figure 2. **Parametric ladder with grid steps**

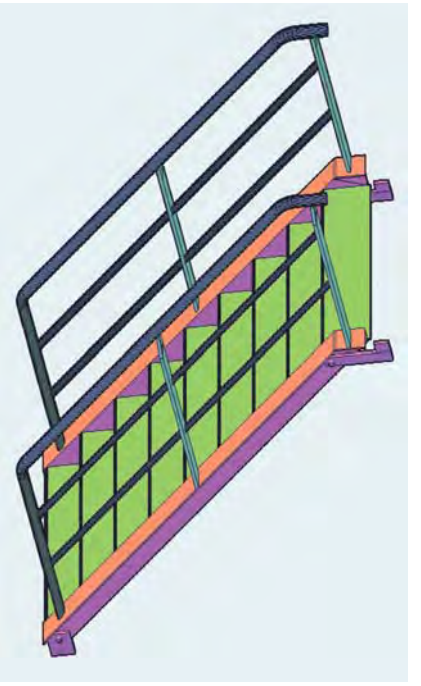


Figure 3. **Parametric ladder with perforated steps**

Parametric modelling is highly effective, but requires more skill in model creation. Skilfully created parametric models are easier to maintain and modify.

Parametric modelling makes use of parameters to define a model (for example, dimensions). The objects and features created are adjustable. Modelling not only creates parametric parts, assemblies, and production-level drawings, but provides all the tools needed to generate structural elements and complex modules.

Use of CAD software increases the productivity of the designer, raises the quality of design, improves communications through documentation, and creates a database for production.

PROJECT NAME
WP 2
Platform Solutions

Task 8

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
PASI LAAKERISTO **SAMPO MANNI**	**STX FINLAND OY**	**2009 – 2011**	**0.223 MILLION**

Smart Standardisation

Main targets & motivation

The goal is to improve productivity by bringing high-quality development effort to the business and to use the multiplying effects of co-operation. STX Finland's main targets include:

1. Investigating the current standardisation situation at STX Finland and improving the standardisation process according to findings
2. Co-operating with other organisations to support the achievement of STX Finland's business objectives, and establishing a co-operation network in the field of shipbuilding standardisation
3. Exchanging information and know-how on the questions of common interest, and achieving results
4. Avoiding time wastage caused by inefficient procedures, paperwork and bureaucracy.

Results

Investigation of the current standardisation situation demonstrated the need for modern tools to solve problems in the standardisation process systematically. The following lean problem solving tools were analysed:

1. One Page Problem solving (A3)
2. Ishakawa (Fishbone) Diagram
3. Plan, Do, Check, Act (PDCA)
4. 5-Why Analysis

The best lean problem solving tools were then adapted for STX Finland as the result of the investigation. Problem solving is one of the keys to a successful lean process development because it empowers all those involved.

Co-operation with other organisations was the most value-adding part of the task. Co-operation was established on the belief that the development and quality of shipbuilding professionals will be enhanced by national and international co-operation. Exchanging experiences and know-how with professionals no longer seemed overwhelming once a co-operation network had been established.

Exchange of information and know-how has been introduced for the purpose of developing and revising numerous state-of-the-art STX Finland Corporate Standards over recent years. Standards open up markets around the world.

Figure 1. **Standardisation pyramid**

Networks and international co-operation

The task has participated in an expert role in a number of local and foreign companies. These companies have acted on the basis of self-financing. The rationale behind STX Finland's support for international co-operation is driven by the fact that only a very small proportion of total knowledge production takes place in Finland. It is crucial that research is connected to international co-operation networks.

Applications & impact

The impact of the task for a national and international co-operation network has been positive. STX Finland has also climbed to totally new levels at the top of the standardisation pyramid, with significant first steps taken to both National Standardisation and International Standardisation level. Future development efforts can be continued and multiplied according to principles of continuous improvement.

Design Integration Model, Tools and Data Collaboration

Competitive edge with agile processes

State-of-the-art design and production processes and tools such as easy-to-use 3D CAD tools were developed and implemented, along with development of interfaces between several CAD tools to synchronise data from conceptual to production design.

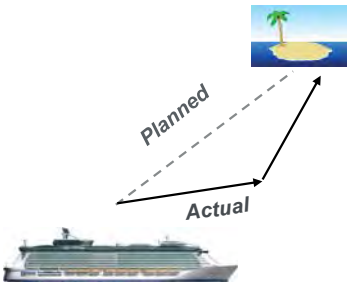


Figure 1. **Infrequent review points make steering difficult and increase deviations from plans**

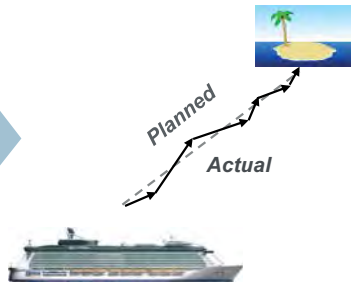


Figure 2. **Continuous monitoring of key metrics improves steering and control**

Case "Viking Grace": Concept implemented

Agile processes and a 3D engineering database resulted in better design quality, leading to higher efficiency in production. The concept was implemented in the Viking Grace project.

This was the first ship designed using a full 3D engineering database, where over 150 designers from 20 different companies worked simultaneously in their own offices with the same 3D model.

3D engineering database in a nutshell:

- All objects have about 50 separate attributes
  (e.g. Mass, System, Manufacturer, Treatment...)
- 16,200 components
  (= valves, motors, connection box, doors, etc.)
- 112 km pipes, 14,300 elbows and 4,660 pipelines
  (in "TUI Mein Schiff 3" 210 km pipes and 32,000 elbows)
- 25,000 prefabricated outfitting parts
  (pipes, AC ducts, modules...)
- About 10,000 cables
  (in "TUI Mein Schiff 3" over 20,000 cables.)
- About 3,000 drawings
  (in "TUI Mein Schiff 3" over 11,000 drawings)

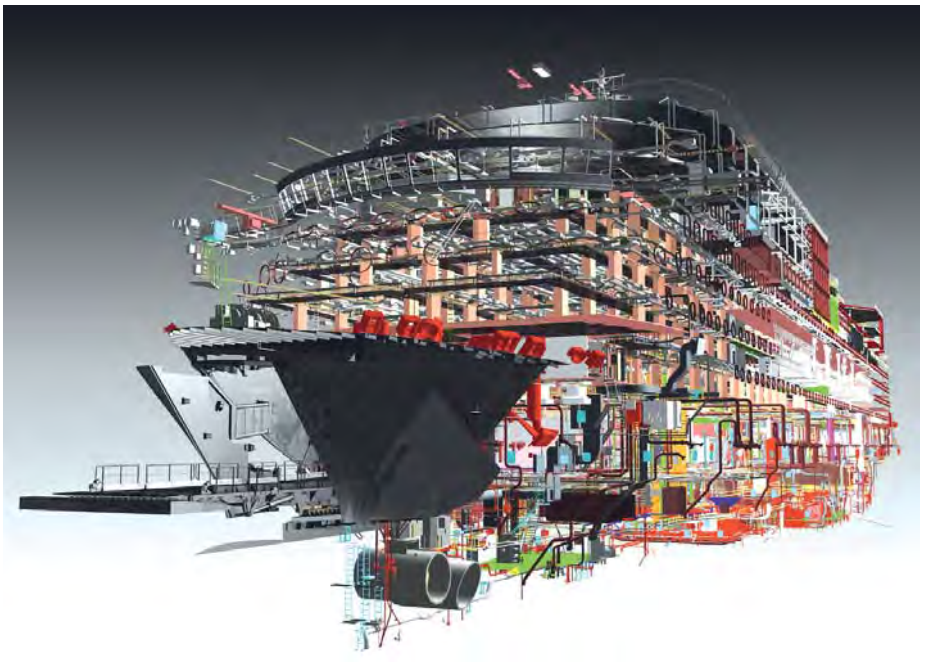


Figure 3. **Screenshot picture from 3D engineering database in "Viking Grace" project**

Case "TUI Mein Schiff 3": Concept validated

In practice, this meant double the amount of design work in the model compared to Viking Grace. Approximately 300 designers from over 40 different companies worked simultaneously in their own offices with the same 3D model. Modelling totalled about 250,000–300,000 hours. The scalability of the concept was validated in the "TUI Mein Schiff 3" project.

The degree of completion at launching was 65%, which is much higher than in the past. The main reason was the high block outfitting ratio based on agile processes and 3D tools.

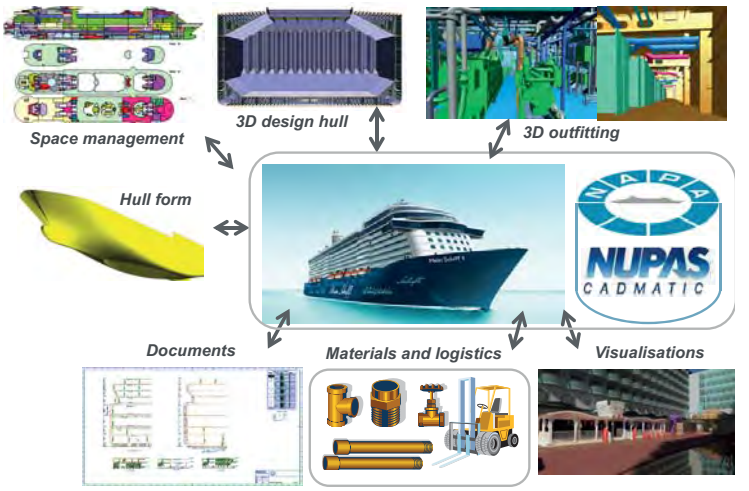


Figure 4. **Example structure of 3D engineering database**

Documentation for assembly and manufacture

One of the main functions of the 3D engineering database was to produce documents for assembly and manufacture. The following documents were published from the 3D engineering database:

- Assembly drawings/instructions
- Prefabricated drawings
- Visualisations for production
- Material and work load estimations
- Bill Of Materials
- Cutting lists
- Work orders
- Logistic instructions
- Etc.

PROJECT NAME
WP 3
Design Processes and Tools

Task 1

CONTACT PERSON
PEKKA PURANEN
STX FINLAND OY

PARTICIPANTS (ORGANISATIONS)
CADMATIC OY
CARGOTEC FINLAND OY
ELOMATIC MARINE ENGINEERING OY
NAPA OY
NESTIX OY
STX FINLAND OY
SWECO INDUSTRY OY
VARIANTUM OY

PROJECT DURATION
2009 – 2013

PROJECT VALUE (EUR)
14.253 MILLION

Design Integration Model, Tools and Data Collaboration

Main targets & motivation

This task involved development of design and production processes and related tools, such as easy-to-use 3D CAD tools. The core strategy of the Finnish maritime industry is to design and build highly demanding products with a short lead-time. Companies make use of a large global network to enable them to implement the strategy on the very competitive global marine market. The main target was to implement new design and production methods to increase productivity.

Results

NAPA and CADMATIC played a major role in the development. The developed interface, besides covering structural and opening information between NAPA and CADMATIC, also covers compartment information from NAPA to CADMATIC. Compartment information is further used in cable routing, logistics of prefabricated pipes and Safe Return to Port (SRtP) calculations, among others.

The use of 3D design tools formed a key element in the industrialisation and modularisation processes developed in WP 4 Task 3. These tools enabled the design of modules and platform solutions, and also produced better data on production. In the new modelling process, drawings were generated from a 3D model of the engine room and technical spaces.

The control chain for cables and electrical design were implemented in a digital design environment. Cable routing is traditionally one of the most difficult tasks in shipbuilding because of the sheer quantities involved (10,000–25,000 individual cables). Now it is possible to manage each individual cable, including all necessary metadata (length, routing, production completion level, etc.). This permits SRtP design, reduces cable surplus and enables earlier closure of ceilings, giving more time to finish interior spaces.

New series ship management was developed based on the 3D engineering database. Traditionally carried out by copying drawings, sister-ship management is now more detailed as copying can be done object by object. This helps the designer to manage copying objects from prototype to series ship.

All together, there was an increase in the profitability and competitiveness of Finnish shipbuilding. In addition to the abovementioned issues there were a number of other significant results, the most important being automatic generation of classification drawings from a 3D model, generation of HVAC prefabrication drawings from a 3D model, extraction of CAM data from a 3D model to pipe-bending machines, integration between 2D diagram and 3D model, a new change management process, material estimations for logistics, a new process for arrangement and door design.

Key publications

1. Lassila, J. (2013), Suunnittelutehokkuuden parantaminen kansainvälisessä monitoimisto-organisaatiossa, Turun Yliopisto, TSE Exe FE3.
2. Kurki, T. (2010), Utilization of Integrated Design and Mesh Generation in Ship Design Process, COMPIT, Gubbio.
3. Hulkkonen, T., Cabos, C., Kidogawa, M. et al.,(2013) Utilization of a 3D product model to fulfill the new IACS CSR-H rule requirements, ICCAS 2013, Busan.
4. Holmberg, T. & Hunter, S.D. (2011), Increasing Efficiency in the Ship Structural Design Process", COMPIT, Trieste.

Number of Master's Theses: 4

Applications & impact

The results were and will be used within the order book of STX Finland. The results are also applicable in other shipyards and in the entire shipbuilding network. Cadmatic and NAPA have strengthened their position in the maritime CAD market, and their results are already commercialised. Together with Work package 4 Task 3, Developing Shipbuilding Methods, the productivity in outfitting has improved an average 35 per cent. (see p. 95) The results are significant within the Finnish maritime cluster.

PROJECT NAME
WP 3
Design Processes and Tools

Task 2

Speed, quality and accuracy with advanced design tools

Product Configuration Methods, Processes and Tools

Design configurator for bulk carrier hatch covers

With this tool the design lead-time of a bulk carrier hatch cover system can be reduced from eight weeks to a few days. Such a dramatic change in lead-time is possible for three reasons. Firstly, the new product architecture enables strength analysis to be conducted as R&D work prior to customer projects. Secondly, the design tool enables configuration of a customer-specific 3D model. Thirdly, design documentation for shipyard, manufacturing and class society is created automatically. The new side rolling hatch cover design tool includes all necessary technical solutions for configuration of the hatch cover solution.

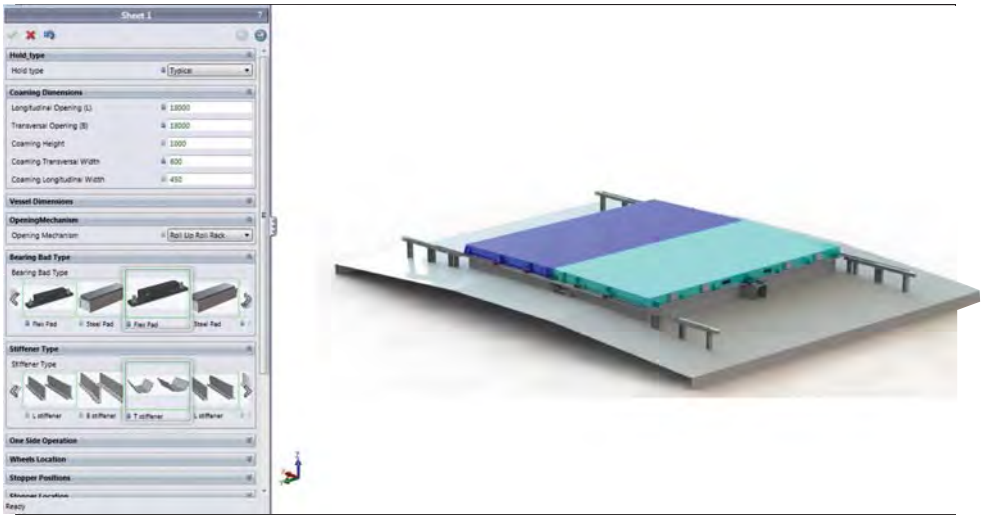


Figure 1. **Hatch cover (SR-type) configurator tool**

Although the effect is not as dramatic as in the case of design lead-time, a radical reduction in component variants has also been achieved, as well as in the need within steel structure for manual welding of component supports, lessening the need for structure straightening. These improvements show that simplicity and consistency in product architectures will have positive effects throughout, from product design to final solutions, both on quality and in cutting costs.

"Step up" from a traditional project-based business model towards product platform thinking and continuous development

During this development project we have been able to move from a traditional project-based business model towards product platform thinking and continuous development. The main challenge has been to reconcile customer requirements, product weight and ideas about modularity, without endangering existing competences. Modular product architecture has required a re-design of various components and details in structures. The most significant change, however, has been achieved by changing the mindset within the company and personnel.

Automated structural optimisation tool

Optimisation (as opposed to estimation) of hatch cover steel structures right at the start of the customer project is a huge advantage in the cost-conscious shipbuilding business. The automated structural optimisation tool for bulk folding-type hatch covers enables specification of optimised solutions for each customer. Most importantly, this can be done in few hours, compared to the previous days or weeks.

The automated structural optimisation tool consists of a parametric 3D model simplified for finite element analysis (FEM) purposes, a standardized FEM-analysis template, and pre-defined optimisation scripts. With these, engineers with little or no structural optimisation experience can prepare analysis and use results to define customer-specific solutions.

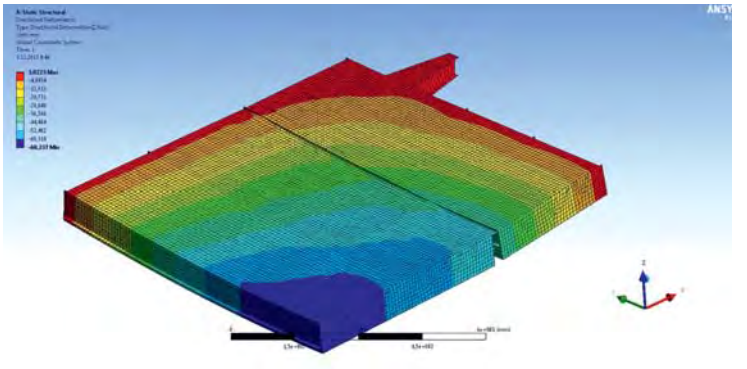


Figure 2. **Automated strength optimisation tool**

PROJECT NAME
WP 3
Design Processes and Tools

Task 2

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
HENRI PAUKKU CARGOTEC FINLAND OY	**CARGOTEC FINLAND OY** **VARIANTUM OY**	**2009 – 2013**	**0.984 MILLION**

Product Configuration Methods, Processes and Tools

Main targets & motivation

Configurable product architectures are somewhat worthless without efficient tools and processes that can be used to create, modify and manage customer-specific configurations. In other words, these tools (e.g. configuration software integrated with CAD and PDM) help users to manage complex product architectures efficiently. This is especially critical in project-based businesses where complex, customer-specific configurations must be made to a strict deadline and without error. The mix of standardised, modular and parametric features in a single product entity makes this particularly difficult. The main target for this project was to develop configuration tools and processes for product architectures developed in WP 2.

The requirement for 150 to 200 design drawings and documents creates a significant amount of work that is largely repeated from project to project. The main target for this project was to **develop configurable product architectures** for existing hatch cover types to bring about a radical shortening of existing design lead-times and to automate repetitive design and documentation tasks.

Novelty & added value brought by this work vs. state-of-the-art

Product configuration tools and processes have traditionally been developed for businesses applying the assembled-to-order type of processes. Project-based companies applying the engineered-to-order paradigm (e.g. shipbuilding in general) have encountered application problems. This project marked the first development of an advanced product configurator application for marine hatch

covers. Another first was the development of an automated optimisation process for hatch cover steel structures.

Research problems solved

How do we apply advanced configuration methods, processes and tools within a project business environment and complex product architectures?

Results

A product configuration tool was developed for the side rolling hatch cover type. The tool is based on TactonWorks software provided by Tacton Systems AB. With this tool the entire product can be configured to customer-specific requirements (e.g. hatch cover dimensions, loading and operation system), while the required design documentation is created automatically. The tool embodies an innovative method for modifying and controlling steel structure geometry.

A configurator was also used to model the hatch cover platform, in this case a VariProd configurator developed by Variantum Oy. The model included the basic cover structure with proper component selections and related calculations. The configuration time was about 4 seconds for generating the masses and structure of all hatch covers for the specified ship according to pre calculated FEM-modelled cases. Compared to a manual process, the productivity increase is about a thousand fold.

The project also involved development of an automated hatch cover steel structure optimisation system. The system consists of an Ansys Workbench project template (FEM analysis) and a MatLab template (response surface methodology optimisation), with Python scripts enabling automatic integration between these two. In practice, the process is based on iterative optimisation of steel structure mass (steel plate thicknesses) within given limits (allowed stress and buckling values set by classification societies). See figures 1 and 2 pp. 68–69.

Key publications

1. Lehtinen, J., Pajunen S. & Heinonen, O. A. (2013), Perfect Fit. ANSYS Advantage, Volume VII, Issue 2.
2. Heinonen, O. & Pajunen S. (2011), Optimal design of stiffened plate using meta modeling techniques, Journal of Structural Mechanics, Vol. 44, No 3, pp. 218-230.
3. Heinonen, O. (2011), Applying Response Surface Methodology to Strength Analysis, Master's Theses, Tampere University of Technology.

Number of publications: 2

Number of Master's Theses: 1

Applications & impact

The results have been applied to Cargotec's current order book and will be developed further. The through put time for the design process has shortened dramatically. This is an excellent showcase for other industries of the impact of product configuration tools.

Product Visualisations, Animations and Simulations

A look into the future of professional virtual reality

The first idea was to improve quality and process in exterior and interior visualisations. See figures below:

Figure 1. **Exterior visualisations from Autodesk Alias Design Studio**

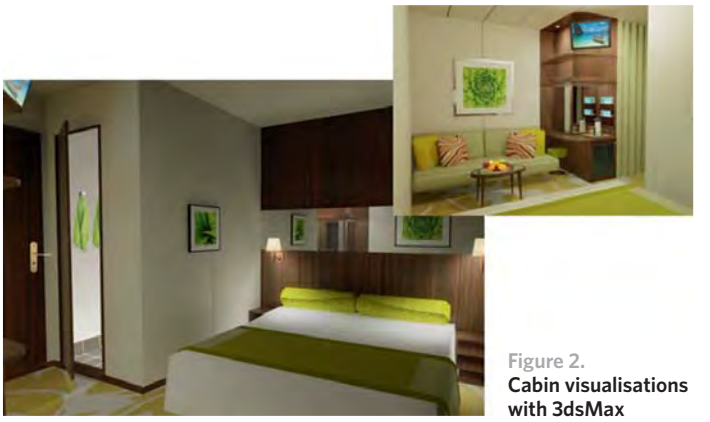


Figure 2.
Cabin visualisations with 3dsMax

The next step was to create a 3D experience concept and design process

The aim was to create a realistic 3D experience of the 3D engineering model developed in FIMECC I&N WP 3, Task 1.(See pp. 61–66) With 3D experience it is easier to make decisions and, with early decisions, to save money.

During a realistic 3D experience it is possible to walk in a 3D virtual environment and to interact with the model, for example by changing colours. One exciting aspect was investigating if 3D glasses could be dispensed with. The end result was that it is possible to build an immersing 3D experience without the need to use 3D glasses.

Implemented operations:

- Investigation and procurement of a 3D stereo projector
- Investigation and procurement of a PC and display drivers
- Testing of 3D glasses
- Demonstration material from 3D engineering model to 3D virtual environment
- Investigations of 3D experience concepts used in the game industry
- Plan for a low-cost cheap 3D show room enabling presentation of the 3D experience concept (see pic)
- Design process and tools from the game industry that can provide material for the 3D experience.

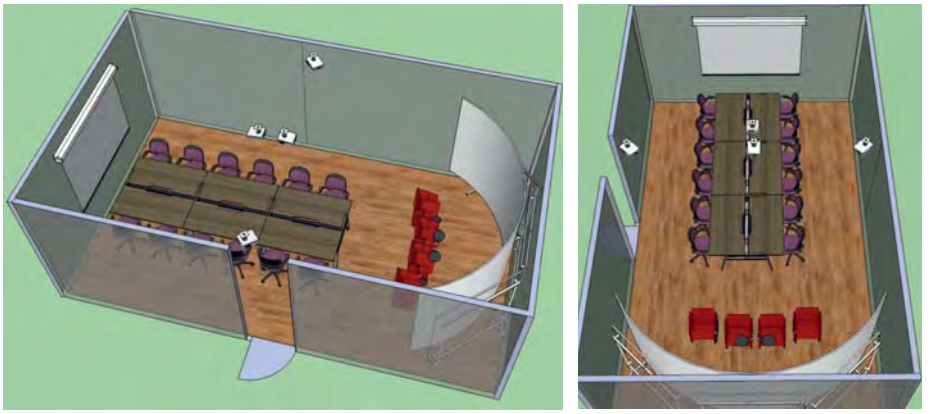


Figure 3. **Example picture of a low-cost 3D show room**

True virtual reality is closer than we understood at the beginning of the project

During the development we noticed the rapid advancement of virtual reality in the game industry. One example was the "Oculus Rift" virtual reality headset. The Oculus Rift development kit was released in 2013, and the 3D experience concept that we implemented was included in the Oculus Rift development version.

We introduced our 3D experience concept using the "Oculus Rift" virtual reality headset at the Cruise Shipping Miami fairs in 2014.

We can now combine our customer's visions with our ship concepts and agile engineering tools to show how a newbuilding will really look, before production has started.

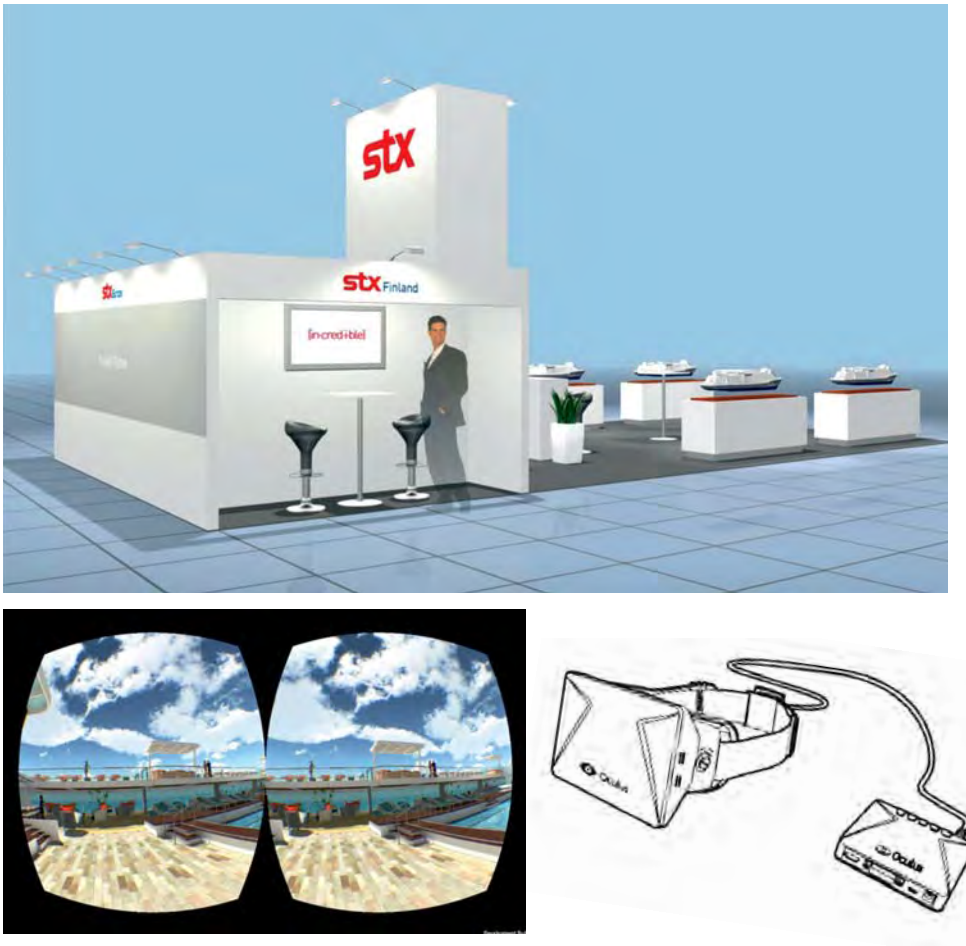


Figure 4. **NSTX Finland stand in Cruise Shipping Miami fairs in 2014 included 3D showroom with "Oculus Rift" virtual reality glasses and model from "TUI Mein Schiff 3" project**

PROJECT NAME

WP 3
Design Processes and Tools

Task 3

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
PEKKA PURANEN STX FINLAND OY	**CARGOTEC FINLAND OY** **STX FINLAND OY** **VARIANTUM OY**	**2009 – 2013**	**0.974 MILLION**

Product Visualisations, Animations and Simulations

Main targets & motivation

The result of the task was to create a holistic design and construction process that brings naval architectures, engineers and architects closer.

Results

- Improved quality and process of exterior and interior visualisations
- Plan of a 3D showroom
- Design process and tools for a realistic 3D experience
- A Virtual Reality show at Miami Cruise&Shipping fairs
- Connection with the engineering model using the new Virtual reality tool “Oculus Rift”, enabling communication between shipyard and customer to be raised to the next level.

Complete NDT within 48 hours by using modern digital NDT and information technologies

Digital NDT

A programmed NDT plugin in an existing ERP system with digital RT could revolutionise the survey reporting procedure.

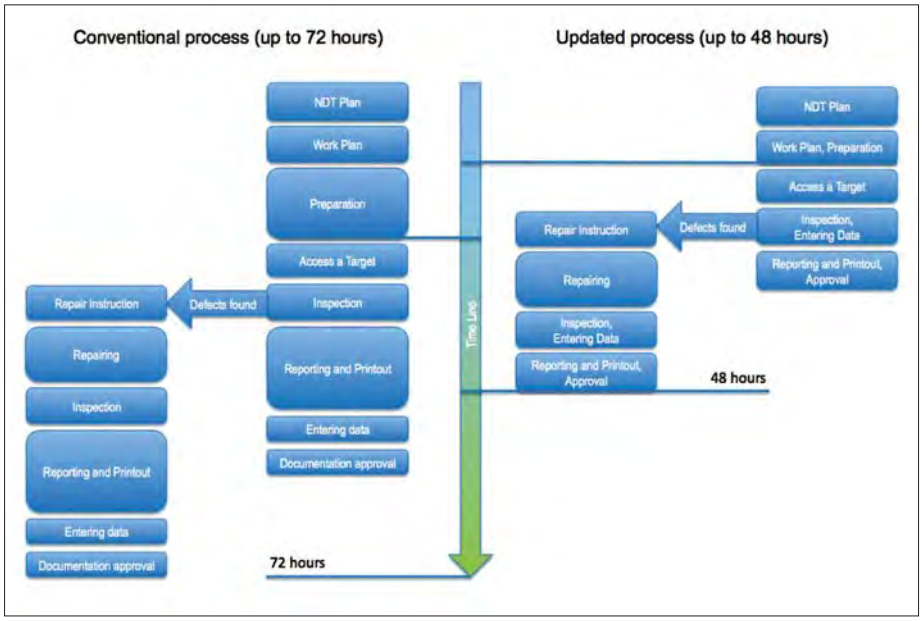


Figure 1. **Scheme of conventional production and NDT process related to the updated process**

Main Results

- Digital radiographic examination of welded joints proved to be feasible in shipbuilding production:
  - Feedback was available instantly for issuing repairing instructions without delay
  - The radiation dose was lower compared to the traditional X-ray method
  - The radiation restriction zone was reduced
- The programmed NDT plugin revolutionised the survey reporting procedure i.e. the inspector was able to use the database of the existing enterprise resource planning system at yard:
  - Prefilled report, which the inspector completed with the results of the weld examination
  - Drag and drop support allowed the inspector to mark all surveyed objects effortlessly instead of having to draw them
  - All data was in one place
- The modern NDT methods with enhanced testing process including software support proved that completing within 48 hours with NDT is practicable.

PROJECT NAME

WP 4 Production Processes and Methods

Task 1

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
JARI SALMI STX FINLAND OY	**DEKRA INDUSTRIAL OY (former Polartest Oy)** **STX FINLAND OY**	**2009 – 2013**	**0.270 MILLION**

Digital NDT

Main targets & motivation

A combination of global shipbuilding competition and global economic pressure is demanding more cost-effective processes, not only in manufacturing but also in quality control, including examination of welded structures. The development of digital techniques has enabled non-destructive testing (NDT) methods to make use of more sophisticated systems and computer applications. The main targets of this project are to investigate the feasibility of modern non-destructive testing methods in shipbuilding production, such as digital radiography examination and digital ultrasonic testing, and to clarify if customised software might enhance the convention of the testing process, including the preparing and reporting of functions, such that the whole process can be completed within 48 hours. Consideration is also given to approvals for developed systems and the qualifications of personnel.

Results

Two digital radiography examination methods, Digital Detector Array (DDA) and Computed Radiography (CR) were evaluated in 2009 at the Polartest NDT Laboratory in Vantaa [1, 2], and demonstrated at shipyard in 2012 [3]. These evaluations examined the technical qualifications of the methods, the visibility of IQIs, and the ability to detect indications in welds. The evaluations proved the methods to be feasible in the shipbuilding industry and applicable in the production process, although the equipment in place was rather sensitive, especially the surface material of the DDA flat panel which tended to scuff in an industry environment. Digital radiographic techniques use an imaging plate of photostimulable phosphor (CR) or silicon panel of photodiode arrays (DDA)

instead of conventional film. High-resolution image produced by the plate or panel are available for immediate analysis on a computer screen. Requiring less radiation than traditional X-ray film, the digital panel also reduces the size of the radiation restriction zone. In demonstrations at yard, the examination of image quality with the DDA was nearly equal to a film image. The radiographic scanner and an illustration of the flat panel structure are shown in figure 1.

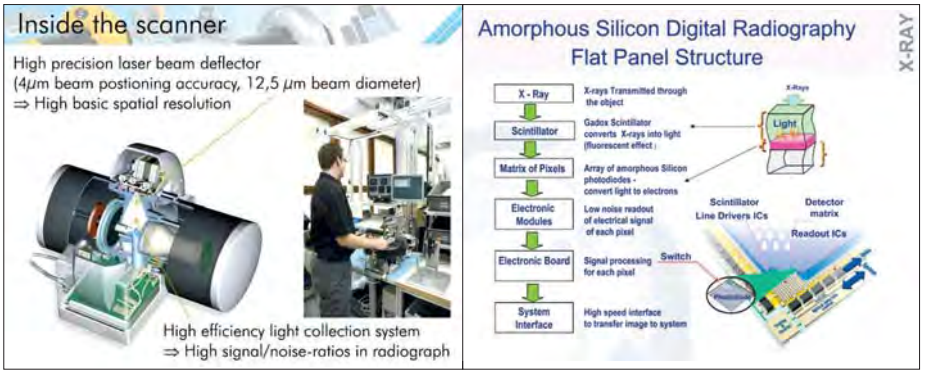


Figure 1. **Digital Radiographic Scanner and Flat Panel Structure (images from Dürr and Vidisco booklets)**

Instead of developing a whole new computer application, it proved more cost-effective to programme a customised NDT plugin in an existing enterprise resource planning system, Nestix ERP, in use at yard. This solution connected NDT as a process to form part of workflow, i.e. NDT was embedded in production planning and block construction supervising processes, as shown in figure 2. The NDT plugin provided access to the Nestix ERP database, versatile reports such as NDT progress reports, summary reports, defect statistics, and controlling reports to be produced using statistical tools. The plugin also revolutionised the survey reporting procedure. With the conventional NDT reporting method, the inspector produces all data by writing each detail of the survey on a blank sheet. The NDT plugin, on the other hand, produces a prefilled sheet from the object output data which the inspector completes with the weld examination results. Using the drag and drop support provided by the Nestix ERP, the inspector is able effortlessly to mark all the surveyed objects instead of having to draw them.

The review of NDT and shipbuilding production processes has revealed the time consuming stages to be the periods for work plan and preparation and for reporting and data entry. As shown in page X (figure 1), the digital NDT with customised plugin in the Nestix ERP eliminates the bottlenecks effectively. With digital radiographic examination, an imaging plate (IP) produces high-resolution images that are available for immediate analysis. If indications are detected, the feedback is available instantly so that repairing instructions can be issued without delay. The inspection reports generated are stored simultaneously in the digital reporting system.

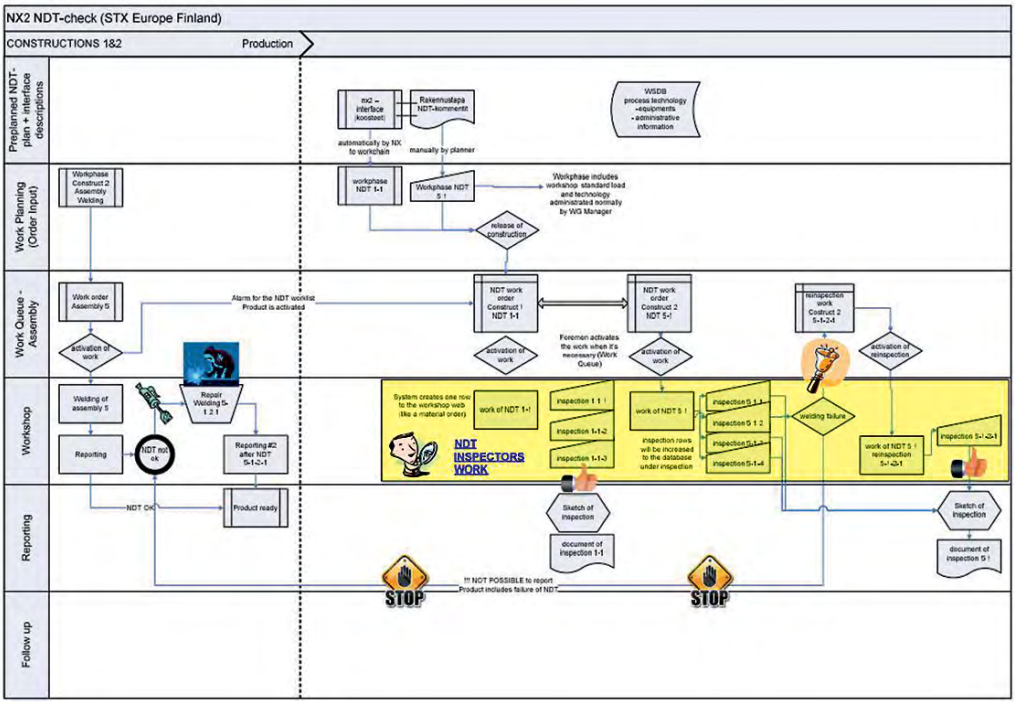


Figure 2. **NDT plugin in the Nestix ERP as a part of shipbuilding workflow**

With the evaluations and demonstrations accomplished one can conclude that DDA and CR digital radiography methods are suitable for use in the shipbuilding industry. As a consequence of ASTM International[1] and ASME[2] publishing several standards and METSTA[3] in Finland recently approving standard SFS-EN ISO 17636-2, digital radiographic examination of welded joints will enter use as part of NDT in future shipbuilding projects, once the extent of the method's adoption meets economic requirements and is approved by the classification society.

[1] ASTM = the American Society for Testing and Materials

[2] ASME = the American Society of Mechanical Engineers

[3] METSTA = Mechanical Engineering and Metals Industry Standardization in Finland

Applications & impact

The modern NDT methods with enhanced testing processes, including software support and NDT plugin in the existing ERP system, proved that in many inspection cases complete NDT within 48 hours is practicable in shipbuilding production. More study is needed, however; the software user interface was too complicated for new inspectors, and the process for data entry is ineffective in that it requires the permanent attention of a designer from the production planning department.

The study of digital non-destructive testing methods was constrained by the limitation of the resource available at yard. The evaluation of modern ultrasonic testing methods such as Phased Array (PA) and Time of Flight Diffraction (TOFD) techniques will therefore be completed in the near future in the next project.

References

Polartest Oy/TS 19 October 2009

Polartest Oy/TS 26 October 2009

Demonstration report by Inspecta/9 October 2013

Laser welding

Use of laser welding in hull production!

A study was made to determine the area and structures where laser welding is considered to improve the efficiency and quality of steel work. Structures where laser hybrid can be used are presented in figure 1. The limits and boundaries for laser hybrid welding were also determined. Sufficient visual welding quality for fillet welds can be achieved with single side full penetration welding up to 10mm. The maximum thickness of laser hybrid welding of butt welding changed from 7mm to 15mm. Test welding scantlings were designed and welding positions set in accordance with the results of the study.

The tests conducted in the project confirm that both modern laser sources – disk laser and fibre laser – can be used in hybrid laser welding. The laser types can be used in both fillet and butt welding. The parameters found are also compatible between both laser types if the beam parameters are equal. Results can be used as a base for future investments.

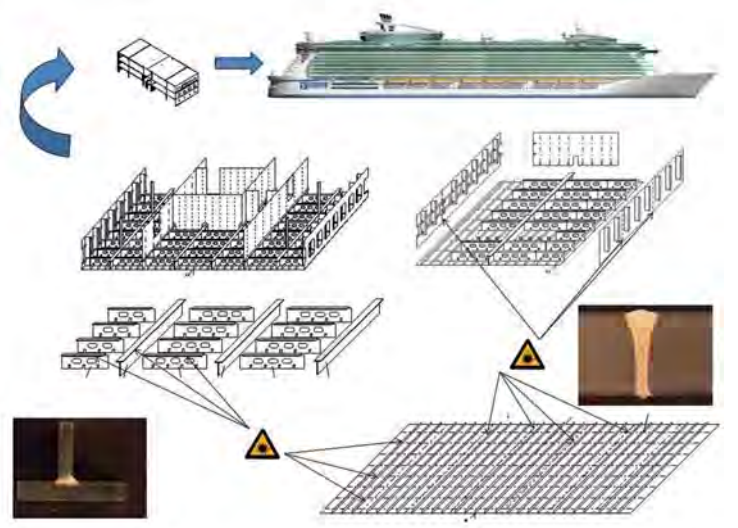


Figure 1. **Structures where laser hybrid welding can be used**

PROJECT NAME

WP 4 Production Processes and Methods

Task 2

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
ANTTI ITÄVUO	**STX FINLAND OY**	**2009 – 2011**	**0.473 MILLION**

Laser welding

Main targets & motivation

The use of laser processes in shipbuilding has been recognised as giving significant benefits compared to traditional shipbuilding methods. The challenges of reducing fuel consumption and emissions mean that in today's shipbuilding weight optimisation, thinner materials and complex structures are the rule rather than the exception. Novel production methods, such as laser processes with less distortions and higher accuracy, are required to fulfil the standards. The main target of the project was to determine the boundaries and feasibility of laser hybrid welding in typical ship structures, in order to increase productivity and decrease the amount of remedial work in subsequent phases of the hull process. One of the problems with laser hybrid welding has been the limited thickness range in butt welding. Several processes have been needed to weld the required thickness range in panel lines.

Results

The initial phase of the project involved completing a study of areas and structures where laser welding is considered to improve the efficiency and quality of steel work, see figure 1. The study determined the limits and boundaries for the welding. Test welding scantlings were then designed and welding positions set according to the results of the study.

In the butt weld test series the thickness range was 7mm to 25mm using high power lasers. The welding tests were conducted up to 25mm but weld quality was sufficient up to 15mm, see figure 2. The joints where plate thickness was more than 20mm tended to have hot cracking in the middle of the plate, see figure 3.

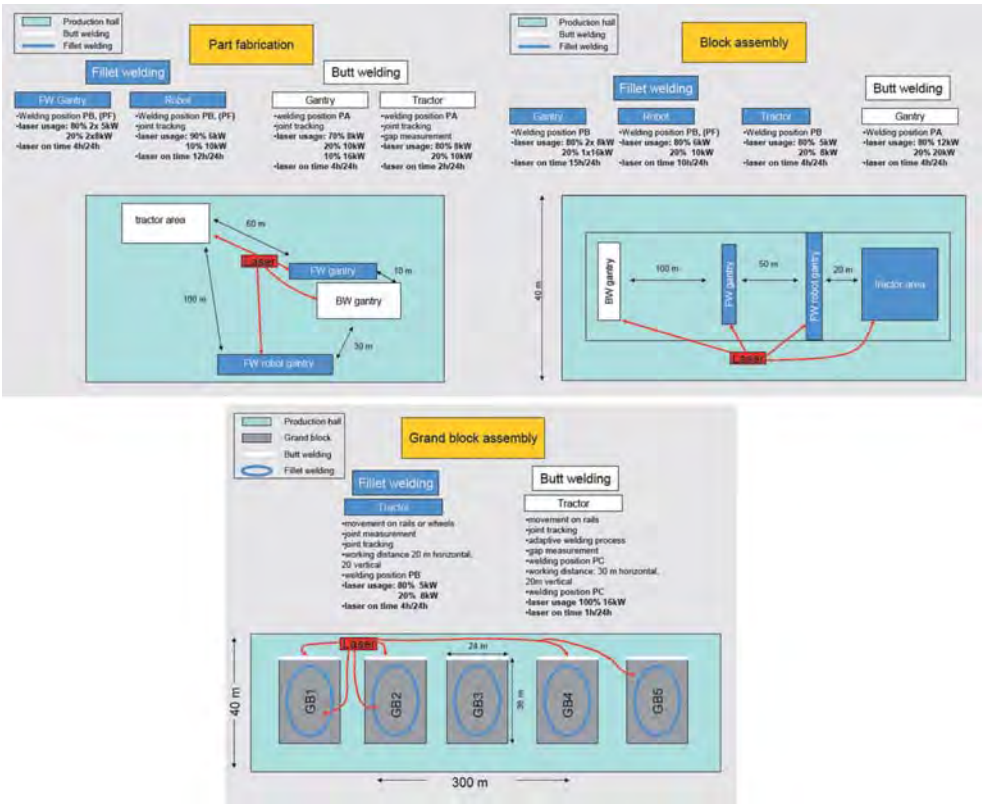


Figure 1. **The production phases where laser welding was considered and studied**

The actual thickness range welded with laser hybrid in production is from 3mm up to 7mm but following the test welds this can be extended up to 15mm. This covers 90% of the butt welds in today's cruise ships.

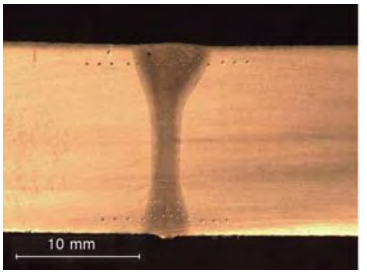


Figure 2. **The macro sample of 15mm plate welded with laser hybrid welding. The weld quality is visually approvable**

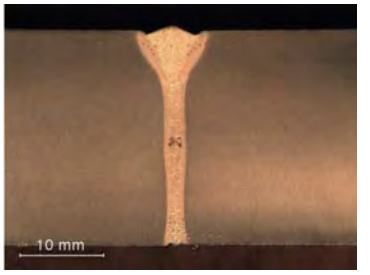


Figure 3. **The macro sample of a 25mm specimen welded with laser hybrid welding. The weld quality is not approvable**

Apart from butt welding, tests were also carried out on fillet welding using a high power disk laser. Thicknesses ranged from 5mm to 10mm, which includes most of the fillet joints in a cruise ship. The tests showed that sufficient visual welding quality can be achieved with single side welding up to 10mm. The results can be seen in figure 4.

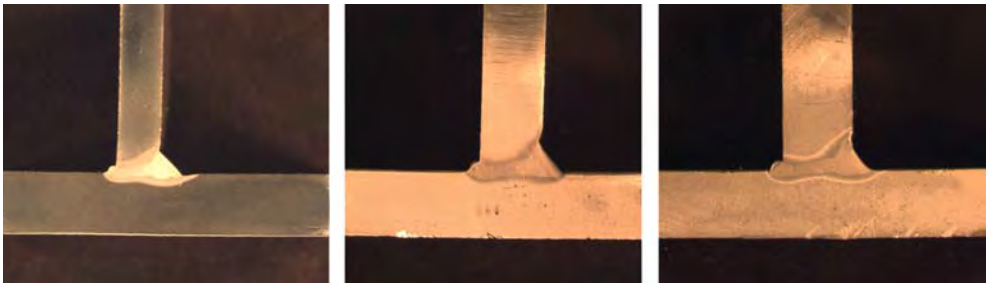


Figure 4. **The macro samples from the fillet welding tests. From left to right, thicknesses 5mm, 8mm and 10mm**

Applications & impact

The results can be implemented in various types of ships, and give the necessary knowledge for estimating future investments and strategy in steel production. Together with the study of structures and areas where lasers can be used, the test results create a solid base for simulation of the processes and for continuous development.

Developing Shipbuilding Methods

Best building methods for cruise ships

Remarkable increase in productivity

The modularisation of ship's key areas proved to be a true success story during evaluation of the results derived from pilot projects. Productivity gained 30% on average and the block outfitting rate doubled over conventional building method. Work quality was better than usual and nonconformity costs smaller. Weight savings were reported, as well as a significant decrease in fire work during the ship outfitting phase. Modules containing piping were pressure-tested prior to installation in the hull. Despite many bold new features and changes in the way of working, schedules were maintained and all major expectations met.

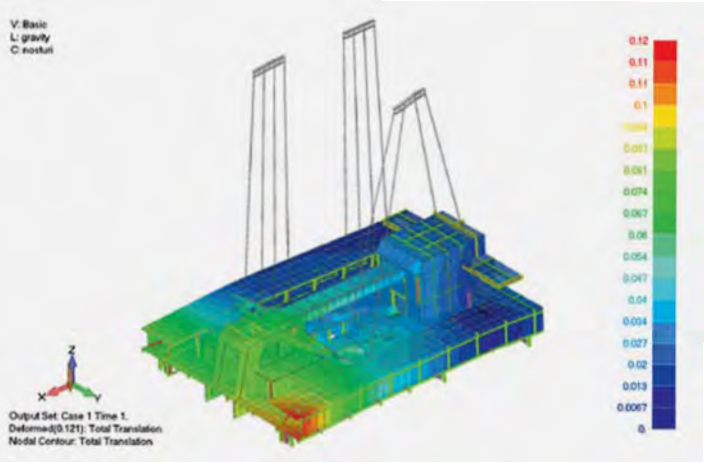


Figure 1. **FEM analysis of lifting for a maxi block 730**

Result 1: External passenger decks

The new building method has brought a remarkable increase in productivity for external passenger deck construction. Outfitting of exterior decks was performed mainly inside assembly halls. The goal was to build the exterior decks more efficiently, and to minimise the effect of weather conditions on the schedule, as well as the amount of heating required. The goal was also to increase quality. It was found that grand blocks could be executed in even larger entities, known as maxi-blocks – a combination of two grand blocks. The results have made it possible to shorten the schedules of further projects.

Figure 2. **Maxi block 740 en route to NB-1383**

Result 2: Modularised air conditioning rooms

Air conditioning rooms were modularised under the project. The new construction method has been patented. A totally new building method was tested in Mein Schiff 3, where the modules were lifted on to the hull and the grand blocks lifted on top of the modules. The modular way of working has meant a significant improvement in the schedule.

Figure 3. **AC module being lifted and installed**

Result 3: Further modularised cabin areas

Modularisation was also applied to cabin spaces to a larger extent than before. Cabins have long been modularised, but modularisation now extended to the piping in the cabin areas. The pipe package modules were developed with subcontractor Shippax Oy. The modules increased the quality of the work and also made it possible to transfer work outside the ship so that working conditions improved significantly. The modules also had a positive impact on the schedule.

Figure 4. **Workshop mock-up of a cabin area pipe module**

Figure 5. **Pipe module installed and covered at the block stage**

Result 4: Remarkable increase in the number of engine room modules

The total number of modules was increased from a few to nearly a hundred in Mein Schiff 3.

Figure 6. **One of four engine room modules**

PROJECT NAME

WP 4 Production Processes and Methods

Task 3

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
HEMMO HUTTUNEN STX FINLAND OY	**STX FINLAND OY** **MOBIMAR OY** **TECHNOLOGY DESIGN AND ENGINEERING ENG'nD OY**	**2009 – 2011**	**0.685 MILLION**

Developing Shipbuilding Methods

Main targets & motivation

Today's marketplace reality in the shipbuilding industry is characterised by expanding and deviating demands on product design and manufacture. Continuous, rapid and uncertain change has become the epitome of modern shipbuilding. New ideas, market opportunities, product features and end customer demands constantly arise within increasingly short periods of time. Harsh competition forces shipyards to concentrate on specific market segments with a growing product range. All this causes internal complexity in the product which is difficult to manage and oversee.

The key elements in solving modern shipbuilding challenges are reducing time to market by speeding up the development process, strategically flexible product design and production friendliness.

Good product architecture is the key and can be achieved with modularity.

A target was set

- to improve productivity by 30%
  - modularisation cuts direct costs and lead-time
- to increase the block outfitting ratio by 40%
  - block outfitting can be done in good industrial-grade facilities
  - both work and material quality improvements can be achieved
  - necessary tests on machinery and piping can be done prior to ship phase

- to implement modularisation in new areas
  - reduces the total cost of the ship
  - gives higher flexibility and quicker response time to customer demands
  - improves quality.

Results

As a result an average of 35% productivity increase in outfitting work was achieved. This was based on a modular construction method, better working environment and an up to 40% increase in block outfitting ratio. Fire safety was improved remarkably, with an up to 80% reduction in fire work on board ship. The results will be utilised in further ship projects.

Key publications

Lahdenranta, J. (2011), Laivojen ilmastointihuoneiden modulointi, BSc Thesis, Turku University of Applied Sciences.

Number of patent applications/patents: 1

Applications & impact

The results have also had a wider impact. The project has given the subcontractors an opportunity to test the new method and to develop their work. Some of these companies have started to apply the results in their work and these new ideas have brought major improvements to their projects. The results will be utilised in further ship projects. The impact of modularisation is significant, and a new company standard with tools will be developed based on the results of this task.

Standardisation of Outfitting Scheduling

Quick and reliable schedules with automated planning

This research and development project has demonstrated the efficiency and reliability of computer-aided area outfitting planning. The project's first phase defined and documented the terminology and key elements of the standard planning process. The second phase involved an analysis from previously built ships of the outfitting sequence and individual outfitting tasks of various area types. This information was used to create outfitting sequences and cycles for the outfitting area types in the developed planning procedure. The third phase implemented the created process in a computer application and tested both process and application.

The outfitting areas are the key elements of the developed planning process. A standard set of outfitting cycles, consisting of individual outfitting tasks, are defined for each area type. The cycles form groups, and the sum of the groups defines all the tasks needed to complete outfitting of the subject outfitting area.

A sizeable quantity of attribute data is linked to each outfitting cycle from other engineering applications and databases. Such information is used for automatic task duration estimation and resource allocations, for example. In practice, all information necessary for generating an automatic area outfitting schedule is either programmed or imported to the system. The application can be used for efficient generation of an area outfitting schedule for new ship projects shortly after the ship contract. In particular, the early availability of the area outfitting schedule significantly improves co-operation with TK, system and material suppliers and eliminates mistakes originating from the use of outdated, purpose-made schedules.

The process and the application were tested during the design and production phases of MS Viking Grace. The vessel's area outfitting schedule was created and maintained with the developed application. The developed process and software met all the targets of the research project. The results have been so promising that the principles developed in this project will also be used in modernisation and automation of other planning processes. This project clearly demonstrates that a well-designed planning process implemented in an efficient software application can reduce manual work significantly, while improving the quality of the area outfitting schedule, especially in the early stages of a newbuilding project.

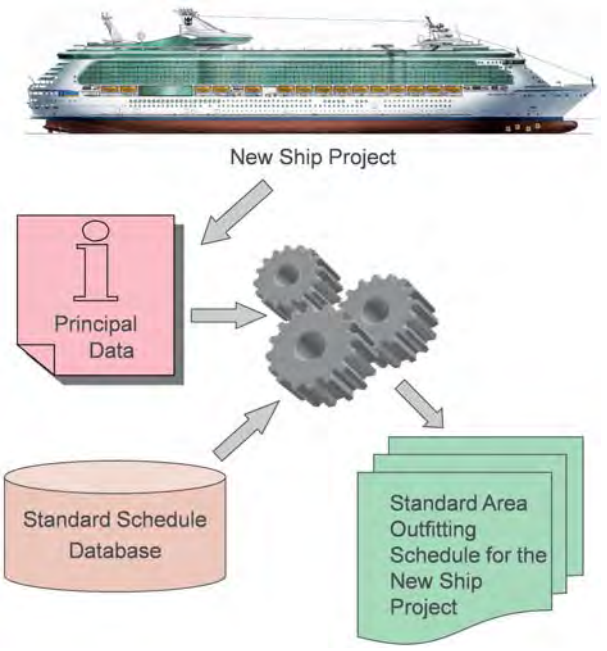


Figure1. **Principle of automated planning process**

PROJECT NAME

WP 4 Production Processes and Methods

Task 4

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
MINNA HEIKKILÄ	STX FINLAND OY	2009 – 2013	0.251 MILLION

Standardisation of Outfitting Scheduling

Main targets & motivation

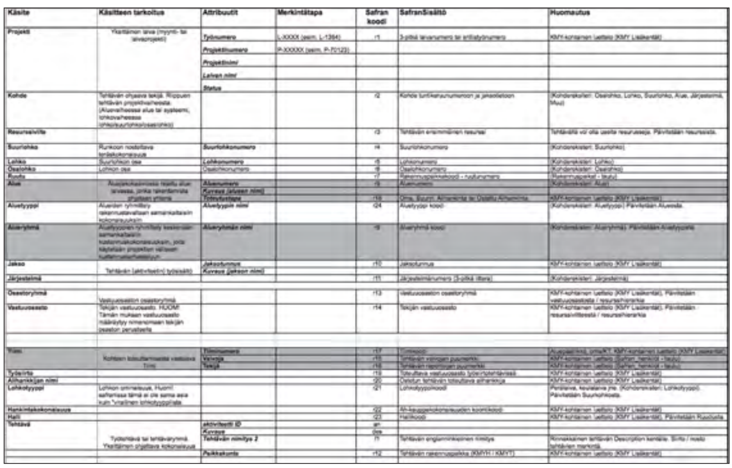
The aim of the task was to automate and standardise the planning of outfitting production to make a draft version of the outfitting schedule available at an early project stage, while improving its accuracy by applying standardised terminology and outfitting sequences. The existing planning process contained certain weaknesses which prevented efficient use of the outfitting schedule by some stakeholders. Publication of the first schedule version also involved a great deal of manual work.

Efficient co-operation with subcontractors and system and material suppliers requires availability of a common outfitting schedule at an early project stage. A common schedule published for all stakeholders simplifies co-ordination and eliminates errors and misunderstandings that easily originate from the use of un-synchronised schedules, such as those created for preliminary resource allocations and timing of system and material deliveries. Furthermore, the planning of outfitting production is a task common to all ship projects, one that results in the achievement of significant savings in human resources by increasing automation in the planning process.

Results

At an early stage of the project it became apparent that terminology and the meaning of terms commonly applied to outfitting planning were not precisely defined and documented. It was clear that development and automation of the planning process could not be started without harmonisation of commonly applied terms and definition of their exact meaning.

The project started with analysis of commonly applied terminology. Terms and their meaning in various planning applications were analysed and terms relevant for outfitting planning selected, defined and documented to form a solid basis for subsequent development steps. Some completely new terms were necessarily defined for the logical structuring of outfitting activities and for the easy implementation of the computer-aided scheduling process. Cycle, outfitting area, area group and milestones were selected as the most important key elements of the automated planning process and a completely new term, 'phase', created to support the timing of various outfitting activities. The relationship of the elements was defined and these, together with various other elements used to define the outfitting sequences and related activities, used in development of the automatic schedule generation.



Käsite	Käsitteen tarkoitus	Attribuutit	Merkintätapa	Safran koodi	SafranSisältö	Huomautus
Projekti	Yksittäinen laiva (myynti- tai laivaprojekti)	Työnumero	L-XXXX (esim. L-1364)	r1	[illegible]	[illegible]
		Projektinumero	P-XXXXX (esim. P-70123)			
		Projektinimi				
		Laivan nimi				
		Status				
Kohde	[illegible]			r2	[illegible]	[illegible]
Resurssiviite				r3	[illegible]	[illegible]
Suurlohko	[illegible]	Suurlohkonumero		r4	Suurlohkonumero	(Kohdeluokka: Suurlohko)
Lohko	[illegible]	Lohkonumero		r5	Lohkonumero	(Kohdeluokka: Lohko)
Osalohko	Lohkon osa	Osalohkonumero		r6	Osalohkonumero	(Kohdeluokka: Osalohko)
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Jakso	[illegible]	Jaksotunnus		r10	Jaksotunnus	[illegible]
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Järjestelmä				r11	[illegible]	(Kohdeluokka: Järjestelmä)
Osastoryhmä	[illegible]			r13	[illegible]	[illegible]
Vastuuosasto	[illegible]			r14	Tekijän vastuuosasto	[illegible]
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[illegible]				r22	[illegible]	[illegible]
Halli				r23	[illegible]	[illegible]
Tehtävä	[illegible]	aktiviteetti ID		[illegible]		
		Kuvaus		[illegible]		
		[illegible]		[illegible]	[illegible]	[illegible]
		[illegible]		r12	[illegible]	[illegible]

Figure 1. **Example of terminology definitions**

The outfitting process of an area already starts in the block production phase. It was therefore necessary to create a process to identify all the blocks forming an entire outfitting area. The NAPA ship model containing information on the block boundaries was used for this purpose. Blocks forming an outfitting area could be identified by comparing bounding coordinates of the outfitting area and bounding coordinates of each individual block. Area outfitting activities possible and desirable to make in the block production phase were created automatically and scheduled on the basis of block production schedule.

It was decided to base the automatic generation of area outfitting cycles on outfitting area type. A standard set of outfitting cycles was created for various types of outfitting areas. Several attributes were also linked to each outfitting area type and to standard outfitting cycles such as size of area, milestones defining the outfitting time frame, the team performing the outfitting, etc. A matrix defining outfitting cycles of various outfitting area types was available at the shipyard. This table was updated according to the input of various engineering and production disciplines and used in this project.

Jakso / Aluetyyppi Matriisi

Jaksoryhmä 1 (Vaihe)	*Jakso*	11 Konehuonealueet	12 Tankkialueet	13 Konekuilut	14 Paja- ja varastotilat	15 Sähkölaitetilat	21 Vene- ja lauttakannet	22 Vintturikannet	23 Lastitilat	24 Merenkulkualueet	25 Lastivalvomot	26 Aurinko-, Uima-allas- ym ulkokannet	31 Matkustajahyttialueet	32 Miehistöhyttialueet	41 Matkust_ yleiset tilat	42 Miehist_ yleiset tilat	43 Pääportaikko	44 Muut portaikot	45 Atriumit	51 Puhallinhuoneet	52 Sähkölaitetilat	53 Hissit	54 Kuilut	61 Keittiötilat	62 Muonavarastot	63 Pesulat	64 Muut erilliset palvelualueet
01	**Tausta-asennukset Seinä**																										
ERL	Eristys: Läpiviennit	1			1	1			1	1	1										1		1			1	1
SVK	Seinäkoolaus				1	1				1	1	1	1	1		1	1	1	1	1	1			1	1	1	1
02	**Tausta-asennukset Katto**																										
ERI	Eristys: Ilmakanavat	1		1	1		1		1		1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ERP	Eristys: Putkistot	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
IKO	Ohutlevykanavat				1	1			1	1	1		1	1	1	1	1	1	1	1	1		1	1	1	1	1
IKT	Tulo- ja poistoilmalaatikot												1	1	1	1	1	1	1					1	1	1	1
KVI	Ilmanohjaus pellit / vedonestot (pellitys)												1	1	1	1	1	1	1					1	1	1	1
KVK	Kattokoolaus					1				1	1	1	1	1	1	1	1	1	1	1	1			1	1	1	1
LEI	Paksulevykanavat	1	1		1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
LEK	Kaapeliradat/-läpiviennit	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
PUF	Springler-putkien asennus				1				1	1	1	1	1	1	1	1	1	1	1					1	1	1	1
PUG	Springler-putkien koeponn.+ suutt.as.				1				1	1	1	1	1	1	1	1	1	1	1					1	1	1	1
SÄN	Pitkien kaapelien veto									1		1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
SÄP	Kaapelien klemmaus	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
SÄV	Aluekaapelointi (Vedot alueen sisällä)	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
03	**Lohkorajatyöt**																										
LER	Rajaraudat											1	1	1	1	1	1	1	1					1	1	1	1
MAR	Lohkorajamaalaus	1	1	1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1		1	1	1	1	1
031	**Laiteasennukset**																										
KOI	Inventaarit,varaosat	1			1				1																		
KOL	Laiteasennukset (esim. AC-kojeet)		1	1	1	1	1	1		1	1	1	1	1	1	1	1	1	1	1	1	1		1	1	1	1
KOV	Veneet ja lautat						1																				
PUK	Putkiston kytkentä (koneet ja laitteet)	1							1		1		1	1	1	1	1			1				1	1	1	1
04	**Muu Aluevarustelu**																										
ERA	Tila-/alue-eristys (pellitys tässä jaksossa)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
ERS	Eristys ja pellitys: Pako-ja savukaasuputket	1		1																							
ERT	Eristys: Tyynyjen asennus (laipat,venttiilit, yms)	1		1																							
IKS	Ilmastoinnin säädöt					1							1	1	1	1	1	1	1				1	1	1	1	1
LEO	Ovet ja luukut (palo- ja teräsovet)	1		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
LEP	Pakoputket			1																							

Figure 2. **Example outfitting area related outfitting cycles Definitions**

A relational database application based on MS Access was created to generate an area outfitting schedule for new ship projects. The application defined outfitting cycles of various outfitting area types and read the necessary attribute information from supporting software and databases. By defining certain key information, such as ship type, outfitting areas, main dimensions, deck heights, etc. the application generates a draft version of the area outfitting schedule. The draft schedule can be transferred easily to the official planning and scheduling software of the shipyard, and updated and modified according to the specific needs of the actual ship project.

The generated process and the application were tested and verified in the planning and production processes of a cruise ferry under construction during development of the application. The process and the application were found to meet all the targets set for the development project. The application shortened the planning process significantly and provided a solid basis for scheduling of outfitting areas.

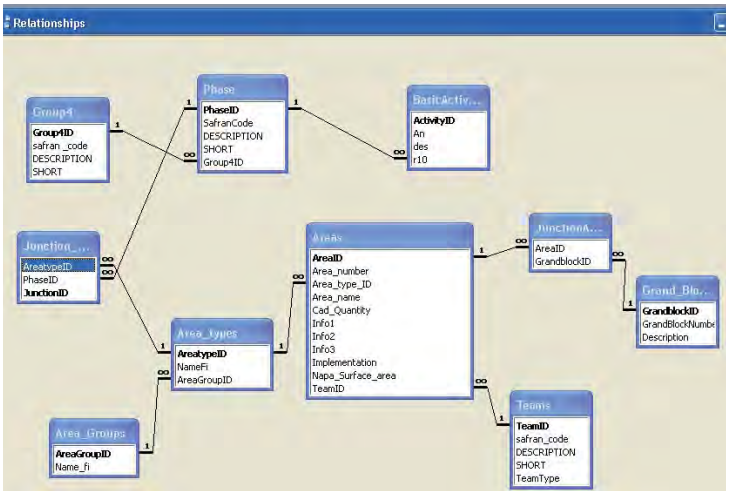


Figure 3. **Attributes related to an outfitting area type**

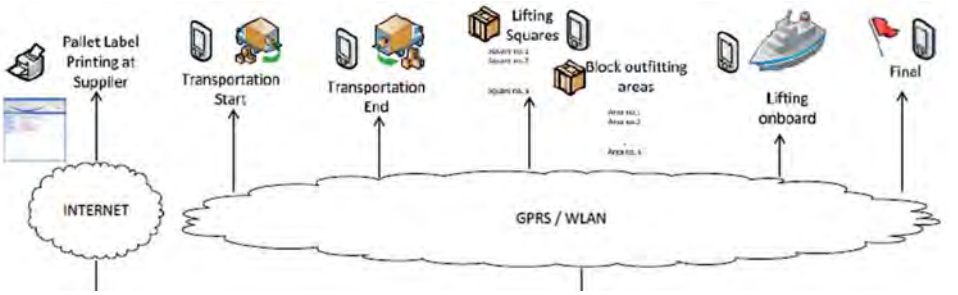
Applications & impact

The developed area outfitting scheduling process and computer application met all the targets set for the development project. The project demonstrated that standardisation and automation can improve the quality of area outfitting schedules significantly, especially at the beginning of a ship project, while human resources can be moved from time-consuming activity definition and task scheduling to more critical tasks, such as bottleneck, capacity, material and risks analysis. Computer-supported scheduling will save costs and improve the quality of area outfitting planning in all our forthcoming newbuilding projects. Experience gained during this development project will also be used in the planning process development of other disciplines.

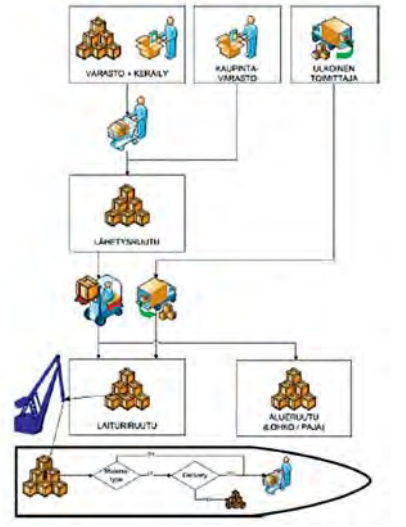
Developing Logistic Methods and Tools

Real-time logistics tracking and tracing

The shipbuilding process has traditionally suffered substantial uncertainty in material availability. This development project was established to reduce this uncertainty in the last phase of the material process from warehouse to installation. The following type of process chart was developed in the initial project phase:



Final process chart also describing the multichannel feature of material flows:



A tailor-made address label with 2D bar code is used. The bar code standard is Datamatrix.

Project	Ship Area	Square	Opening
383	037A	146	036R-S

Deck	Side	Foreman	Date
3		reini	23.09.13

Phone		Activity
0505207892	M-569990-01	240-EMS

Picker	Planner	Final Destination	
JYLa	TRei	036R-S	
Note		Weight 458.00	

The Motorola MC65 is used in field operation in both warehouse and transport operations.

PROJECT NAME

WP 4 Production Processes and Methods

Task 5

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
SAMULI KAHALA	STX FINLAND OY	2009 – 2011	0.363 MILLION

Developing Logistic Methods and Tools

Main targets & motivation

The main motivation for this development task was to create real-time follow-up systems and methods for outfitting material. The benefits of these would be:

1. Improved material delivery accuracy, both time and location
2. Improved efficiency and control of material transport and lifting operations
3. Improved housekeeping level of logistics operation areas
4. Reduced amount of lost material
5. Less time for locating lost material
6. Improved productivity for outfitting installation work.

In the first phase this novel system would be used for tracking and tracing material at pallet level. The content of each pallet may also be reported and followed. There would also be investigation into the feasibility of item-level installation follow up.

Results

The first phase of the development project was to investigate if commercial systems and software could be used, or whether development of a tailor-made solution was needed. We considered current software used by STX Finland as well as other commercial software.

The selection process led to a commercial software, Motus WMS, supplied by Leanware Oy. This was considered to suit STX's purposes without major modification, while the user interface was simple and clear.

A new functionality was also developed in STX's current material management system MARS, for creating pallets and sending a transport request to Motus. Pallets can be followed both in Motus and MARS (supplied by Danish Aveva). An SMS and/or email is sent to the contact person when a pallet is delivered to its final location.

A separate solution for creating pallet labels by subcontractor network was also specified. This will be used on a public internet website.

Wide market research was conducted to find the best possible hand-held computers for use by warehouse and transport personnel. The main requirements were:

- Pocket-sized: workers must be able use both hands when moving pallets
- Clear screen, suitably large
- Keyboard not too complicated
- Battery capacity for full day operation
- Adequate range of operating temperature: –20 °C to +30 °C. This was tested in real temperatures before the final decision.

The chosen equipment was Motorola MC65 with the following features:

- Microsoft's Windows® Mobile® 6.5
- 512MB RAM/1GB Flash and a user-accessible micro SD card slot with support up to 32GB
- Support for Motorola's Enterprise Mobility Developer Kit (EMDK) APIs
- 802.11a/b/g tri-mode radio connects to both 2.4Ghz and 5Ghz WLANs
- Bluetooth® v2.0 with EDR
- Drop (impact) test: multiple 6ft/1.8m drops per MIL-STD 810G
- Operating temperature –10 °C to +50 °C (tested at –20 °C)
- Environmental sealing IP 64.

Applications & impact

When this novel tracking and tracing method is fully implemented and used in the proper way it will bring significant improvement in the quality and productivity of internal logistics operations in shipbuilding. Management of logistics will obtain better and more data of each transport and lifting transaction. The logistics operator receives online information of work load in each of the logistics operative locations and/or units. The location of pallets is available in real time, meaning that remarkably less time is used in searching for materials.

Production teams who are customers of internal logistics operations receive real-time information by SMS or email when materials are delivered to the final locations, which means that their installation work can start without delay or intermediate storage in production areas. This improves the housekeeping level of these areas and thus helps in reducing the amount of fire load.

Innovation in Network Collaboration (INC)

Enhancing and boosting the innovativeness of networks

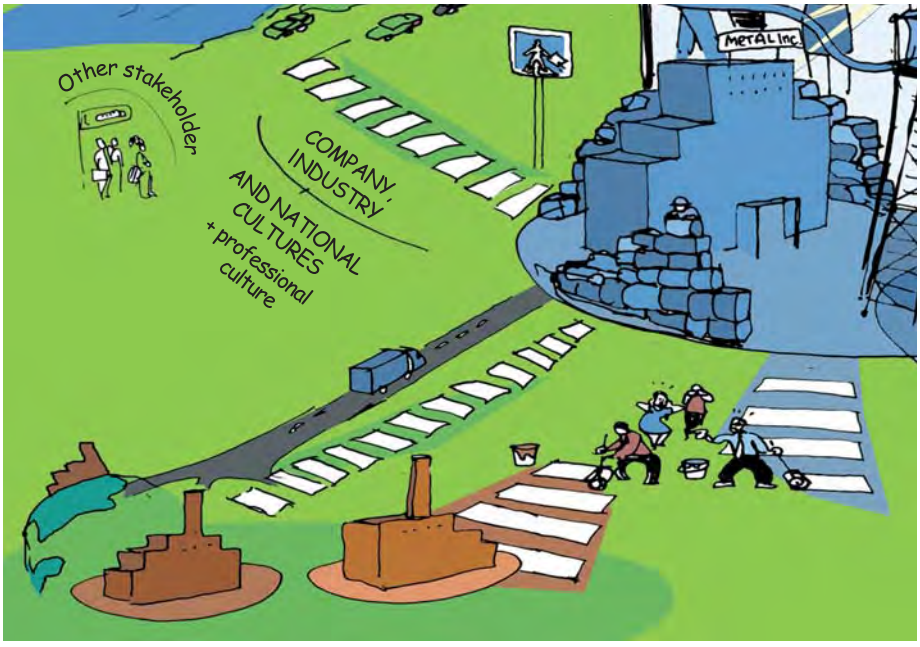


Figure 1. **Breaking barriers, boosting innovation**

New knowledge was generated and applied in an industrial context:

- Success factors and challenges in the implementation of open innovation in collaborative networks, and the role of technical, business, legal and other aspects in it;
- Systematic assessment concerning organisational innovativeness; "innovation due diligence";
- Productive idea screening and selection process in a corporate environment
- Internal and external innovation ecosystems and their potential impact on the innovation front end.

The INC project aimed at discovering how firms can enhance their innovation capability by giving greater consideration to their innovation ecosystem, and in particular by tapping into the potential of their existing internal and external networks. Special attention was paid to collaboration and co-creation methods between suppliers in the provision of products and services to their customers. Topics were addressed through joint case studies between researchers and participating companies.

Open innovation in closed networks

"The boundaries between a firm and its environment have become more permeable. In order to stay competitive, companies must learn how to innovate and create value in collaborative networks. Our company has gained a lot of useful knowledge, not only about the advantages but also challenges concerning co-creation with other companies. Lessons learnt in the contractual challenges resulted in a continuation project within another FIMECC technology programme."

***Seija Junno**, Rautaruukki*

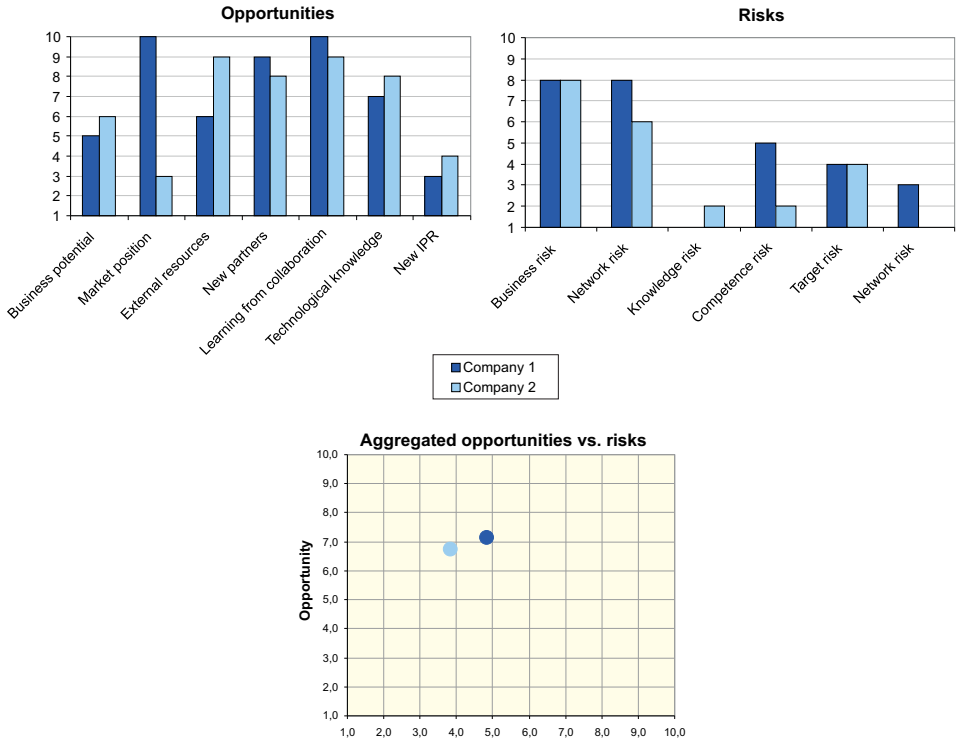


Figure 2. **Summary of risks and opportunities**

"Idea collection, processing and development activities are a crucial part of an organisation's capacity to innovate. The input from the INC project has been essential in developing an idea screening system able to utilise all kinds of ideas, not only those that are product-related. Particular attention has also been given to the utilisation of ideas created in the network surrounding the company."

***Esa Wendelin**, Cargotec Finland*

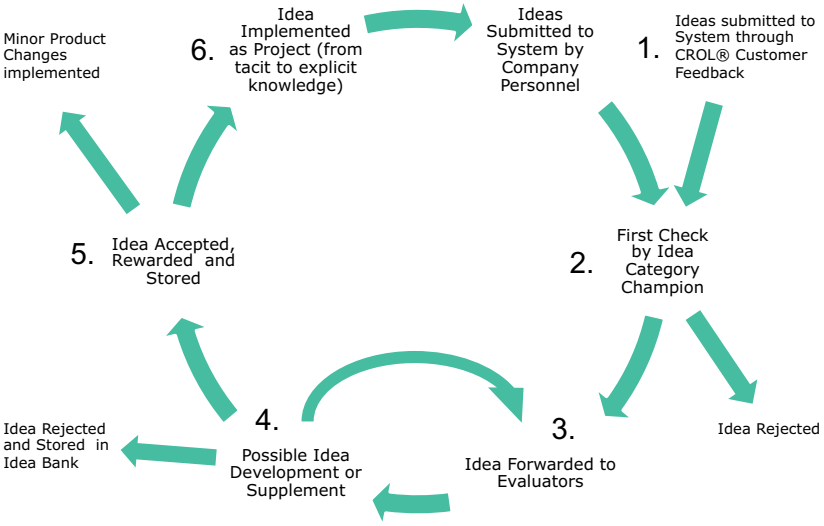


Figure 3. **The idea screening process**

PROJECT NAME

WP 5
Innovations in Flexible Networks

Task 1

CONTACT PERSON
KIM WIKSTRÖM
ÅBO AKADEMI UNIVERSITY

PARTICIPANTS (ORGANISATIONS)
CARGOTEC FINLAND OY
INNO-W OY
RUUKKI OYJ
VTT TECHNICAL RESEARCH CENTRE OF FINLAND
ÅBO AKADEMI UNIVERSITY

PROJECT DURATION
2009 – 2013

PROJECT VALUE (EUR)
1.359 MILLION

Innovation in Network Collaboration

Main targets & motivation

The key objective of the project was to find out how firms could enhance their innovation capability by giving more consideration to their innovation ecosystem, and in particular by tapping into the potential of their existing internal and external networks. The target was to boost innovativeness through developing and defining a shared framework and innovation process for product development activities, and creating a collaborative environment fostering innovativeness in the business network.

Key research questions concerned coping with innovation mechanisms in global networks. How should innovation lead in global networks? Which characteristics enable – and which disable – innovation when creation takes place in a collaborative environment? What kinds of network structures enable innovation-rich constellations? As innovation is becoming increasingly democratised in many business segments, one particular question was to find out how business and innovation mechanisms can prepare for working in open source constellations.

Results

- Systematic assessment method for organisational innovativeness; “innovation due diligence” process
- Methodology for an idea-screening process in a corporate environment
- Mapping process for an innovation ecosystem, with particular emphasis on innovation front end
- Success factors and main challenges in the implementation of open innovation in collaborative networks

Key publications

1. Paasi J., Lappalainen I., Rantala T. & Pikkarainen M. (2013), Challenges for product and service providers in open innovation with customers in business-to-business markets, Journal of Innovation Management (accepted for publication).
2. Tallqvist T., Gustafsson M. & Laaksonen K. (2010), Innovation Ecosystem in Mature Firms. EURAM 2010 conference, 19–22 May, Rome, Italy.
3. Leppänen, P. (2010), Open innovation in collaborative networks, Turku School of Economics in collaboration with Åbo Akademi University.
4. Lappalainen, I., Apilo, T. & Mäkitalo-Keinonen, T. (2010), Typology of user-driven innovation – How can customer and end-users be involved in companies' innovation process? 11th International CINet Conference – Practicing innovation in times of discontinuity, Zürich, Switzerland, 5–7.9.2010. Proceedings of the 11th International CINet Conference.
5. Laaksonen, K. (2009), Idea Screening and Processing within Innovation Ecosystem, Laboratory of Industrial Management, Åbo Akademi University.

Number of publications: 8
Number of Master's Theses: 2

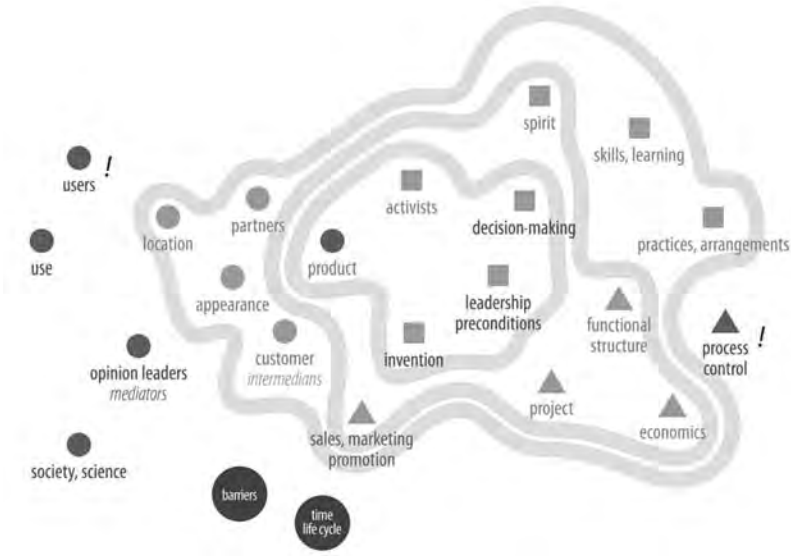


Figure 1. **Levels of attention given to different aspects of innovation by activists participating in the innovation ecosystem** (Tallqvist et al., 2010)

Networks and international co-operation

Challenges and opportunities concerning collaborative networks were analysed in international workshops and new solutions improving the functionality of the innovation ecosystems devised, partly in connection with researcher exchange and meeting with international experts. These activities took place in Turku, Finland (Prof. Krys Markowski, ESIEE Engineering, Paris), Technische Universität Berlin, Germany (Prof. Hans-Georg Gemünden, Dr Alexander Koch) and Kellogg School of Management, USA (Prof. James Conley, Prof. Mohan Sawhney, Prof. Kim Wikström).

Applications & impact

The results of the project benefit organisations that aim to maximise their innovation capability through the efficient use of network collaboration. Significant attention was given to the innovation front-end (idea collection, screening and development) that is able to capture the value from the integration of the external network, and helps to ensure that R&D activities are marketoriented. Another aspect was the development of tools and processes that help to discover, analyse and implement a company's internal innovative knowledge, experience and ideas in order to yield business opportunities. A web-based idea collection tool was implemented during the project in one of the participating companies, based on the results achieved.

Results concerning the success factors in the implementation of open innovation in industrial networks can be used proactively to enable smooth collaboration (e.g., trust between the partners, risks vs. opportunities, aligned business interests, legal vs. business aspects). The use of the "innovation due diligence" method developed in the project will help organisations to build an ecosystem that is able to carry out sustained innovation.

BEST PRACTICE

Case Ruukki

The Innovations and Network programme and its various partners performed a key role at Ruukki during the development of our innovation process, especially the front-end phase. We developed new tools together, as well as new working methods, and learnt a lot. One of the most interesting things we learnt came through an open innovation case led by VTT and Åbo Akademi. This revealed practices that bog down co-creation between companies: IPR sharks swim in the wide moats that surround them, and business people tend to delegate contracts to lawyers whose main target is to minimise risks, and not by any means to maximise potential common benefits. So the crosswalks never join. The simplifying and visualising of contracts was a very interesting research topic for the FIMECC User Experience programme. On the whole, we have found a very useful and productive way of organising research people of different programmes so that they work together with the same business challenge or topic. The areas of expertise and different viewpoints complete each other and allow us to discover fresh research questions and novel solutions.

Over recent years the moats have narrowed and the sharks have got smaller, while the walls around companies have fractured and even broken down here and there. This can be seen as an influence of FIMECC I&N and other co-creation programmes.

Annual Monitoring and Prognostication

Probing foresight and facts for the Finnish marine industry

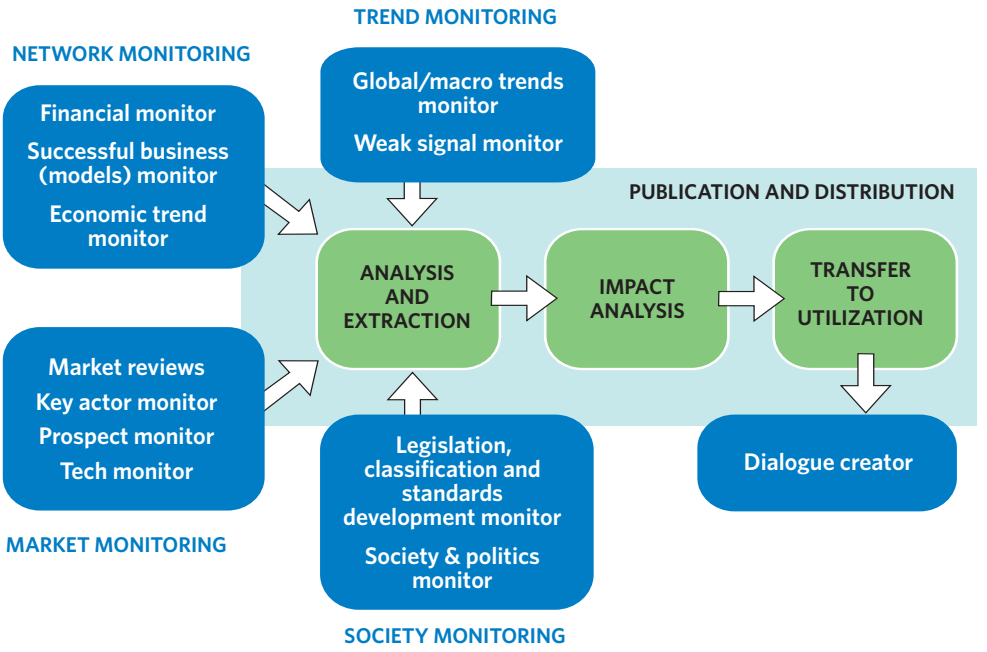


Figure 1. **The Finnish marine industry needs a specially hand-crafted intelligence concept for understanding industry dynamics, performance and future development**

Main Results

A new marine industry intelligence concept planned, tested and implemented with various analysis tools and prognoses.

The developed concept provides cluster level intelligence on:

- Financial performance of the marine industry companies
- Total industry volume development
- Short-term business expectations
- Long-term industry evolution and critical developments

Selected results highlights

1. New measurements of the Finnish marine industry

- Annual turnover of the Finnish marine industry levelled out at 7.4 billion as the all-time high in 2008 and declined to 5.7 in 2011 – yards declining and marine equipment system suppliers prospering
- Diversity of company performance increasing – industry's success cannot be determined uniformly

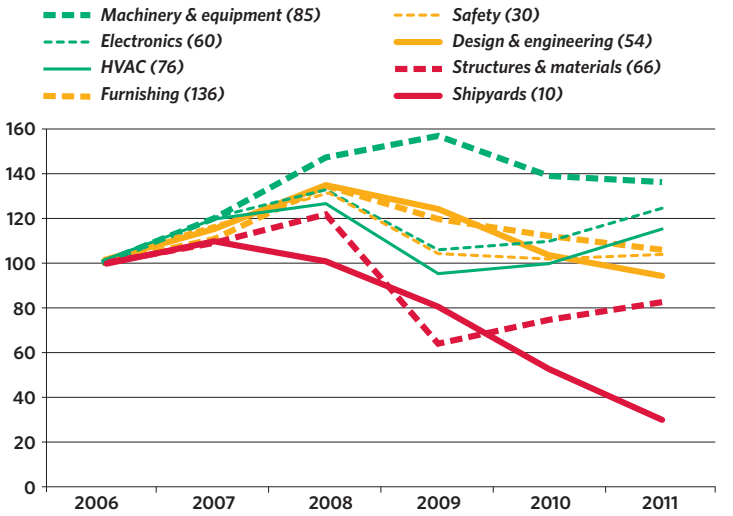


Figure 2. **Annual turnover divergence between different marine industry groups (2006=100)**

2. Markets and trends require specific strategic choices from the marine industry companies

- From the product-centred business model towards service-dominant logic
- Increasing joint value-creation with customers
- Progressive internationalisation steps required for utilising the growing global markets

3. The whole marine industry about to come to a turning point – alternative scenarios possible
   - Evolution – Adaptive survival
   - Devolution – Industry decline
   - Revolution – Industry renewal and reshaping

The marine industry itself votes equally for Evolution and Revolution. In practice, the difference between the pathways is huge for the marine ecosystem. One strategy and implementation is needed.

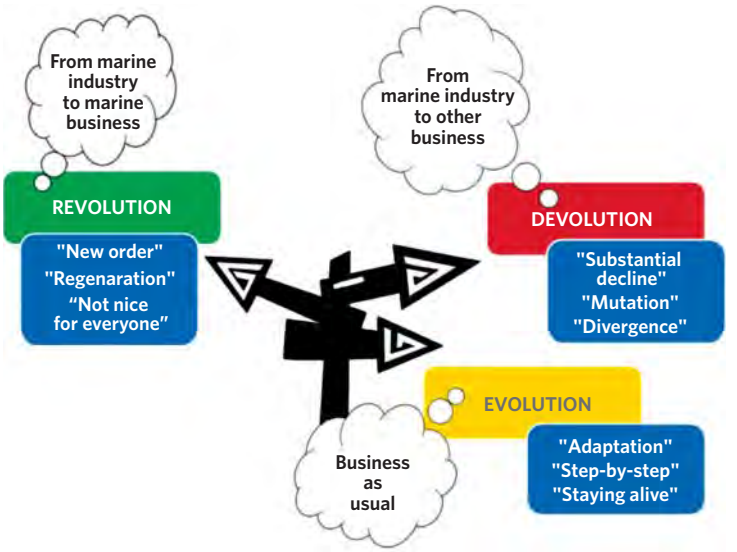


Figure 3. **Alternative development scenarios for the Finnish marine industry**

Industry comment

The Probe project contributed significantly to the understanding of Finnish marine industry development and performance, and created analysis tools of a type that had not previously existed. The whole industry needs these sophisticated and reliable measures and tools for backing up strategic decision-making and increasing our competitiveness. This is why Finnish marine industries are also continuing the process beyond the project, together with the Universities.

***Merja Salmi-Lindgren**, Association of Finnish Marine Industries*

PROJECT NAME

WP 5
Innovations in Flexible Networks

Task 2

CONTACT PERSON
ANTTI SAURAMA
UNIVERSITY
OF TURKU

PARTICIPANTS (ORGANISATIONS)
UNIVERSITY OF TURKU
ÅBO AKADEMI UNIVERSITY

PROJECT DURATION
2009 – 2012

PROJECT VALUE (EUR)
0.850 MILLION

Annual Monitoring and Prognostication

Main targets & motivation

Around 500 firms belong to the core of the Finnish marine cluster. The past decade in the marine industry has witnessed rapid changes, cyclical developments and restructuring becoming permanent features. Monitoring the change dynamics is becoming more challenging because companies serve various market segments, operate with networked business models and face different business cycles. This calls for cluster-level intelligence processes to understand current performance, change drivers and impact mechanisms.

Finland's marine industry needs a novel concept for monitoring its performance and understanding the dynamics of cluster development.

The main objective of the project was to provide thorough **performance and trend analysis of the Finnish marine industry**, and to **set up a permanent concept for monitoring and analysing industry development**. The results are set to give indications on how market dynamics impact on Finnish companies, which trends are shaping the industry's future, how firms, industry stakeholders and public sector agents should prepare for changes in the business environment, and how the industry is performing. The analysis process supports strategic decision-making concerning both business development and investments.

Results

The results of the project were achieved by

- Creating an intelligence method framework by selecting key phenomena, indicators and data sources
- Piloting and testing analyses, validating results and modifying the process iteratively
- Creating a permanent intelligence concept for the marine industry

Improved understanding of the state and development prospects of the Finnish marine industry

The project provided long-awaited accurate data of the business performance of the marine industry, changes in the business environment, and rising scenarios. This improved awareness of the current state and foreseen development of the industry has been widely used in public decision-making.

Among the marine industry performance results is the cluster turnover time series, which indicated that the industry reached its all-time high in 2008, with annual turnover of 7.4 billion euros. Since then the volume has decreased every year, to 5.7 billion in 2011, which is approximately same as in 2006. The results also show the highly heterogeneous economic performance of marine industry companies in Finland, with some branches excelling and others in severe economic difficulties.

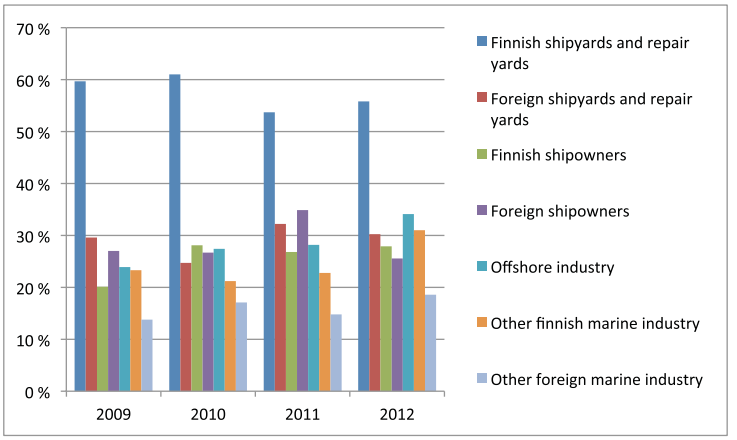


Figure 1. **The share of Finnish marine industry companies that rate different customer segments as important to them (n= 130–154 companies)**

Applications of industry foresight – taking a grip on the coming development through scenario thinking

The project put significant effort into improving methodology and increasing proactive information on marine business foresight. Based on extensive longitudinal data gathering through business outlook and innovation behaviour surveys, industry reports, expert interviews and workshops, three scenarios were formed for the marine industry; devolution, evolution or revolution. This provocative yet fact-driven approach successfully fed various discussions, and encouraged the consideration of different aspects when planning the marine industry's next steps.

Practical input to companies regarding future focus areas

Based on the project's market segment analyses, recommendations were made as to what the marine companies should focus on in order to improve their market position. Innovations in terms of energy efficiency, software solutions and alternative fuels provide great opportunities. Investments in R&D are required to develop and commercialise innovations. The suppliers were also encouraged to address the after-sales market through developing life-cycle solutions based on a closer dialogue and co-creation with the end customers. Flexible business models and technology transfer reduce risks and also allow serving different customers internationally, and not only the local shipyard. Collaboration and representation abroad is highly recommended.

Intelligence concept to monitor marine industry development

Project created a concept for continuous performance monitoring which will function as a continuance to the above described work. The concept includes three dimensions: financial performance and volume development of the industry, short-term development perspectives and long-term visions. This intelligence concept will be carried out in co-operation with the Association of Finnish Marine Industries (METY) and the University of Turku, and launched in 2014.

Key publications

1. Makkonen, T., Inkinen, T., & Jouni Saarni, J. (2013), Innovation types in the Finnish maritime cluster. WMU Journal of Maritime Affairs. Vol. 12, Nr. 1., pp. 1–15.
2. Saarni, J., Saurama, A., Karvonen, T., Heikkilä, A. & Holma, E. Meriteollisuuden talouden ja suhdanteiden kehitys 2006–2020 – FIMECC Probe-hankkeen toimialakatsaus 2012. Publications of the Turku School of Economics, E1/2013.
3. Andrésen, A., Luotola, H. & Karvonen, T. Meriteollisuuden toimintaympäristön ennakointi. Megatrendit, trendit ja muutosta ohjaavat signaalit, segmenttien kehitys. Report 2011.
4. Saarni, J., Saurama, A., Karvonen, T. & Haapakangas, K. Katsaus meriteollisuuden talouden kehitykseen ja suhdanneodotuksiin vuodelle 2012. Report 2011.
5. Koponen, A. & Pohjola, M. Meriteollisuuden talouden kehitys ja innovaatiotoiminnan vaikutus yritysten menestykseen. Report 2011.

Number of publications: 17

Networks and international co-operation

As many as 357 Finnish marine industry companies contributed to surveys, polls and qualitative assessments. 20 key marine industry organisations participating in the industry foresight process. Rich interplay with the Association of Finnish Marine Industries (METY) and the Maritime Cluster Programme. International data collection made in co-operation with the PBI St. Petersburg office.

Applications & impact

The PROBE project provides a novel concept for understanding the dynamics and future development scenarios of the Finnish marine industry by

- Providing companies and public sector actors with a clear picture of market development, as well as the conditions, challenges and opportunities on which to base their decision-making
- Identifying and showing the diversity of company success, dynamics and market potential among the marine industry companies, previously understood as a homogenous cluster
- Involving a total of 357 Finnish marine industry companies and creating a unique data foundation concerning the industry's business and development
- Creating a permanent cluster analysis concept and process that will be carried out in co-operation with the industry after the programme phase

International Co-operation: Finnish Maritime Industry's International Research Co-operation

Figure 1. **Co-operation forums**

Finnish Marine Industries, later AFMI, is one of the Branch Associations of the Federation of Technology Industries. The members are leading shipbuilding and ship repair yards, marine equipment manufacturers, turnkey suppliers in the field of marine technology, ship designers and offshore industry companies. The aim of the task was to increase the marine industry's international co-operation in research, and to help the companies and research organisations to gain access to financing for their RDI actions.

The crucial asset for competitiveness in the global environment is business-driven innovation. A change is taking place in the technological and economic balance of global business and markets. Positioning the Finnish maritime industry's competences as a leading nation requires a strengthening of proactivity in international co-operation and networks within the trusteeship. The importance of international co-operation in research and development will increase in future, influencing funding instruments and themes according to the needs of the innovation actors.

Within innovation actors, AFMI represents the industry as a trustee in European networks such as Waterborne, SEA Europe and Martec II. These networks concentrate on developing network co-operation, funding themes and instruments. The aim of the task was to gather information from these networks, engage in co-operation and take part in the activities. This would lead to effective, agile and, especially, proactive functions within the European networks.

Result 1: Condensed international co-operation

One result of the Innovations and Network programme is a significant condensing of international co-operation and networking with other European actors. SEA Europe SEA RDI and Waterborne TP participation has created an opportunity for AFMI members and stakeholders to obtain information and impact on EU work programmes. These forums have also been good sources of insider information on waterborne-related issues. In addition, AFMI also conducted a questionnaire on internationalisation for its member companies (figure 2).

Does your company take part in some international research programme or project?

	Answer	Number	Percentage	20%	40%	60%	80%	100%
1.	Yes	7	29.17%					
2.	No	17	70.83%					
	Combined	**24**	**100%**					

Figure 2. **Questionnaire on internationalisation**

Result 2: Co-ordination of the Strategic Research Agenda

Finnish Marine Industries coordinated the composition of the marine industry's Strategic Research Agenda (figure 3) which aims to identify the main themes and areas of research that the Finnish Maritime Cluster will need in the future. In addition, the agenda aims to provide a comprehensive overview of the state of the industry, and to define the skills and competence needs involved. AFMI has also compiled a roadmap for the Strategic Research Agenda aimed at finding perfect funding instruments for research at either international or national level (figure 4). In addition, AFMI has worked for the dissemination and implementation of the Strategic Research Agenda. The work has had a notable impact in Tekes' new programme "Arctic Seas".

MERITEOLLISUUS
Finnish Marine Industries

Figure 3. **AFMI SRA**

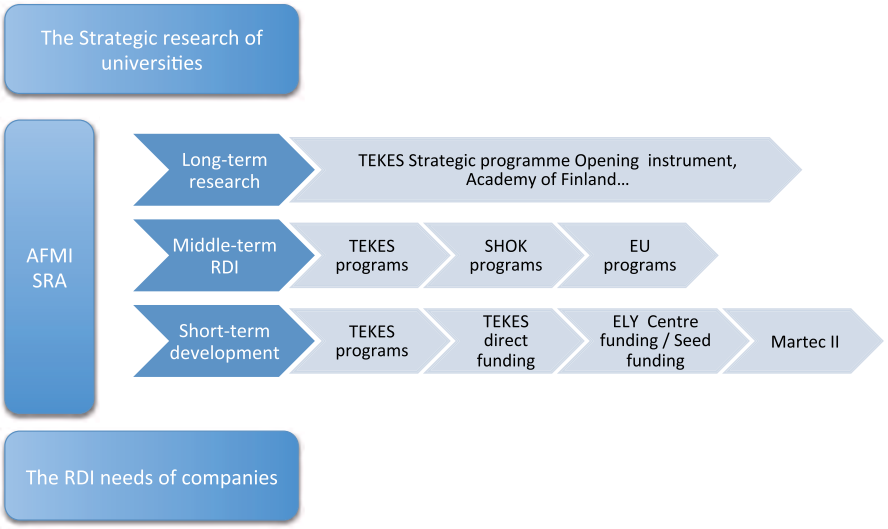


Figure 4. **Financing possibilities for the SRA**

Result 3: Seminars and excursions

AFMI has planned and organised international excursions to European maritime companies and an excursion for SEA Europe RDI to Finnish maritime companies. In addition, Finnish Marine Industries has organised four Future Reception research seminars aiming to disseminate information on research programmes and to help Finnish companies create networks for participation in these programmes. Each seminar has attracted 50 – 100 industry members.

Result 4: Companies taking part in European Co-operation

AFMI, in distributing information concerning EU programmes and helping companies to find partners, has assisted companies that have taken part in Vessel for the Future PPP and Martec, two projects in the 7th framework programme. AFMI has also set up a work group, and chosen leaders who are currently composing projects for Horizon 2020 and the next Finnish Tekes programme, Arctic Seas.

PROJECT NAME

WP 5
Innovations in Flexible Networks

Task 3

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
ELINA VÄHÄHEIKKILÄ	**FINNISH MARINE INDUSTRIES**	**2009 – 2013**	**0.238 MILLION**

International Co-operation

Main targets & motivation

The task "International co-operation" aimed to ease international research for Finnish maritime companies by disseminating information to companies about the EU's research programmes and projects and to activate programme participation. Finnish Marine Industries, later AFMI, also participated in organising European research framework programmes FP7 and Horizon 2020. The task has also given maritime companies the opportunity to influence European work programmes and calls. International research programmes create not only new scientific results but also international co-operation, and are a way of finding new markets.

The research questions concerned the kinds of development needs that Finnish maritime companies have and how these companies could co-operate internationally in the RDI field. One of the main activities for Finnish Marine Industries during the project involved establishing the national maritime research and development agenda, later SRA, and defining its implementation. The SRA was collected from the member companies and stakeholders. The other main activity was to increase proactivity in defining the necessary themes for Horizon 2020 and to activate companies and research institutes towards participating in EU framework programmes. Other important actions included keeping industry informed, interdisciplinary co-operation within other industry sectors, arranging workshops, seminars and e-letters, and promoting the integration of technologies.

Results The task has condensed international co-operation. Finnish Marine Industries has participated in creating European co-operation for the branch. AFMI has taken part in the RDI research and development work group of the European Ships and Maritime Equipment Association (SEA Europe) and in Waterborne TP, the technical platform for European maritime clusters. Through Waterborne, AFMI has also co-ordinated the Public-Private Partnership programme for the maritime cluster in Horizon 2020, known as "Vessel of the Future".

Finnish Marine Industries has discovered items of interest for research topics and themes among maritime companies by means of workshops, appointments, meetings and seminars and the sending of emails. Finnish Marine Industries has also organised Strategic Research Agenda 2020 creation through companies. The agenda (SRA) was published in February 2013, with AFMI's contribution performed as part of Innovations and Network. The SRA aims to identify the main themes and areas of research that the Finnish Maritime Cluster will need in the future. Writing of the agenda involved the participation of Finnish Marine Industries and its Research Committee, whose members include representatives from all branches of the Maritime Cluster, including shipyards, suppliers, ship owners, the Finnish Transport Safety Agency, the Naval Research Institute and other research institutes and universities.

The SRA aims to influence decision-making processes and themes of European Union and national research programmes under consideration. It also seeks national and international resources for future Finnish maritime companies' research activities. The main themes of the SRA are cruise ships and ferries, Arctic technology and offshore activities. Cross-cutting themes are competence, new business models, environment and energy. SRA dissemination and implementation has been taking place since the agenda was published. The SRA roadmap has been built to inform of activity in the research field and to find funding instruments for research programmes on international or national level. Finnish Marine Industries has supported the implementation of the SRA by activating companies towards participating in the preparation of research projects. It has also found project groups to form horizontal consortiums with the aim of succeeding in research programmes at national and European level.

Influence over the European Union's framework programmes has also been achieved, in accordance with the SRA, both nationally

and internationally, through national authorities and EU cooperation stakeholders. Finnish Marine Industries has also collected and condensed information on forthcoming research programmes, for the use of the industry and for decision-making processes. Drafts of Horizon 2020, for example, have been distributed to industry for comment. Finnish Marine Industries has also organised Future Reception seminars for the industry and research organisations to inform and activate them into participating in Horizon 2020 calls, Martec II and national programmes, among others. Excursions have also been organised within the framework of this task, for example to the Netherlands (with Finnish company participants) and to Finland (introducing Finnish companies, research programmes and universities to European visitors). There has also been co-operation with PROBE in conducting a survey of the level of internationalisation in companies today.

Networks and international co-operation

While the whole task was about international co-operation, the main co-operation was with SEA Europe RDI, Waterborne TP, Martec II and the members of these forums.

Applications & impact

Structural changes in the Finnish marine industry are still ongoing, and today we have many strong branches, such as offshore, special vessels, Arctic technology and ship equipment. Task 3 has succeeded in keeping the industry together and gathering common interests of research. This task has also invited the industry and nearly whole university network in Finland together to four Future Reception -seminars with different focus areas. The task made it possible for Finnish Marine Industries to also participate in Martec II Era-Net program. MARTEC II is a network of 30 ministries and funding organisations from 25 countries, responsible for the development and funding of national/regional research programmes on maritime technologies. The task in Martec II is to carry out co-operation with Waterborne TP.

The results are currently being utilised. The SRA is used in communicating the industry's development needs to relevant parties. The SRA has also been used at national level, for example in a regional research platform's Turku Seas 2020 programme, and in universities and research organisations. The goal is for the SRA to be implemented through the next national and EU research programmes. The SRA has also had a notable impact in the new

Tekes Arctic Seas programme. The task has been highly significant for the research actions of Finnish maritime companies; through it the industry has had a direct channel to information on EU-projects as well as an opportunity to make a difference. Through the project the industry has created a plenty of new contacts in with the European marine industry actor and received a great deal on insider information. The results of the international research programs have also been remarkable and created competitive advantage for the participants.

Direct International Marine Business Networks and Models

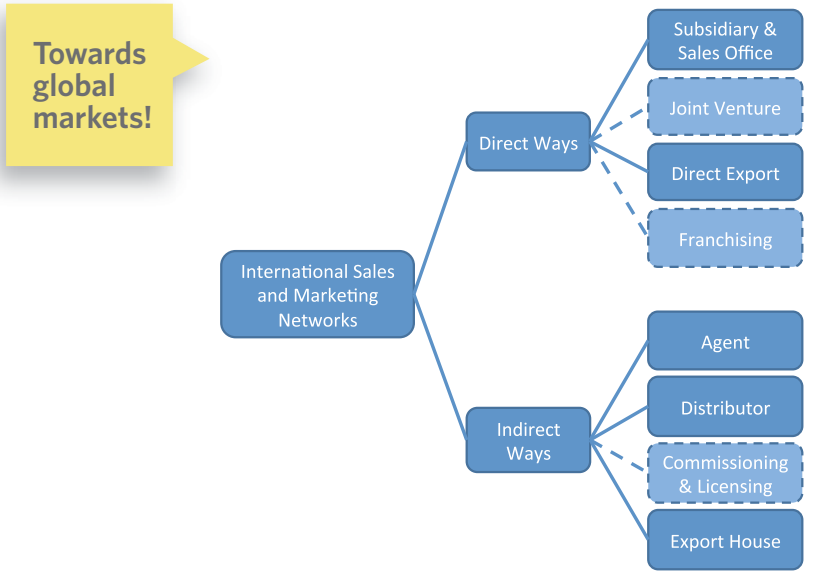


Figure 1. **Market channels and options**

International business orientation and focus is the key to business opportunities and growth among Finnish small and medium-sized marine sector enterprises (SMEs)

Main Results

Linking scientific models and concepts of international business to company practices and finding solutions for developing international operations.

Four selected perspectives provide managerial advice on:

- Company management approaches
- Market entry options
- Networking and business models
- Future development trends

Selected results highlights

1. The role of mindset and planning in the internationalisation of medium-sized marine firms has a strategic importance

- Finnish marine SMEs are found to be rather adaptive compared to an overall population of firms. This means that they emphasise structural solutions, flexibility and high alertness over strong strategic planning approaches.
- This setting allows firms to do relatively well in an industry environment characterised by change and the associated uncertainties of shifting centres of economic activity.
- Among the sample of ten firms analysed in depth, the majority apply a typical reactive attitude. This requires closeness to suppliers, partners, allies and customers, and an open mindset that allows changes to be perceived, enabling firms to adapt quickly or find viable opportunities.
- Given the overall adaptive preference of marine SMEs, the recommendation for firms increasing their international commitment would be to build strong relationships, particularly with tight international networks, in order to anticipate changes and align their business systems on time. This might require more investment in tightly coupled networks, which increases the risks of dependency on a particular network and its success, but at the same time lowers competitive risks.

2. New marine SMEs aim progressively at international markets

- Marine industry SMEs in Finland differ in terms of internationalisation pathways
  A. Traditional SMEs – step by step, first to near markets
  B. Born Globals – quick international expansion, several markets
  C. Born-again Globals – sudden major international step after years in home markets
- Born Globals are the most recently established companies, the majority are traditional
- Future development requires strategic abilities and business support for rapid and progressive internationalisation from the beginning – a fundament for marine industry success.

3. The Future of Marine Industry

An international marine industry expert panel pushes Finnish companies to

- Develop more customer-centric business models
- Focus on diverse global niche technologies
- Integrate and collaborate to supply larger systems
- Develop commercial and managerial competencies together with technological know-how

PROJECT NAME

WP 5
Innovations in Flexible Networks

Task 4

CONTACT PERSON
ANTTI SAURAMA
UNIVERSITY
OF TURKU

PARTICIPANTS (ORGANISATIONS)
UNIVERSITY OF TURKU
VTT TECHNICAL RESEARCH CENTRE OF FINLAND

PROJECT DURATION
2012 – 2013

PROJECT VALUE (EUR)
0.331 MILLION

Direct International Marine Business Networks and Models (NET)

Main targets & motivation

Small and medium-sized enterprises (SMEs) in the Finnish marine industry are facing both push and pull with regard to international markets. Factors range from market opportunities and managerial ambitions to diversified customer segment development, structural changes in the industry, constant evolution of international value chains and global sourcing. These create many challenges for companies either taking their first steps into foreign markets or expanding their existing international businesses.

There is an increasing need to find managerial practices to support successful management of the internationalisation process and market entry among small and medium-sized companies.

The main objective of the project was to **investigate drivers, pathways and models of internationalisation** among Finnish marine sector SMEs and **to support managerial decision-making that enhances international expansion, market entries and competitiveness** to meet expected future developments in the industry.

Results

Management in international business

An in-depth analysis of ten internationally active SMEs in the marine sector provides taxonomy of four different management types of marine sector SMEs. We know them by name as "Guesser", "Follower", "Knower" and "Here-and-nower". Each is characterised by a different level of openness in the managerial mindset and a different level of emphasis on prediction, thus implicating totally different managerial approaches.

The results clearly show the full range of managerial behaviour behind SMEs in the marine sector. Moreover, although the causality of managerial approach and company success cannot be judged based on this ten-company case analysis, the results indicate that firms with an open mindset but not giving equal emphasis to prediction in their strategy perform less well than those with high emphasis on prediction. The results provide company directors with relevant recommendations for how to achieve and sustain growth.

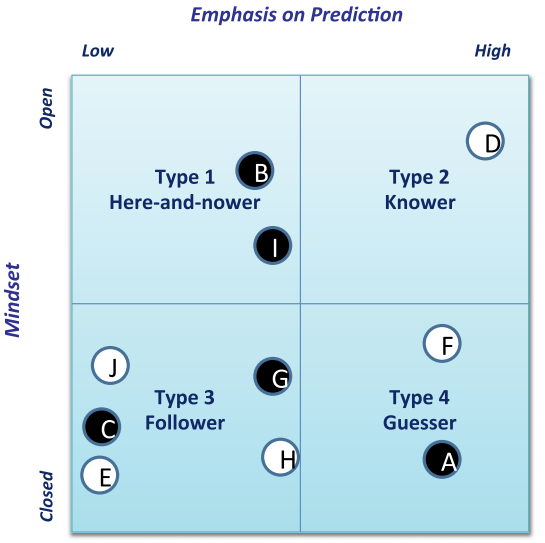


Figure 1. **Sample company taxonomy and link to actual turnover development** (white = revenue growth, black = revenue decline)

Internationalisation pathways

The project focused on investigating and categorising marine sector SMEs according to their internationalisation pathways, development history and growth. Sample analysis from eleven internationalised companies reveals a variety of internationalisation

processes and pathways, rather than one traditional, incremental process. The companies (in the sample) founded most recently tend to represent "Born Globals", with rapid and systematic internationalisation from the beginning. The majority of the marine industry SMEs, however, are "Traditional" in terms of their internationalisation pathway, and tend to make their international steps incrementally and first-to-markets geographically close. Targeting the same markets does not require the same process and models for all, as the case investigation of the Brazilian market shows. Decision-making and process related to Brazilian market steps should focus carefully on assessing the competition and related regulative market conditions, the need for a physical presence in the country, impacts of industry policies on sectoral business practices, a suitable country manager profile, and language barriers.

Downstream business models and networks

Analysis based on 11 case companies indicates strong company orientation towards traditional exporting, and foreign sales offices favouring control over partnering and other available collaborative models. The companies, all of whom have years of experience in international business, rely less on agents, dealers and partners in their international networks. Joint venturing among the SMEs investigated was non-existent.

The results acknowledge that selection of the organisational model for the international distribution network is always dependent on the context, markets and development phase. The model may also evolve over time. There is thus no single recommended solution that fits all. The various options contain different challenges regarding the resources needed, the commitment of partners, contracting, pricing, control of the market, and contacts with customers.

Future factors influencing international business

The project resulted in an industry-level future assessment of factors impacting the Finnish marine industry globally, and measures for the companies and industry that would lead to success in the future. The assessment was performed by a panel of 9 distinguished experts from the marine sector, representing industrial companies, customers and academia. Experts highlighted the need to:

- Develop more customer-centric business models
- Focus on diverse global niche technologies

- Create integration between companies to supply larger systems
- Develop both technological know-how and commercial and managerial competencies.

Key publications

1. Kallio, E. (2013), The role of a firm's mindset in international success – Case study of Finnish Marine Industry Firms, University of Turku, School of Economics, Master's thesis.
2. Kallio, E. & Zettinig, P. (2013), The Role of a Firm's Mindset in International Success, Proceedings of 12th Vaasa Conference on International Business, University of Vaasa, 21-23 August 2014.
3. Kuuluvainen, A. (2013), Finnish marine SMEs in Brazil, Baltic Rim Economies, Issue 6, Nov 2013.
4. Jansson, K., Karvonen, I. & Vaittinen, A. (2014), On Using Collaborative Networked Organisations in International Outbound Logistics, Proceedings of 4th International Conference on Dynamics in Logistics (LDIC 2014), Bremen, Germany, 10–14 February 2014.
5. Kallio, E. & Saurama, A. (2014), Meriteollisuuden globaali liiketoimintaympäristö ja suomalaisyritysten tulevaisuus – Delphi-tutkimus, Publications of the Turku School of Economics, E1/2014.

Number of publications: 6
Number of Master's Theses: 1

Networks and international co-operation

The Brazilian case study was made in close co-operation with the Federal University of Pernambuco (UFPE), Recife, Brazil, and with Finnish company offices in Brazil. The Delphi panel involved several company directors located outside Finland.

Applications & impact

The NET project provides understanding on processes, challenges and solutions related to internationalisation of marine sector SMEs. The results are targeted at company managers and provide practical business advice on how to

- Develop management practices and approaches needed to guarantee success in international operations
- Plan market entries, assess risks and opportunities
- Select suitable networking and business models
- Position company strategy in line with future development of the industry.

Contextual Factors in Project Business

To be successful a project-based firm needs to either adapt to its environment – or adapt the environment itself

Designing new service-based business models

Project-based firms are taking increasing responsibility for their customers' businesses by servicing and operating their installed base of equipment. Because project-based firms operate in different competitive environments, however, solutions that are highly successful in a given context are not necessarily transferable directly to other supplier firms or customer cases. When designing new service-based business models, firms need to consider whether the revenue creation logic for the customer is a) transaction-based (short-term) or b) relationship-based (long-term), and whether the service is centred on a tangible core product or customer's business process, as illustrated in figure 1 below.

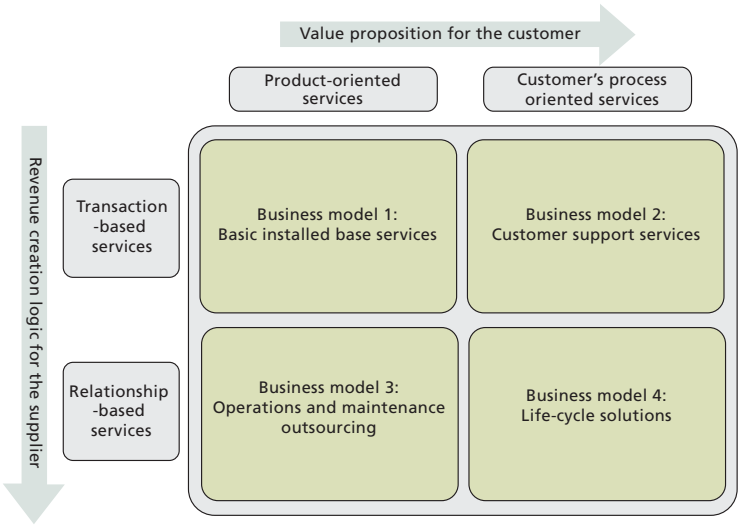


Figure 1. **Selection of appropriate service-based business model**

Furthermore, research carried out within FIMECC I&N WP 6 discovered that the most advanced project-based firms are capable of flexible use of all four alternatives when providing solutions for their customers on a global scale. In narrower business contexts, mastering one (or two) of the four quadrants may be preferable, as this allows for additional focus on perfecting the chosen business model type.

In addition to the dimensions described in figure 1, the following factors should be considered carefully when choosing the most suitable business model for a **specific** customer solution:

- **The supplier's or the customer's institutionalised and accustomed business practices** (What are the standard operating practices that are rarely questioned?)
- **The customer's maintenance organisation** (Does the customer have its own maintenance organisation? If yes, how powerful is it within the customer's organisation structure?)
- **The skill-level of the maintenance organisation** (How capable is the customer's own maintenance organisation in contrast to the supplier's level of expertise?)
- **The perceived complexity of technology** (How complex is the technology from the customer's viewpoint?)
- **The customer's financial resources** (Will the customer prefer to own, or to lease or outsource?)
- **The supplier's marketing approach** (Is the supplier organisation capable of articulating clearly the benefits of different solution-based alternatives for the customer?)

Industry insight on contextual factors in project business

"Understanding of contextual factors – often related to the customer's business – is important for the flexible and effective way of designing solutions that fit the customer's and Outotec's business goals. The research on solution-specific business models, and factors influencing the choice of such business models, has contributed significantly to this understanding in Outotec."

***Asmo Vartiainen**, Director, Technology Portfolio, Outotec Oyj*

PROJECT NAME
WP 6 Project Business and Services

Task 1

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
KARLOS ARTTO AALTO UNIVERSITY	**AALTO UNIVERSITY** **ÅBO AKADEMI UNIVERSITY** **UNIVERSITY OF OULU**	**2009 – 2010**	**0,415 MILLION**

Contextual Factors in Project Business

Main targets & motivation

This task analyses the contextual factors affecting the choice and performance of different business models. A project-based firm needs either to adapt to its business environment or adapt the environment itself. To be able to position itself in the environment and develop its customer offering the project-based firm needs detailed information about the environment.

Key results

The research findings clarify the factors influencing the emergence and choice of business models in project-based firms that use different operation logics and strategies in global networks. The most significant criteria are:

- value proposition to the customer
- revenue creation logic for the supplier

Based on these criteria (and additional customer-specific criteria discussed in detail in Kujala et al., 2010) the supplier may use one or several of the business models (figure 1):

1. Basic installed base services
2. Customer support services
3. Operations and maintenance outsourcing
4. Life-cycle solutions

Furthermore, a project-based firm may employ several business models simultaneously (Mutka, 2010) and develop new ones through innovative delivery projects.

Key publications

- Kujala, S., Artto, K., Aaltonen, P. & Turkulainen, V. (2010), Business models in project-based firms – Towards a typology of solution-specific business models, International Journal of Project Management, 28(2), pp. 96–106.
- Kujala, S., Kujala, J., Turkulainen, V., Artto, K., Aaltonen, P., & Wikström, K. (2011). Factors influencing the choice of solution-specific business models. International Journal of Project Management, 29(8), 960-970.
- Mutka, S., Aaltonen, P. & Ahola, T. (2010), Business models of a project based firm, European Academy of Management EURAM 2010 conference, Rome, Italy.
- Mutka, S. (2010), The set-up of multiple business models in a project-based firm, Master's thesis, Espoo, Finland, Aalto University School of Science and Technology, Department of Industrial Engineering and Management.
- Vuori, E., Mutka, S., Aaltonen, P. & Artto, K. (2013), That is not how we brought you up, International Journal of Managing Projects in Business, Vol. 6 Iss: 1, pp. 88–105.

Number of publications: 5
Number of Master's theses: 1

Networks and international co-operation

Stanford University, Technische Universität Berlin

Applications & impact

The tool (see figure 1) and list of factors discussed in Kujala et al. support project-based firms in their strategict-level decisions regarding the following questions:

- What kind of service-based business model (or models) is most suitable for the focal firm?
- What factors support or hinder the adoption of new service-based business models?
- How can a project-based firm use projects as vehicles for experimenting and developing novel and innovative business models?

Task 2

Business Model of a Project-based Firm and its Performance

The concept of business model is a powerful strategic tool for all project-based firms as it enables the systematic analysis of alternative ways of creating value for customers and other core stakeholders of the firm

Business models provide strategic direction for project-based firms and their delivery projects by describing how the firm interacts with its environment consisting of customer, suppliers, partners and other relevant stakeholders. A business model highlights different flows (of materials, money, and value) between involved actors, and differentiates the focal firm's logic of doing business from those of its competitors.

In particular, business models analysis is a valuable tool for:

- Identifying **new business opportunitie**s (e.g. new service elements to be included in future deliveries)
- Developing new ways to **exploit the capabilities embedded in the value network** (consisting of e.g. subcontractors and partners) of the project-based firm
- Developing new ways to **differentiate** the offering of the firm from its competitors
- **Identifying mismatches** between elements affecting the creation of value by your firm (mismatches lead to destruction of value)

Describing and understanding the current business model of the project-based firm is a necessary step prior to refining/renewing the model. The following Table 1 serves as a tool for supporting this purpose. Fill in details (as accurate as possible) regarding your firm in the right-hand column. It is advisable to complete this task during a workshop attended by both senior management and individual(s) responsible for the firm's most significant delivery projects. Note that cells typically contain several – even conflicting – viewpoints for presentation during the workshop. It is essential to document all these viewpoints carefully and avoid striving for a clean and coherent "answer" to each cell. The discussion concerning individual cells contributes towards a shared understanding of the topic area for all participants.

Table 1. **Tool for analysing the business model of a project-based firm (or individual delivery project)**

Element of business model	Descriptive key questions	Fill in details for your firm (and/or individual delivery project)
Offering	• What are the contents of the firm's offering?	
Resources and capabilities	• What resources does the firm possess in-house? • What are its key capabilities?	
Internal organisation and activities	• How does the firm organise its production internally? What activities are carried out in-house?	
Revenue creation logic	• *How does the firm make profit (e.g. through equipment sales, parts sales, performance guarantees, etc.)?	
Customers	• Who are the firm's customers and, equally importantly, who are not?	
Value proposition	• How does the firm promise to create value for its customers (value creation mechanism)?	
Value network	• What is the role of partners, subcontractors, and other external actors in value creation? • How dependent is the firm on them?	
Competitive strategy	• How does the firm differentiate itself from its competitors? • How does the firm compete against its competitors?	

After the table above has been filled with content, the next step is to focus on the following questions:

- **Is there conflicting content within individual cells, and if yes, why?** (Conflicting content does not necessarily indicate a problem – it may mean e.g. that different business models are followed in different key delivery projects.)
- **Are there conflicts between different cells?** (e.g. is the offering of the firm perfectly aligned with the internal organisation of the firm?)
- **Can multiple overlapping business models be identified, or is the firm relying on a single business model?** (e.g. different divisions and projects may have differing business models)
- **What are the recent developments regarding the cell content? What is explaining these changes?** (Business models are not static, rather they evolve over time.)
- **What new elements could be introduced, either to complement current cell content OR replace them entirely? How would the introduction of new elements be related to other cells?** (This final part focuses on the development and testing of new business model ideas.)

PROJECT NAME
WP 6 Project Business and Services

Task 2

CONTACT PERSON
KIM WIKSTRÖM
ÅBO AKADEMI UNIVERSITY

PARTICIPANTS (ORGANISATIONS)
AALTO UNIVERSITY
ÅBO AKADEMI UNIVERSITY
UNIVERSITY OF OULU

PROJECT DURATION
2010 – 2014

PROJECT VALUE (EUR)
1.507 MILLION

Business Model of a Project-based Firm and its Performance

Main targets & motivation

- Outline the new emerging business models for firms engaged in project business in a continuously changing network environment.
- Identify the factors that influence and explain the effectiveness of different types of business models today and tomorrow, and generate practical applications in project business.

The tendency is to move from equipment delivery to entire project delivery on a turnkey basis, and to provide complete integrated solutions. This leads to a situation where a larger portion of the value is created based on interaction and various types of collaboration schemes outside the boundaries and direct control of the firm. The analysis of business models should not be limited to the traditional firm, or to business-unit level; the sources of competitive advantage and value creation often span the boundaries of both the firm and the industry. The broader view of organisations, beyond traditional firm boundaries, that this requires is valuable for understanding wealth creation and performance. This thinking is related to concepts as open business models, ecosystems and project ecologies. Three types of business models have been recognised: 1) Individual projects, 2) Egocentric networks and 3) Business networks (Wikström, Artto, Kujala & Söderlund, 2010).

Results Business models provide strategic direction for project-based firms and their delivery projects by describing how the firm interacts with its environment, consisting of customer, suppliers, partners and other relevant stakeholders. A business model highlights different flows (of materials, money, and value) between involved actors, and differentiates the focal firm's logic of doing business from those of its competitors.

In particular, business models analysis is a valuable tool for:

- Identifying new business opportunities (e.g. new service elements to be included in future deliveries)
- Developing new ways of exploiting the capabilities embedded in the value network (consisting of e.g. subcontractors and partners) of the project-based firm
- Developing new ways of differentiating the offering of the firm from its competitors
- Identifying mismatches between elements affecting the creation of value by the firm (mismatches lead to destruction of value)

Figure 1 illustrates the interaction between the individual elements of the business model of a project-based firm

Business models may also be boundary-spanning (see applications & impact part).

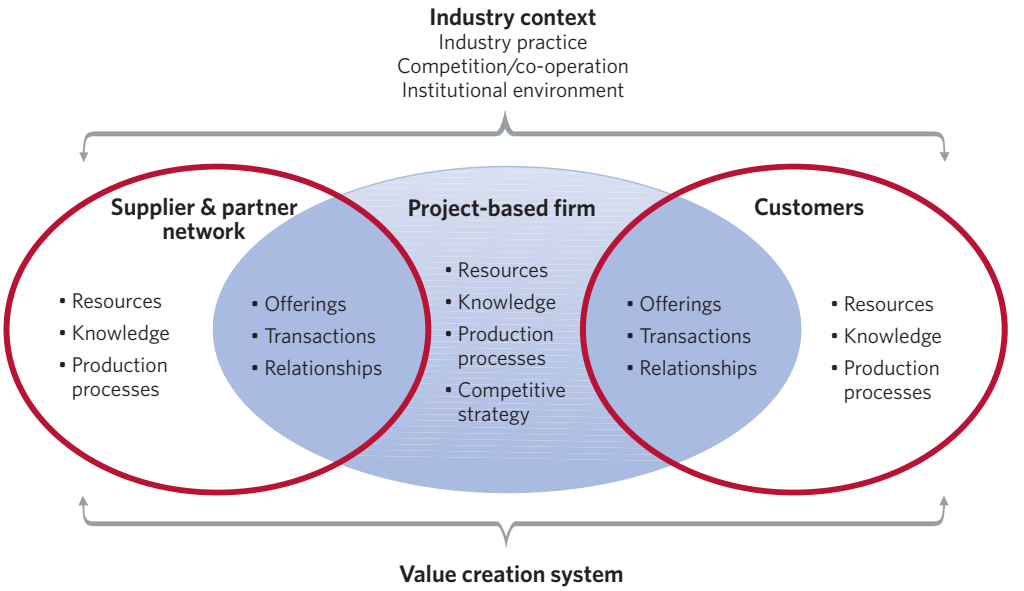


Figure 1. **Illustration of how the business model of a project-based firm interacts with its business environment**

Key publications

- Ahola, T., Kujala, J., Laaksonen, T. & Aaltonen, K. (2013), Constructing the market position of a project-based firm, International Journal of Project Management, Volume 31, Issue 3, pp. 355–365.
- Forsberg, T. (2012), Operations of a project-based firm, Master's thesis, Aalto University.
- Mutka, S. & Aaltonen, P., The impact of a delivery project's business model in a project-based firm (2013), International Journal of Project Management, Volume 31, Issue 2, February 2013, pp. 166–176.
- Turkulainen, V., Kujala, J., Artto, K. & Levitt, R. (2013), Organizing in the context of global project-based firm – The case of sales-operations interface, International Marketing Management, Volume 42, Issue 2, pp. 223–233.
- Wikström, K., Artto, K., Kujala, J. & Söderlund, J. (2010), Business models in project business, International Journal of Project Management, Volume 28, Issue 8, December 2010, pp. 832–841.

Number of publications: 22
Number of Master's theses: 1

Networks and international co-operation

Stanford University, Technische Universität Berlin

Applications & impact

General implications:

- Segment your customers and project.
- Develop different business models for the segments.

Implications for boundary-spanning business models:

- Boundary-spanning projects characterised by interaction and collaboration schemes extending traditional boundaries, including customers, suppliers and third parties
- Open systems firms interact through various schemes that are often not regulated by direct contracts between the organisations.
- Boundary-spanning projects are open systems and require "open business models".
- Develop your relationships with your key (sub)-suppliers and third parties.
  To make use of boundary-spanning business models, firms need to extend their capabilities to cover larger parts of the overall system to be delivered.
- Innovative capability of the network has not been fully utilised.

PROJECT NAME
WP 6 Project Business and Services

Task 3

Services and Service Business

Project-based firms have only recently started to realise the richness and diversity of the mechanisms through which services may contribute to the success of the firm

Project deliveries are becoming increasingly complex. Firms that used to focus on delivering tangible installations (such as power plants) and proprietary equipment (such as escalators and ore-processing equipment) are increasingly including intangible components in their customer deliveries. The problem, however, is that the value of these intangible components is often both difficult to communicate and to evaluate objectively. The model illustrated in figure 1 describes how the content of modern project deliveries can be broken down into both tangible and intangible components, and how these components form three nested layers that are each related to the adjacent layers. The value created for the customer is dependent on how well the two perspectives interact – i.e. hardware is of no value if it is not used appropriately! The purpose of the model below is to help potential customers understand how different components of the delivery provide value, and how the components interact with each other. For optimal impact, the example discussed in the figure should be replaced with those describing the customer-specific details in delivery at hand.

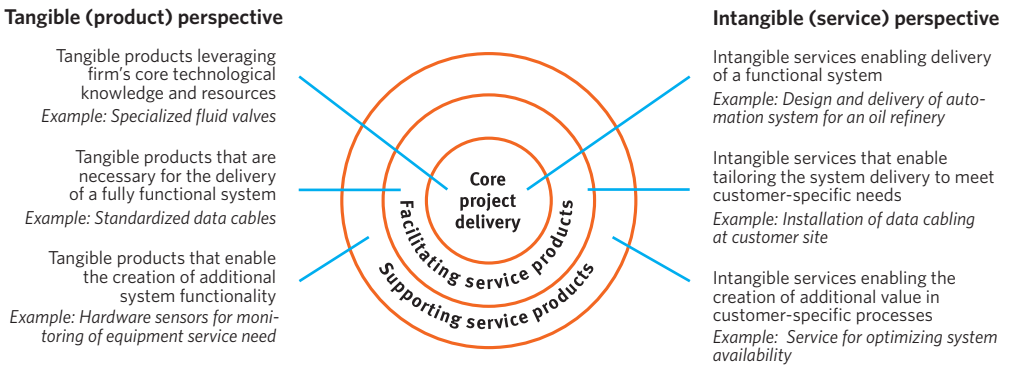


Figure 1. **Model for breaking down the customer value of project deliveries**

Prospects of increased revenues constitute the primary rationale for project-based firms to start offering services to their clients. While revenues often develop favourably, few project-based firms are fully aware of the many additional mechanisms through which services may benefit the firm. Table 1 below illustrates how the provision of services may result in **strategic and financial benefits, as well as benefits in marketing & sales, learning & innovation, and efficiency**.

Table 1. **Potential benefits of services for a project-based firm**

Perspective	Examples of potential benefits for project-based firms
Strategic benefits	• offer product differentiation possibilities • product-level differentiation based on availability of aftersales services; guaranteeing system availability or performance. • local services are often a mandatory requirement and thus provide an entry barrier to new competitors.
Financial benefits	• increase turnover • stabilise revenue and provide a predictable revenue stream • offer higher profits compared to products
Marketing & sales benefits	• maintain customer relationship between project deliveries • frequent interactions offer the supplier a change to recognise customer's needs and signs earlier, and may provide information concerning competitor's activities within the customer organisation • increase familiarity, and trust between supplier and customer • increase supplier credibility and the supplier image
Learning & innovation benefits	• provide offering and access to useful information for R&D • offer ideas or show the need for process improvements • offer a chance for the supplier to learn about the customer's habits, processes and procedures to help in compiling more customised offers
Efficiency benefits	• increasing delivery efficiency through exchange of information, close co-operation, aligned processes • provide ideas or show the need for process improvements • offer the supplier an opportunity to recognise the customer's changed requirements and valuations as early as possible

Industry insight on services in project business

"Services have an important role in building a strong relationship with the customer. They support our sales activities by conveying information about new products to our customers and identifying potential investment opportunities for the customer. The service department also supports our R&D activities by collecting customer feedback which is then used to develop new features for our machines."

Hannu Riihimäki, Senior Manager, Service Sales, Finn-Power Oy

PROJECT NAME
WP 6 Project Business and Services

Task 3

CONTACT PERSON
JAAKKO KUJALA
UNIVERSITY OF OULU

PARTICIPANTS (ORGANISATIONS)
AALTO UNIVERSITY
ÅBO AKADEMI UNIVERSITY
UNIVERSITY OF OULU

PROJECT DURATION
2009 – 2014

PROJECT VALUE (EUR)
0.621 MILLION

Services and service business

Main targets & motivation

To develop services and new project contents with a life-cycle focus that can be integrated, productised and managed in combination with and addition to the firm's current offering. To understand the enabling and restricting features of the existing technology base when further developing the business model with respect to services and business networks.

Key results

- Project-based firms are increasingly complementing their project deliveries with different types of services.
- Services have significant influence on the business model of a project-based firm (Wikström et al., 2009; Kujala et al., 2010) → this connects Task 3 to Task 2 results.
- Project deliveries may be analysed conceptually by separating them into a tangible and intangible component, as illustrated in Figure 1.
- Services have a versatile role in supporting the business of a project-based firm, which can be analysed from the following five perspectives:
  - Strategic
  - Financial
  - Sales and marketing
  - Research and development
  - Project implementation (efficiency)

Key publications

- Huikuri, S., (2011), The role of services in project business: A case study within three project-based firms from industrial sector, Master's thesis, University of Oulu.
- Kujala J., Artto K. & Parhankangas A. (2009), Factors influencing design and performance of the business model of a project-based firm, Project Perspectives 2009, Projektiyhdistys ry.
- Kujala, J., Ahola, T., Huikuri, S. (2013), Use of services to support the business of a project based-firm, International Journal of Project Management, Volume 31, Issue 2, pp. 177–189.
- Reen, N., Rekola, K. & Gustafsson, M. (2011), Service failure – A golden opportunity or a potential disaster? 11th European Academy of Management Conference, 1–4 June, Tallinn, Estonia.
- Wikström K., Hellström M., Artto K., Kujala, J. & Kujala, S. (2009), Services in project-based firms: four types of business logic, International Journal of Project Management, 27, pp. 113–122.

Number of publications: 7
Number of Master's theses: 1

Networks and international co-operation

Stanford University, Technische Universität Berlin

Applications & impact

- Figure 1 and the five perspectives listed previously serve as tools for marketing communication and development of the project sales portfolio as a whole. (Communicating the tangible and intangible component of the project support achieving additional sales)
- Services are an emerging and strategic part of project business that has a considerable amount of unused potential
- Research results obtained clearly demonstrate the versatile role of services in the business of a project-based firm (i.e. a project-based firm benefits from offering services in surprisingly many areas)

PROJECT NAME

WP 7 Novel Innovations in Production Solutions

Task 1

SmartShip

SmartShip – more intelligent digital services

The project conducted research and business creation within the area of the development of integrated information and communication technology (ICT) services, in order to serve the internal functions of ships and comparable operating environments and offer their customers improved services. A central goal was to develop competitiveness and new business opportunities for the maritime industry amid major structural change. In terms of the market size of the new business developed within the area of systems integrations and intelligent services, we estimate a yearly market potential for maritime vessels and comparable operation environments of at least EUR 15 million. During its course, the project contributed to the founding of two new companies.

The three fronts of new business generated in the project

1) New markets

Members of the project consortium managed to reduce dependency on just a few customers, and to gain new customers and reach new markets (e.g. offshore fields, small vessels, large network operators). In terms of market outlook, the project consortium recognised the development possibilities at international level, and were thus able to broaden the target markets of the participating companies, especially with regard to better scaling of product offerings to various analogous target markets. The goal of creating international markets was realised, and the partners are benefiting from this in their current business activity.

2) New partners

The project enabled networking with important new partners, leading to development and realisation of new business opportunities. The competitiveness of the cluster was improved by gathering a cluster of ICT companies to collaborate in providing synergistic technology solutions for ships and comparable target environments.
This represented a great improvement on the frequent practice of resorting to working mainly in isolation or in smaller circles. Participants were able to expand their product offering and increase their competitiveness on the market by carrying out product piloting in collaboration with major industry players, e.g. in the mass transport environment (buses and trains). The research results were used, among other things, to begin business collaboration with major telecommunications operators.

3) New products

The project carried out important system integrations with industry-leading corporations, and created new product concepts in a collaborative environment, benefiting from the multifaceted expertise of the different companies. Preparatory research within the project, for example in the point of sale (POS) systems industry, contributed to the commercialisation of new products and to agreements with key industry players on concrete plans for further collaboration. The project's market analyses and research fortified the product concepts. The integration of voice-guided evacuation procedures with other systems of information provision, and the integration of digital signage displays and POS systems with complementing applications, such as Hazard Analysis and Critical Control Points (HACCP) procedures in galley functions aboard ships and in other comparable operating environments, served as prime practical business cases in the later stage of the project.

Figure 1. **Enhanced operational efficiency through integrated applications** (Image: QEM Software Oy)

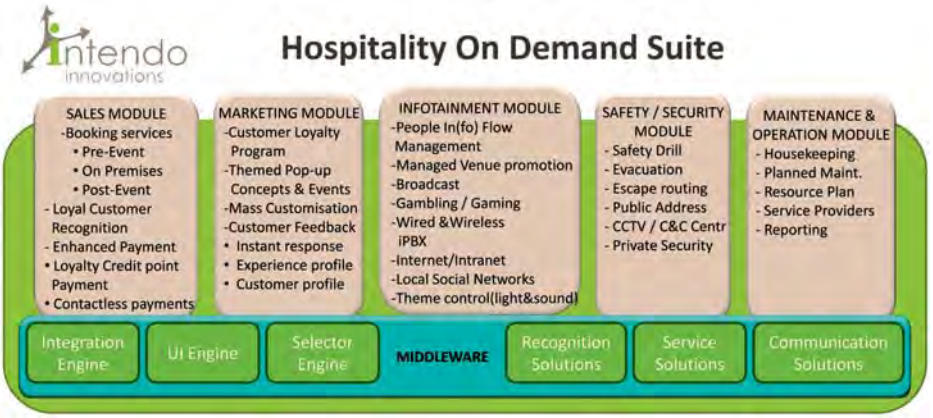


Figure 2. **Integrated ICT service suite spanning various hospitality functions on board.** (Image: Intendo Innovations)

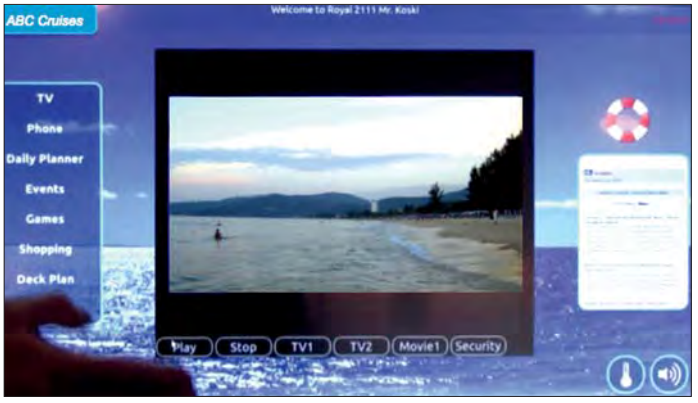


Figure 3. **Safety and iTV demonstrations.** (Image: T. Ranti)

PROJECT NAME

WP 7 Novel Innovations in Production Solutions

Task 1

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
MIKKO JALONEN QEM SOFTWARE OY	**ASAN SECURITY TECHNOLOGIES OY** **AUDICO SYSTEMS OY** **LINGSOFT OY** **QEM SOFTWARE OY** **STX FINLAND OY** **STX FINLAND CABINS OY** **UNIVERSITY OF TURKU**	**2009 – 2013**	**1.186 MILLION**

SmartShip

Main targets & motivation

At the outset, there was recognition of the need to find ways of increasing deployment of domestic ICT expertise in innovative new solutions and services in the Finnish maritime business area. The first target was to develop a network of companies that could act in an agile manner and deliver state-of-the-art technological solutions for clients in the maritime industry. A profound technological need was also recognised: the integration of various systems, with improving safety on board as one of its main goals, had to be deeper and better functioning. The necessary requirement analyses and testing of concepts thus formed part of the project. The kind of network-centred approach enabled by the research programme promoted active collaboration among the members of the value network, and allowed focus to be maintained on issues relevant from the trade point of view. The purpose of the research conducted in the project was to answer to any needs the companies would encounter during realisation of their development and commercialisation efforts, and also to form part of the process of discovering new solutions and business opportunities that could be realised by the network companies. Overall, the central goal has been to carry out research to a) increase product offering on new customer branches, b) reinforce the partner network, c) create international markets, d) prepare new competitive capabilities through systems integrations and e) carry out related piloting activities.

Novelty & added value brought by this work vs. state-of-the art

The intelligence of different systems and applications, for example of cruise vessels, has not been optimised in terms of leveraging operational benefits from efficient information-sharing between them. The main value stems from the integration of complementary resources and services to bring greater added value for the end-user. Integration enables the creation of methods for carrying out required tasks, for example on board ship, more efficiently and more cost-effectively. Examples include the integration of voice-guided evacuation procedures with other systems, and integration of digital signage displays and POS (point of sale) systems with complementary applications, such as HACCP procedures (Hazard Analysis and Critical Control Points in the quality control of food stuffs) in galley functions aboard ships and in other comparable operating environments.

Research problems solved

Solutions were found for the following research problems: the kind of existing functions and processes that can be enhanced through the integration of information technology assets; the kind of new services can bring value-adding benefits both to the ship operators and their customers; how the solutions can be applied in areas other than the ship environment, e.g. in shopping centres and hotels.

Results

The research programme and project have enabled members of the project consortium to reduce dependency on just a few customers, and to gain new customers and reach new markets (e.g. offshore fields, small vessels, large network operators). They have also been able to benefit from networking with peers to develop new business opportunities together, rather than working mostly alone or in smaller circles. Participants have carried out product piloting e.g. in the mass transport environment (buses and trains) in collaboration with major industry players, and have thus expanded their product offering and increased their competitiveness on the market. Preparatory research carried out in the project has allowed project participants to make important system integrations e.g. with an industry-leading corporation in the point-of-sale systems industry, including negotiations for further collaboration. Market analyses and research carried out in the project have fortified the product concepts. In terms of market outlook, the project has helped in recognition of the development potential at international level, and thus in broadening the target markets of the participating companies, especially with regard to

better scaling of product offerings to different analogous target markets. Public research results have been used, inter alia, in order to commence business collaboration with major telecommunications operators. The goal of creating international markets has been achieved and is now being realised by the partners in their current business activity. A cluster of ICT companies was initiated for collaboration in providing synergistic technology solutions for ships and comparable target environments. Research activities also encompassed interfacing with other companies in the research programme network, thus providing an insight into their ICT resources and possible business development opportunities. The project has contributed to the founding of two new companies.

Key publications

Ranti, T. & Malinen, P. (2014). The utilisation of mobile services – an unfulfilled promise in the cruise industry? ICMB 2014 13th International Conference on Mobile Business, London. (research paper; awaiting publication)

Networks and international co-operation

Contacts with South Korea (STX ForceTec, LG Electronics), the USA (Carnival, Norwegian) and France (regarding the STX Oasis project) were developed and employed for market expansion during the course of the project.

Applications & Impact

The network can now continue to move forwards and deliver offers for ICT solutions as a group of companies sharing common interests. The particular product areas are multifaceted advanced solutions for information provision (e.g. next-generation digital signage, POS and HACCP solutions, smart voice evacuation solutions, and integrated value-added solutions within the aforementioned areas). Research carried out in the project has shown that the main business areas of interest during the project, such as digital signage, continue to display great growth potential. The research showed that project participants can most reasonably capitalise on their solutions and reach wider target markets through collaboration with larger established industry players. The development work prepared in the project has already resulted in new jobs in the participating companies, and contributed to the birth of two new companies. If the solutions gain traction on an international scale, it is likely that there will be new employment opportunities within the companies, as well as entirely new Finnish companies offering complementary services.

PROJECT NAME

WP 7 Novel Innovations in Production Solutions

Task 2

Trilaser

Laser materials processing with high power

R&D work carried out in the project concentrated on two fields: laser welding and laser cladding. A considerable part of the experimental work was carried out at sites abroad, where higher power or other specific equipment were available. In both these application areas the project achieved breakthrough results in utilisation of very high laser power in various processes and applications.

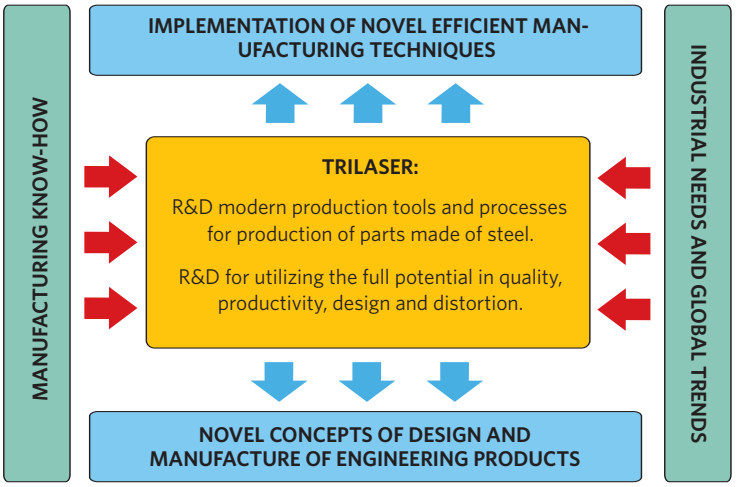


Figure 1. **The structure and function of the project**

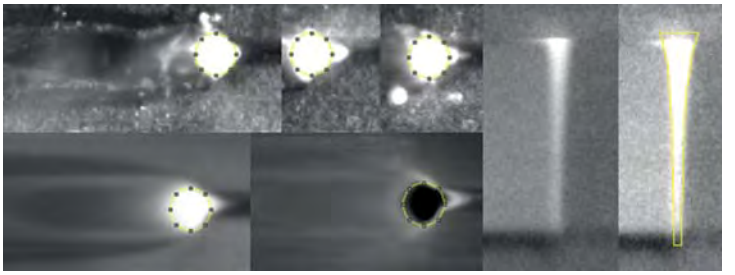


Figure 2. **Keyhole welding process visualised with a high-speed camera: X-ray images during welding**

Demonstrations via achieved results showing capability of novel high power laser processing for new manufacturing solutions and enhanced productivity, particularly in the area of heavy steel structure applications. New data and knowledge from laser welding, laser-arc-hybrid welding and cladding processes and their applicability to e.g. processing of various novel engineering steel grades.

- Experimental validation of welding performance with high power single pass welding showed great potential in heavy-section welding. The joining speed can be increased from that of conventional welding at 0.003 mm^2/min to 25 mm^2/min with lasers for 25 mm thickness.
- Development of the testing procedure for online X-ray measurement of full penetration butt joint welding.
- Validation of the potential of partial vacuum laser welding, improving the penetration depth to double that of laser welding in ambient atmosphere.
- Implementation of high deposition rate laser cladding (16 kg/h) processes for large area coating applications – **the highest deposition rate in the world!**
- Development of a coaxial hot-wire cladding technique for coating and additive manufacturing applications.
- Development of a quality control system with respect to powder feedstock and coating quality.
- Multi-pass narrow gap welding applications.
- New way of designing products using novel joint configurations.
- Joining of tailored multi-material components incorporating different materials with different strength/hardness grades.
- New data and knowledge of mixing behaviour of the weld pool in thick section joints and the effect of welding parameters on mixing and underlying weld properties.

Industry comment

"Research and development of laser cladding in offshore and marine applications, as well as material and powder feedstock research, is of great importance. The FIMECC I&N programme enabled the creation of routines for improving the company's quality assurance and products significantly." *Kokkola LCC Ltd.*

PROJECT NAME

WP 7 Novel Innovations in Production Solutions

Task 2

CONTACT PERSONS	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
ANTTI SALMINEN	LAPPEENRANTA UNIVERSITY OF TECHNOLOGY	2009 – 2014	3.865 MILLION
PETRI VUORISTO	TAMPERE UNIVERSITY OF TECHNOLOGY		
VELI KUJANPÄÄ	VTT TECHNICAL RESEARCH CENTRE OF FINLAND		

Trilaser

Main targets & motivation

A considerable part of manufacturing in shipbuilding and off-shore industries consists of joint and overlay welding. Welding is a critical process, requiring highly skilled personnel and quality management. Laser welding has been considered for many years as a potential welding technique of the future, but only recently has technology advanced to a point where it can pick up the gauntlet thrown down by Finland's welding industries. The new lasers can offer novel innovations in production solutions for use in welding and coating industries, and particularly in shipyard and off-shore industries. Laser welding and cladding can improve competitiveness and assist in confronting problems and reaching development targets.

The Finnish metal working industry has tended to rely on conventional manufacturing methods. New, more efficient, methods of manufacturing have not been implicated in the production. Laser processing methods are effective in giving more freedom to designers and enabling improvement in manufacturing time. End products made with laser processing are also of high quality. The Trilaser project aimed at bringing high power laser technology to Finland. The applied laser power was up to 30 kW, enough to provide production enhancements and lower production and quality costs, particularly in welding thick sections and cladding large areas. The aims of the project were:

- To improve know-how in the field of high power laser processing, reducing the degree of doubt among companies regarding laser processing methods
- To improve processes based on high laser power to fit the requirements of Finnish industry
- To improve process behaviour to raise the quality of the clad layer and weld metal using various techniques, including selection of filler material feeding and process variants
- To test the controllability of the emerging elemental compositional distribution, solidification features/microstructures and ultimately underlying properties of the welds and clad layers
- To improve the quality and quality assurance techniques for processing based on high power lasers
- To test and develop the use of these techniques to suit the requirements of novel materials and applications.

Studies were also aimed at improving the efficiency of laser cladding and welding by using high laser power. The major part of experimental work was carried out as co-operation with foreign research institutes with regard to networking and benchmarking of capabilities. The overall long-term objective of the project was to facilitate the implementation of novel efficient laser processing techniques for the Finnish manufacturing industry.

Results Improved understanding of high power laser processes. Developed method for narrow-gap multi-pass laser-arc hybrid welding of thick sections. New data and knowledge of the requirements of laser/laser-arc hybrid weldability and welding procedures for novel direct-quenched armour steel grade. New data and knowledge of the mixing behaviour of the weld pool in thick section joints, and the effect of welding parameters on mixing and underlying weld properties.

Cladding results can be summarised as:

1. Implementation of high deposition rate laser cladding (16 kg/h) processes for large area coating applications – the highest deposition rate in the world
2. Development of a coaxial hot-wire cladding technique for coating and additive manufacturing applications
3. Development of a quality control system with respect to powder feedstock and coating quality

Key publications

1. Sokolov, M. et al. (2011), Laser welding and weld hardness analysis of thick section S355 structural steel, Materials & Design.
2. Vänskä, M. et al. (2013), Effects of welding parameters onto keyhole geometry for partial penetration laser welding, Physics Procedia.
3. Tuominen, J. et al. (2011), Laser cladding with 15 kW fiber laser, Proceedings of NOLAMP 2011, Trondheim, Norway.
4. Turichin et al. (2012), Technological possibilities of laser cladding with the help of powerful fiber lasers, Metal Science and Heat Treatment, Vol. 54, pp. 3–4.
5. Karhu, M. et al.(2013), Study of Filler Metal Mixing and Its Implication on Weld Homogeneity of Laser-Hybrid and Laser Cold-Wire Welded Thick Austenitic Stainless Steel Joints, Proceedings of ICALEO 2013, Miami, FL, USA, Paper 906.

Number of publications: 46 (+5 to be completed in 2014)
Number of Doctoral Theses: 3 (to be completed in 2014)
Number of Master's Theses: 3

Networks and international co-operation

- 2013. University of Osaka, Japan. 3 months researcher exchange.
- 2012. University of Stuttgart. 1 year researcher exchange.
- 2010, 2011, 2012. Saint Petersburg State Polytechnical University. 1 month researcher exchange, cladding experiments.
- 2010. Lulea University of Technology. Welding experiments.
- 2011, 2010. SLV Rostock. Welding experiments.
- 2011, 2010, 2009. IPG Application laboratory, Burbach Germany. Welding experiments.
- 2009. BIAS. Welding experiments.
- 2010. Trumpf Application laboratory, Ditzingen Germany. Welding experiments.
- 2012. BAM, Berlin. Cooperation.
- 2011. University of Manchester. Cooperation.
- 2011, 2013. Fraunhofer IWS, Dresden, Cladding experiments.
- Networking with Penn State University, USA; University of Permanbuco, Brazil; University of Changchun, China; SIMTech, Singapore; Korea Advanced Institute of Science and Technology (KAIST), South Korea.

Applications & impact

High power laser technology can provide new manufacturing solutions and enhanced productivity, particularly in the area of large components and thick section. The processes and applications were developed especially for welding and cladding of heavy section and large components. Testing of techniques and processes was carried out with industrial real life applications.

The welding methods developed can be used by welding companies to

- Improve the productivity of production
- Enable new structures to improve performance and function of the product
- Enlarge the field of laser welding in production
- Improve quality of their products and lower the cost of quality
- Develop new business models, e.g. service-based.

The cladding methods developed and improved quality control can be used by cladding companies to

- Improve their cost efficiency
- Enlarge their field of cladding applications and business potential
- Improve the quality of their products

PROJECT NAME
WP 8
Design Drive

Task 1

Shipbuilding foresight

Design Foresight

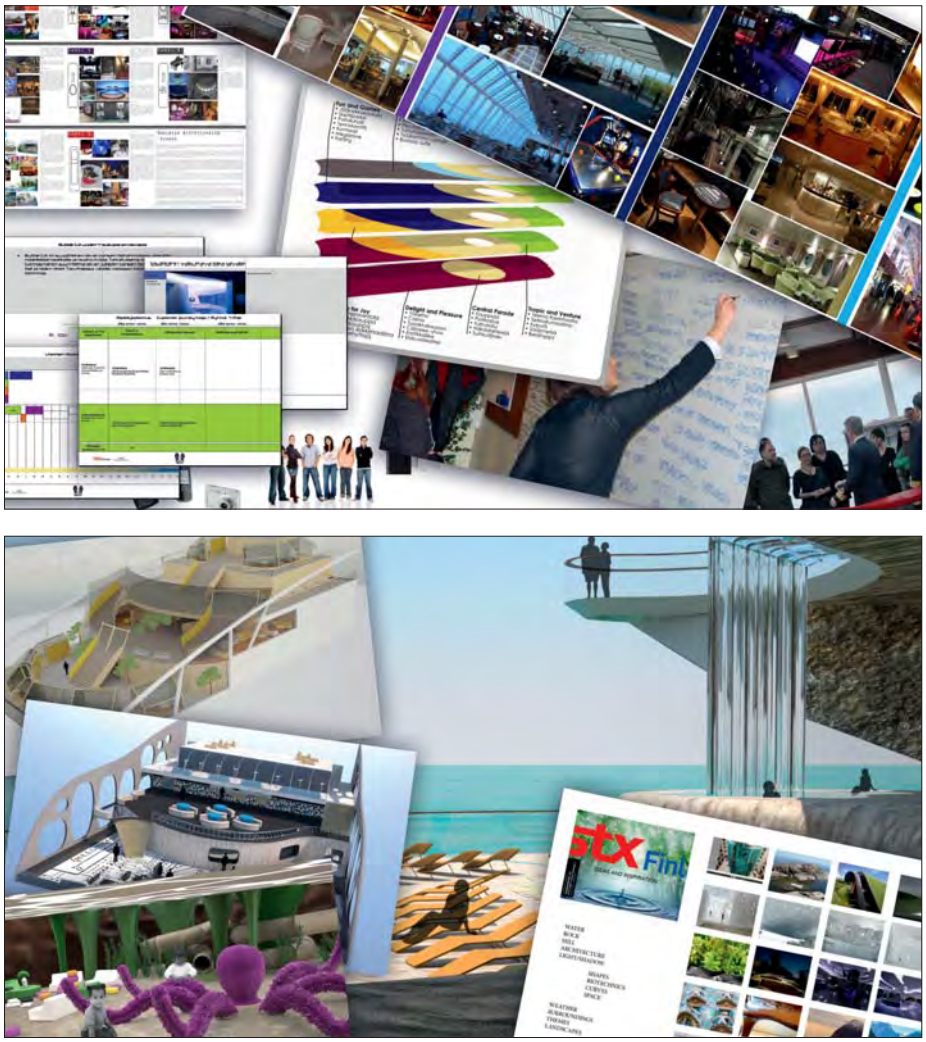


Figure 1. **Projects carried out by TUAS and STX Finland. The goal was to recognise future trends and translate them into new cruise ship concepts. Methods, such as Customer Journey, were used for gathering and analysing raw data. STX took part in creating context for the projects and in evaluation.**

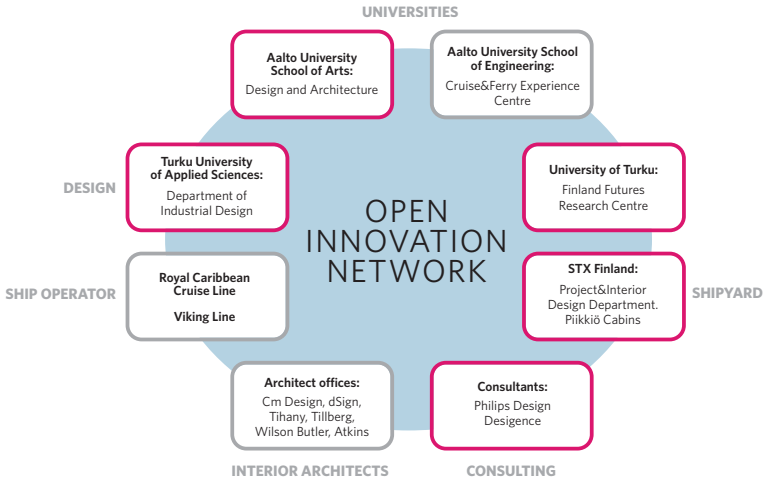


Figure 2. **Open innovation network. Participants in Design Foresight are highlighted in red.**

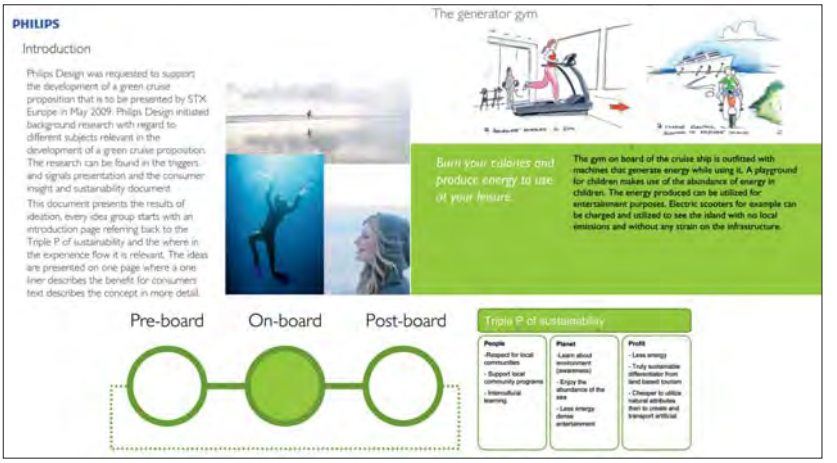


Figure 3. **Philips Design was brought into the project as an experienced design office regarding future-oriented design processes. Philips Design has a well-established process for gathering weak signals and recognising future trends. Quick scenarios are used to translate triggers and signals into concepts.**

Figure 4. **Future monitoring work carried out by STX Finland at the beginning of the FIMECC I&N programme. The aim was to create a platform and routine for gathering signals and data. The work was not completed – translating these signals into concepts in STX Finland would require a forum of specified personnel to analyse and implement them in the cruise ship context.**

PROJECT NAME

WP 8
Design Drive

Task 1

CONTACT PERSON

JANI SIMILÄ
STX FINLAND OY

PARTICIPANTS (ORGANISATIONS)

STX FINLAND OY
RAUTARUUKKI OYJ
AALTO UNIVERSITY SCHOOL OF ENGINEERING
AALTO UNIVERSITY SCHOOL OF ARTS, DESIGN AND ARCHITECTURE
TURKU UNIVERSITY OF APPLIED SCIENCES
UNIVERSITY OF TURKU

PROJECT DURATION

2009 – 2013

PROJECT VALUE (EUR)

0.922 MILLION

Design Foresight

Main targets & motivation

The main objective was to create a network for gathering weak signals and emerging phenomena and to utilise open innovation across the network, including future research institutions, universities, boards of specialists and companies. This will improve collaboration with third parties, increase the diversity of the design process and enhance company flexibility.

Projects piloted inside the network will establish best practices for generating scenarios and visioning future concepts for the needs of the maritime industry.

Successful results will evoke internal interest towards future-oriented design thinking. The aim was to integrate early concept design and establish future-oriented design processes as part of company strategies, thus helping the company to become a leader in offering value-added solutions.

Sustainability has become an increasingly important issue in ship design and development, introduced as early as the concept design phase of new ships. Because of the long lead times and lifecycles of ships, foresight plays an important role in developing ships that are more sustainable. Methods and approaches suited to sustainable design in the early concept design phase are nevertheless scarce. The most common sustainable design methods focus instead on product engineering issues. The goal of the work in Aalto ARTS was to develop methods that address sustainability issues relevant in the concept design phase.

Results As part of the Design Drive programme, Design Foresight has established a network between the shipyard and educational and research institutions (Aalto University, Turku School of Applied Sciences and Turku School of Economics). Such a network has not existed before, and has helped the shipyard to bring in fresh thinking and be more open about its product development and challenges in design.

Two distinctly different time frames were identified in the concept design work conducted at the shipyard. In the short term, concept design is used with customers to discuss the possible features of a ship. In the long term, concept design is used as a tool for visioning what future ships could be like. In either case the use of typical lifecycle design methods is not the best approach to sustainable design: in the short term, detailed issues of materials and construction are premature, whereas in the long term the change of sustainability challenges is likely to render current approaches obsolete and outdated. Furthermore, it was recognised that designers in shipbuilding focus mainly on traditional tasks of design, such as product appearance and overall function. New approaches to sustainable concept design are therefore required.

Acceptability of sustainable products and features was identified as one of the key sustainability challenges in developing ship concepts in the short term. Sustainability can reduce the perceived value of products and result in negative experiences. Therefore, a new role for designers in developing more sustainable products is to improve their acceptability and value (as opposed to only trying to decrease environmental impacts).

The first method introduced for understanding passenger perceptions and acceptability of sustainability was the use of mood boards as interview stimuli. As such, the method is well suited for early concept design work and is particularly useful for defining the design drivers and requirements in terms of sustainable design (e.g. avoid a non-modern appearance because it leads to expectations of outdated technology). The study was conducted in co-operation with the Cruise and Ferry Experience Centre task (WP8 T5).

The second approach focused on passengers' preferred onboard locations, aimed at improving the value ships offer to passengers. Locations that were most and least desirable for passengers were identified through use of a mock-up divided into decks. This method is useful in the process of defining the general arrange-

ment of the ship and how to locate different spaces for maximal passenger satisfaction. In general, upper deck and outside cabins and spaces were preferred over stern and inside spaces and the lower decks. In the future, a virtual version of the method could be useful for streamlining the process of acquiring passenger foresight information.

In a third study, a design concept was developed for studying the desirability of behaviour-steering technologies in cabins, aimed at reducing water and electricity consumption in the ship hotel. Two different groups of students were compared in a qualitative study: students participating in a sustainability-oriented design programme, and students participating in other study programmes. While information about energy and water use was appreciated by both groups, it was found that students with interest in sustainability were more likely to prefer a cabin that rewards its users for sustainable behaviour (i.e. is somehow consequential/intrusive).

Key publications

1. Jokinen, L. (2010) Turku School of Economics (14/1/2010). Corporate Foresight System – Starting Points and Possibilities.
2. Shibasaki, S. (2010) University of Arts and Design Helsinki. Concept Design in STX Europe.
3. Murto, P., Ahola, M. & Person, O. (2013) Forming the Face of Green Products: Mood Boards and Early Consumer Involvement in Ship Interior Design. Proceedings of the 20th International Product Development Management Conference, Paris.
4. Murto, P., Ahola, M. & Person, O. (2013) From Mood Boards to Design Drivers: Understanding User Inferences of Environmental Sustainability in the Early Stages of Green Product Development. Proceedings of the 42nd Annual European Marketing Academy Conference, Istanbul.
5. Pakbeen, H. & Murto, P. (2013) Preference Laboratory: A Study for Understanding the Locational Preferences of Potential Cruisers.

Number of publications: 7
Number of Doctoral Theses: 1
Number of Master's Theses: 3

Networks and international co-operation

A network was established involving the STX shipyard, the Marine Technology research unit of the Department of Applied Mechanics at Aalto University School of Engineering, Aalto University School of Arts, Design and Architecture, the Turku School of Applied Sciences and the University of Turku.

A brief pilot project between STX and Dutch based Philips Design in 2009 was carried out to evaluate Philips Design's future monitoring methods. Philips Design conducts systematic collection of information of future trends and weak signals and keeps the company up to date on the rapidly evolving business world.

No international co-operation, but collaboration with the Cruise and Ferry Experience Centre (WP8 T5).

Applications & impact

The Customer Journey method was tested for data gathering during several TUAS projects. Some of the results have been used by the shipyard as inspirational and marketing material.

The methods and approaches developed and showcased in the project serve to build knowledge on how to address sustainability in concept design work more comprehensively. In particular, the work introduces means for alleviating any potential negative associations that passengers may have towards sustainability. These means are important as complementary assets to technological sustainability improvements. The results from the studies may also be used as initial probes for designing more sustainable ships.

Cruise Ship Architecture Forum

Networking cruise ship architecture

The Design Drive Network was built to develop the architectural design of passenger ships. This first-of-a-kind continuous 5-year programme bound together specialists in design, research and the shipbuilding industry.

Design Drive Network:

- Shipyard: STX Finland Project Department, Interior Design Department, Piikkiö Cabins
- Universities : Aalto University School of Arts, Design and Architecture, Department of Design, Aalto ENG Cruise & Ferry Experience Centre, University of Turku, Turku University of Applied Sciences Department of Industrial Design & Degree Programme in Hospitality Management
- Ship operators: Royal Caribbean Cruise Line & Viking Line
- Architect offices: Cm Design, dSign, Tihany Design, Tillberg Design, Wilson Butler Architects and Atkins
- Design consults: Philips Design and Desigence

During 2009–2013 there were approximately 50 different architecturally oriented projects, and the network learnt to select the necessary participants, promoters and workflow for each development challenge. The Design Drive Network succeeded in achieving goals that were beyond the reach of single participants.

Goals:

- Continuous dialogue between specialists in design, research and the shipbuilding industry
- Research and implementation of sustainable design, eco-design, service design, future research and open innovation
- Improved architectural design workflow and scheduling in the shipbuilding process
- Design guidelines and education for interior designers working in shipbuilding
- Higher usage of industrial building methods and modularisation.

There are two challenges for design coordination and sustainable design:

1. The ship development process is not a linear process in which concepts move to basic design and manufacturing. Instead, there is discontinuity between the different phases and "layers" of the process. These different layers do not always correspond to each other. Work done in the later phases may completely disregard work conducted earlier in the project, i.e. a layer may block the one beneath it. For example, in interior design the original concepts made at the shipyard rarely fully dictate what the ship will actually be like.
2. In the design process many different actors enter the project and leave their mark on the different layers of the project. However, these actors may not always be fully aware of their contributions and the contributions of others, even if work is conducted on the same tasks. For example, the exterior design may be conducted simultaneously in multiple organisations working under very different logics of operation.

With regard to managing and coordinating the ship design process, we propose that managers of ship design and development engage in active transfer of knowledge and understanding among different actors working in the same phases and among different actors in different phases. With regard to sustainable design of ships, we propose managers adopt a goal-oriented view on environmental improvements instead of trying to diffuse universal methods across the development network.

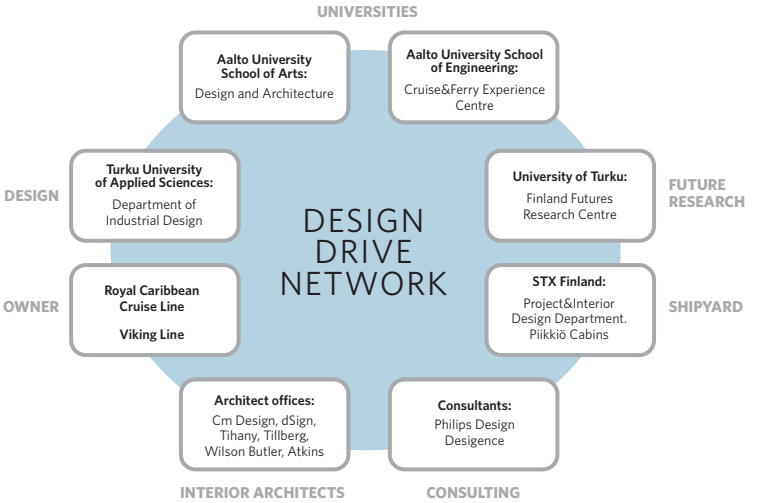


Figure 1. **Design drive network**

PROJECT NAME
WP 8
Design Drive

Task 2

CONTACT PERSON
JANNE ANDERSSON
STX FINLAND OY

PARTICIPANTS (ORGANISATIONS)
STX FINLAND OY
AALTO UNIVERSITY SCHOOL OF ARTS, DESIGN AND ARCHITECTURE
TURKU UNIVERSITY OF APPLIED SCIENCES

PROJECT DURATION
2009 – 2013

PROJECT VALUE (EUR)
0.251 MILLION

Cruise Ship Architecture Forum

Development of cruise & ferry architectural design network

A forum of architecturally oriented design was assembled out of design offices, universities, ship operators, shipyard and design and research consults. Over the five years we were able to test approximately 50 architectural design-related projects in action. The composition of the partners varied from purely the shipyard´s in-house designers to a large open innovation session with 20 invited companies. STX started in the promoter's role, while later the universities and TUAS continued running their own projects without the shipyard's guidance. The large number of projects and different compositions of players helped us to understand what was needed to produce results and the kind of results that could be expected.

The original description of the workflow and partners was a timeline starting from future foresight research and ending up with the ship contract. This was designed for the shipyard's purposes, and everything was aimed to improve architectural design work at the concept design phase. The greatest benefit in this description was that the "fuzzy end" was highly visible. All conceptual design work needs to start from future and foresight research in order to have strategic value. On the other hand, the problem with the workflow was that it was entirely for the yard's purposes and neglected the motives of the other partners.

The final chart for describing Design Drive was without the timeline and workflow. After several different projects it was understood that the most valuable asset is the network of designers and

researchers, and the know-how in their organisations. Constant co-operation taught us what kind of tasks could be done in which organisation, and lowered the contact threshold. The role of promoter was also changed according to the project motive. The size of the network was ideal, while everyone learnt to know each other and knew what each other actually did. (The results of each individual project are presented in WP 8 tasks 1–5.)

Improved architectural design process

An important part of the task has been integrating the architects' design work with the yard's basic design and detail design activities. By analysing and specifying the information from the architects required by the yard's engineers and vice versa, the entire design process has been intensified. Emphasis has also been placed on the scheduled decision-making of architects' design-related issues.

The programme succeeded in creating the educational material for interior architects. Basic knowledge of shipbuilding can be improved by using the yard's lectures explaining principles of ship design, steel structure design, industrial building methods, HVAC, safety regulations and design workflow.

TUI – Mein Schiff 3 interior design included coordination with interior architecture offices such as cm Design, dSign, Tihany Design, Tillberg Design, Wilson Butler Architects and Atkins. Design processes and scheduling was introduced to everyone. All educational material was found to be useful to those who had not participated in cruise ship design before. The most important result of this task was earned by avoiding all the typical design mistakes that occur when this education is neglected.

STX Finland Oy coordinates training with the Shipbuilding School in Turku. The training entitled "Communication and design tools" takes two days and includes 2D and 3D design guidance and document management guidance. Design instructions for controlling cost efficiency are in process. Interior space complexities are classified at different levels and the aim is to go through a design process without causing additional costs.

Industrial building methods and modular techniques are key factors in developing the shipyard's building cost efficiency. Interior architecture could support this by participating in the process earlier and even creating more modular features. Communication between shipyard and interior designers should be continuous, and this should be kept in mind in the next programme.

Beginning of long-term design research

Architectural design in a complex network can suffer from a lack of long-term co-ordination and development. All participants have their own individual goals, and common long-term development might be difficult to implement. It was discovered that architectural offices are unlikely to invest in research – for example sustainable design, eco-design, service design, future research and open innovation. Design Drive was able to obtain several researches that supported the network working with architectural design.

Pekka Murto and Oscar Person studied eco-design principles in a business network through a case study on the work of designers in developing a large made-to-order product. They concluded that Viking Line's "Viking Grace" is a very successful ship in terms of environmental improvements. The design process behind these improvements, however, in many respects contradicts the suggestions in eco-design and sustainable design literature. Murto and Person were also able to describe the improved model for implementing such long-term design goals in a cruise and ferry architectural design network.

WP 8 Design Drive also succeeded in starting the preliminary future research, service design research and open innovation research.

Key publications

Murto, P. & Person, O.(2013), Eco-Design Principles in a Business Network: A Case Study on the Work of Designers in Developing a Large Made-to-Order Product. Paper presented at the Cambridge Academic Design Management Conference.

Number of publications: 1

Networks and international co-operation

STX Finland
Aalto University School of Arts, Design and Architecture
Turku University of Applied Sciences, Department of Industrial Design and Degree Programme in Hospitality Design

Architect offices improving co-ordination with STX: Cm Design, dSign, Tihany, Tillberg Design, Wilson Butler Architects and Atkins.

Applications & impact

Development of the existing architectural design and research network is a long-term process, and the value difficult to estimate in monetary terms. Competitors with no such experience will spend years in starting similar co-operation.

Implementation of sustainable design, eco-design, service design, future research and open innovation will be possible either with offices specialised in such services or with network cooperation. In Design Drive we have taken the first steps in developing know-how in the network.

The cost impact of avoided design mistakes is difficult to estimate, but in the TUI Mein Schiff 3 project it could be around EUR 1 million. Late interior changes cause direct expenses e.g. in HVAC routing and subsequently other design aspects. Existing educational material for architects will be updated enabling similar savings to be achieved in forthcoming newbuilding processes.

The potential for savings in industrial building methods and modularisation amounts to EUR 1–10 million. Now that the importance of the interior architecture process is understood, this could be counted partly as a beneficial impact for future development.

Open Innovation and e-Innovation

Future workshops and open innovation events

Future workshops were an excellent way of introducing open innovation methods, not only to us but to our invited participants. The experts we invited to take part in these open innovation days were from many different fields, something we found excellent for opening new perspectives and finding ways of handling challenging problems (figure 1). Several national, European and world wide innovation competition and open innovation events were also arranged. One such event formed part of the European Architecture Student Assembly, where one hundred students from around Europe were introduced to the cruise shipping business and innovated solutions for the various business challenges presented to them (figure 2).

Figure 1. **Participants of a future workshop**

Figure 2. **STX open innovation event**

Searching for opportunities instead of ideas

Research also covered the innovation processes themselves. The results were clearly differentiated phases between ideas, concept development and product/solution development, with focus on finding opportunities rather than just ideas.

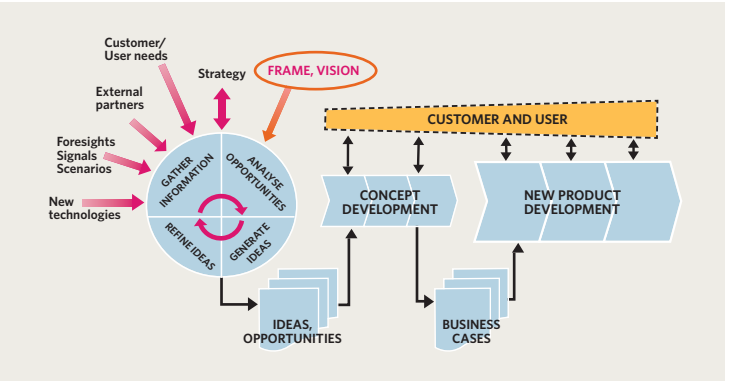


Figure 3. **Balanced innovation process**

e-Innovation networks for sustainable innovation

Corporate sustainability and the green business is regarded more and more as a key strategic business driver for companies to reduce costs, create new jobs, enter new businesses and enhance corporate image. However, recent academic studies show that it is extremely difficult to integrate sustainable, green principles and practices into a company's short-term strategy, leadership and innovation activities. Furthermore, the previous literature on corporate sustainability lacks the theoretical and empirical understanding of how to create and manage *radical green innovations* in resource-intensive businesses. This project therefore focused on examining this strategically important challenge, and succeeded in pinpointing new strategies for value creation.

This research identified *four distinct types of strategies* for value creation through green innovations. The findings emphasise the critical importance of creating value for customers, the company and society through radical green innovations, with progress through incremental change not enough to solve the worsening climate crisis. The findings illustrate that resource-intensive businesses are able to implement and make use of green innovation to *gain competitive advantage* and *revolutionise their industries*. The study therefore suggests new managerial competencies and roles assisting leaders in order to capture value through radical green innovation strategy.

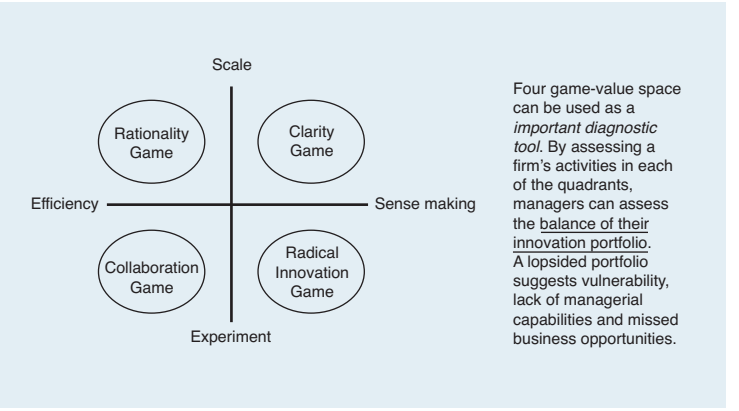


Figure 4. Strategic games-space illustrates the key strategies for success in creating green innovations (Lampikoski, Möller, 2012)

The key results of this project are presented to a wider Finnish societal, business and academic audience through a business book, "Vihreä Aalto", published in September 2013. The book illustrates how green business pioneers are succeeding in leading the transformation towards a green business and in revolutionising their industries by creating new profitable business, gaining substantial cost savings, enriching image and attracting the best talent. This has been enabled through a purpose-driven business that aims to solve the world's worst environmental and social challenges.

For Finland, one emerging potential growth opportunity lies in succeeding in ecologically driven business innovation and leading the development in such clean technology areas as water, waste and smart grid. The next challenge for Finnish companies – small and large – is to master the leadership and business model requirements for transforming into a transparent and authentic player within the green business. This calls for establishment of a new strategic research programme.

PROJECT NAME
WP 1
Design Drive

Task 3

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
KARI SILLANPÄÄ STX FINLAND OY	**STX FINLAND OY** **L M ERICSSON AB** **INNO-W OY** **OPPIFI OY** **ALMA MEDIA OY** **TIETO OY** **RAUTARUUKKI OYJ** **AALTO UNIVERSITY** **UNIVERSITY OF TURKU**	**2009 – 2013**	**1.744 MILLION**

Open Innovation and e-Innovation

Main targets & motivation

- Although most participants have used open innovation methods in one form or another, there has been no methodological application, and only limited research and inadequate understanding of different methods and usability. It was thus deemed necessary to increase knowledge of open innovation methods.
- Participants divided the task into parallel activities and combined the results that were applicable.
- Chesbrough defines open innovation as "A paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market as the firms look to advance their technology."
- Managing sustainability inside a company – the guidelines for creating a sustainable enterprise. This route is also reasonably well studied and there is an increasing amount of management literature on "how to become a green company".
- Managing sustainability within open innovation networks – with resulting effects on business model, collaborative competence, and co-creation culture. There is only limited research and inadequate understanding of this promising route.
- Corporate sustainability and green business is increasingly regarded as a key strategic business driver for companies to reduce costs, create new jobs, enter new businesses and enhance

corporate image. However, recent academic studies show that it is extremely difficult to integrate sustainable, green principles and practices into a company's short term strategy, leadership and innovation activities. Furthermore, the previous literature on corporate sustainability lacks the theoretical and empirical understanding of how to create and manage radical green innovations in resource-intensive businesses. This project therefore focused on examining this strategically important challenge, and succeeded in pinpointing new strategies for value creation. The research further adopted an international focus, by creating continuous knowledge transfer from the pioneering green businesses in Silicon Valley.

- The idea of developing an open innovation process emerged in STX Finland in 2008 to help in the identification of factors affecting future ship concepts, as well as to generate concept ideas in relation to ongoing passenger ship design projects within the company.
- More and better ideas from the fuzzy front end to the product and solution development process.
- Focus shifting from internal work to co-operation.

Results

- STX Finland, together with the University of Turku, concentrated on researching and developing open innovation and co-development methods of different magnitudes:
  - employing a group of experts from several companies and universities, and from different fields of technology, working to identify factors affecting future concepts and to generate preliminary concept ideas, was found to be an excellent method
  - a smaller group of experts with connecting systems on board ship were found to provide each other with many opportunities for improvement just by working together
  - worldwide innovation competition using the Internet and the LEGO digital designer forum provided many new ideas, although not many were commercially viable
  - an open innovation event for European architecture students and national maritime and metal industry innovation competitions for undergraduate students brought out many enthusiastic young talents and new ideas, while providing positive publicity for the maritime industry among the students.
- Aalto, Ericsson, Oppifi and Alma Media concentrated on researching and developing sustainability management within open innovation networks.

- This research identified four distinct types of strategy for value creation through green innovations. The findings emphasise the critical importance of creating value for customers, the company and society through radical green innovations, because progress through incremental change is not enough to solve the worsening climate crisis. The findings illustrate that resource-intensive businesses are able to implement and make use of green innovation to gain competitive advantage and revolutionise their industries. Thus, the study suggests new managerial competencies and roles that assist leaders to capture value through radical green innovation strategy. These insights were achieved through extensive literature review, a series of corporate and academic workshops in Finland and the United States, over 50 thematic interviews with thought leaders in the United States, and continuous high-quality publications and presentations for academic and business audiences.

- Inno-W, together with FIMECC, VTT and Cargotec, has studied and developed tools for networked innovation processes.
  - The "Virtual Innovation Room" concept tool was developed, allowing various stakeholders and experts to connect to a virtual space for real time innovation. The virtual innovation mode (Virtual Innovation Room) supports the different stages of the innovation process from idea generation to project and portfolio supervision, and enables the participants to connect to the shared workspace via web camera and voice.
- Rautaruukki, together with VTT, researched innovation processes.
  - The results were clearly differentiated phases between ideas, concept development and product/solution development, with focus on finding opportunities rather than just ideas.

Key publications

1. Lampikoski, T. & Sippo, J. (2013), Vihreä aalto, Helsingin kaupakamarikustannus.
2. Lampikoski, T.,Westerlund, M. & Möller, K. (8/2013), Beyond greenwashing – strategies to succeed with breakthrough green innovation. Paper accepted for the second round review at California Management Review journal.
3. Lampikoski, T. (to be published) Strategies for managing radical green innovations, Aalto University, School of Business, Doctorate thesis.

Number of publications: 23
Number of doctoral theses: 1
Number of master's theses: 1

Networks and international co-operation

- Open innovation events brought together many national and some international companies and universities, as well as students from around Europe and even further afield. Round table processes were employed with Finnish metal engineering companies, and networks with Finnish and Estonian universities.
- This research established connections with leading thought leaders and firms within green business in the Silicon Valley region, including global multinationals such as Nike, IBM, Intel, Starbucks and Interface. This was enabled through a long-term visiting scholarship at UC Berkeley's Haas School of Business, and included two project members: doctoral student Tommi Lampikoski and Professor Kristian Möller. The project also networked multiple Finnish researchers and business leaders with local universities and firms in the Silicon Valley region, and facilitated the visit of the leading professor of open innovation – Professor Henry Chesbrough – at an event at Aalto University.

Applications & impact

- Open innovation methods will be used in concept, product and production development.
- Internal organisation and processes have been changed.
- Open innovation competitions will be arranged in order to increase positive publicity and to find potential new talents.
- The key results of sustainability management part are presented to a wider Finnish societal, business and academic audience through a business book, "Vihreä Aalto", published in September 2013. The book illustrates how green business pioneers are succeeding in leading the transformation towards green business and in revolutionising their industries by creating new profitable business, gaining substantial cost savings, enriching image and attracting the best talent. This has been enabled through a purpose-driven business which aims to solve the world's worst environmental and social challenges. For Finland, one emerging potential growth opportunity lies in succeeding in ecologically driven business innovation, and in leading the development in such clean technology areas as water, waste and smart grid. The next challenge for Finnish companies – small and large – is to master the leadership and business model requirements for transforming into a transparent and authentic player within the green business. This calls for establishment of a new strategic research programme.

BEST PRACTICE

A few key lessons from Silicon Valley

MSc Econ. **Tommi Lampikoski**

FIMECC's man in Silicon Valley from 2009 to 2013, Mr. Tommi Lampikoski, introduces experiences from Berkeley Campus and the green business world. Tommi has boosted FIMECC's open innovation thinking and practices through co-operation with Prof. Henry Chesbrough and continuous coaching of FIMECC decision-makers. He has also shown the dissipating power of almost chaotic non-steered bottom-up community activity in comparison to clear innovation processes.

I would like to share four critical lessons arising from the interviews of over 50 managers of green businesses in the Silicon Valley region.

Lesson 1. Less is more – simplify the complexity.

Smart leaders eliminate all the good ideas in their organisation and focus solely on great ideas. When companies focus their attention on advancing too many ideas at once it leads to a lack of clarity and to confusion, increased development costs and the launch of meaningless new stuff being hauled to garbage dumps. No wonder most new product launches fail commercially within the first six months. Similarly, many start up companies in Silicon Valley fail through trying to simultaneously advance too many ideas with limited resources.

Lesson 2. Understand the real meaning of open innovation in your organisation.

Open innovation is about advancing *radically different technologies, ideas, products, services and business models when tapping into the best intellectual minds, brands, resources and capabilities of strategic partners.* Managers need to understand what open innovation really means and in which context it should be applied. When considering open innovation opportunities, leaders should ask: *"Are you in a regular type of relationship with somebody or are you truly making a difference that no single firm can make alone?"* Fundamentally, the best open innovators create competitive advantage by finding a way of making a collaboration opportunity attractive in a business sense for all parties, keeping it exclusive to each other for a period of time and creating something that did not exist before.

Lesson 3. The next wave of successful firms will focus on advancing a "purpose-driven" business attracting and retaining the best talent.

The new wave of green business leaders believe in so-called "purpose-driven business", aiming to solve some of the worst environmental

and social challenges. They aim to win the battle for consumers' wallets through reconfiguring the purpose for being in business and seeking answers to *"what kind of game-changing challenge are we solving?"* Fundamentally, leaders need to ask whether *"anyone would care if my company ceased to exist"*. A recent study of 50,000 global consumers showed that *most people would not care if 70 percent of brands ceased to exist (Havas Media, 2012).* The next wave of leaders and companies are continuously asking: "Is our business culturally, ethically, environmentally and socially relevant for years to come?"

Lesson 4. Managing successful green business requires the mastering of four different types of green innovations. The e-Innovation project identified the following four games in which authentic green businesses excel.

The *Rationality Game* is a playground for the majority of companies taking the first steps in greening their business. The emphasis is on improving profitability and productivity through eco-efficiency measures. Innovation focuses on step-by-step improvements in products, processes, and energy efficiency, as well as in cumulated cost savings. The *Collaboration Game* is the next step most companies would take in corporate greening. This includes profound collaboration with suppliers, partners and stakeholders. The main point is to motivate, influence, and interact with partners in adopting and scaling green activities. The *Radical Game* centres on the exploration of breakthrough innovations and experiments. Leaders set grand-level development challenges for employees and partners, facilitate and support radical experimentation, and invest heavily in R&D and innovation deployment. *The Clarity Game* is the most demanding stage of green innovation. This aims to build companies who succeed by connecting the organisation's environmental vision and purpose with leadership, culture, loyal customers, strategy and values. Figure 1 illustrates the four critical games of green innovation.

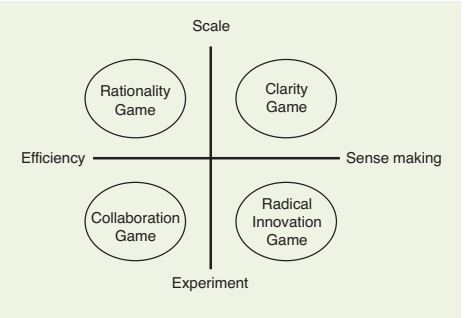


Figure 1. **Green innovation games (Lampikoski, Möller 2012)**

PROJECT NAME
WP 8
Design Drive

Task 4

Innovation Conceptualisation

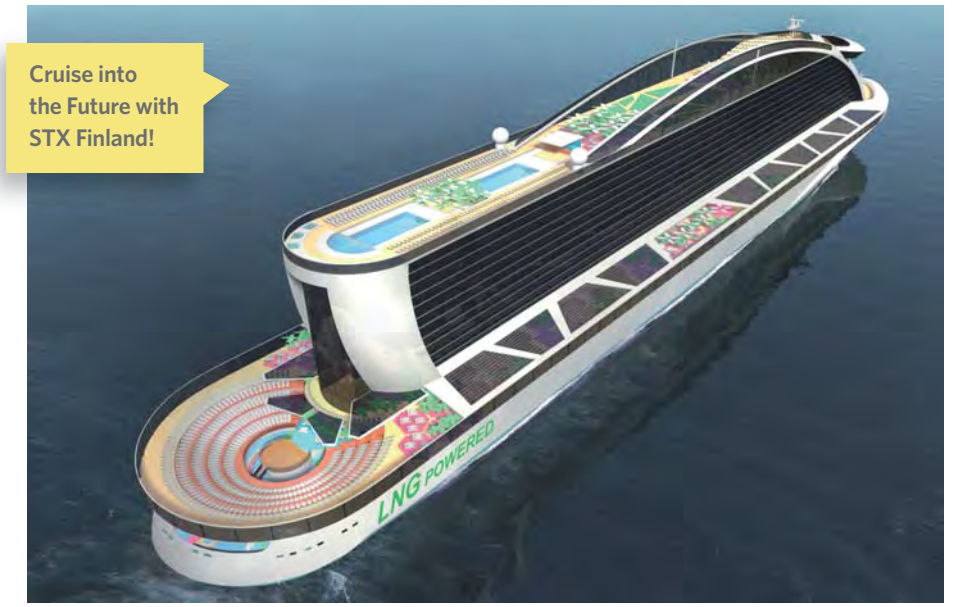


Figure 1. **The XPTray concept, used as a platform for many innovations created in other FIMECC I&N programme tasks**

Figure 2. **Several innovations were utilised from passenger spaces to technical solutions**

Experience the sea

The base for the intelligent concept is an open, large multipurpose deck with a diverse range of attractions, complete with a slim accommodation block on top of the tray. The tray uses staging solutions to serve a range of activities, its appearance changing through day and night – the sun deck transforms into a seaside cafeteria, an entertainment area into a dining venue.

Environmentally friendly

Multipurpose spaces and higher occupancy ratios, together with new and improved technical solutions, ensure the ship's energy consumption is the lowest possible. LNG machinery, waste heat recovery, and many other applications for green and efficient energy production, are further signs that she is the most environmentally friendly passenger ship today.

Efficient operation

With all passenger dining and entertainment venues on the XPTray decks, related service facilities can be combined to offer high-level service with streamlined manning. Service logistics are also improved by shortest possible distances from stores to consumption.

Rational and innovative shipbuilding

The unique layout, with intensified superstructure and a high-level of modularisation, forms the base for achieving a cost-effective shipbuilding process.

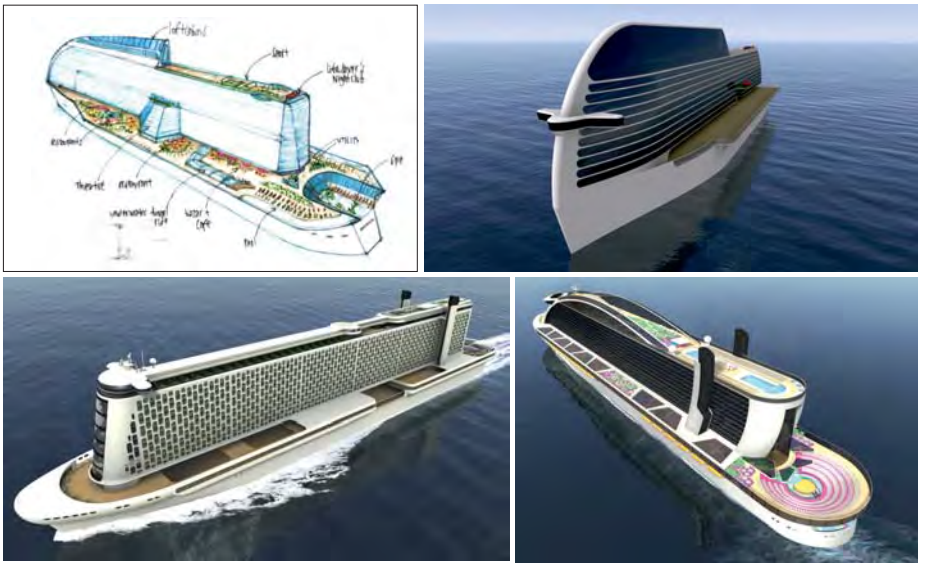


Figure 3. **The XPTray concept saw many changes during the research programme**

PROJECT NAME
WP 8
Design Drive

Task 4

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
KARI SILLANPÄÄ STX FINLAND OY	**STX FINLAND OY** **AALTO UNIVERSITY** **TURKU UNIVERSITY OF APPLIED SCIENCES**	**2009 – 2013**	**0.593 MILLION**

Innovation Conceptualisation

Main targets & motivation

The target of this task has been the integration of other task results, especially those in the design drive work package, thus co-creating new solutions and concepts.

Results

The STX Finland XPTray cruise ship concept was used as a target platform in this task, with the following innovations incorporated:

- Multifunctional passenger public area concept
- Public space concepts utilising natural ventilation and light
- Various cabin concepts
- Production-friendly superstructure with multimodular cabins
- Modular air condition room concept
- LNG machineries

Key publications

1. Two XPTray concept brochures
2. XPTray ship model, which has been modified according to changes during the project

Number of patent applications/patents: 1 patent application, XPTray concept structure

Networks and international co-operation

The XPTray concept has been utilised in some customer projects.

Applications & impact

- The XPTray concept, with its many different innovations, received plenty of interest internationally, increasing our reputation positively as an innovative shipyard
- Many features, and the XPTray concept itself, were utilised in customer projects.

Cruise & Ferry Experience Centre

Project for future passenger ship designers

The complexity of passenger ships has increased considerably over past decades. Nowadays, ships are modern cities in miniature, naturally connecting the latest technology, newest business models and recent design. All this is wrapped in a concept for attracting passengers. The Cruise & Ferry Experience Centre was established at Aalto University to answer the increased need within the shipping industry for professionals from different disciplines. The research and education centre develops multi-disciplinary research in the passenger ship context, and offers higher education for students already mastering their specific field who are willing to learn the basics of naval architecture and communication in a multi-disciplinary project environment.

FIMECC's I&N programme has so far enabled the Cruise & Ferry Experience Centre to publish 16 joint Master's theses as well as peer-reviewed articles, and to establish a study module. Although relatively young, the centre has gained extremely positive international publicity, as well as exerting social impact through organised seminars and exhibitions, and earning awards for high-quality, multi-disciplinary activity. Feedback points to pioneering work, goals exceeded, and the taking of research and education in the passenger ship context to the next level.

Triad – joint Master's thesis program

The Cruise & Ferry Experience Centre sees passenger ships and ferries as a natural combination of different disciplines, with endless possibilities for research collaboration. Through the FIMECC I&N programme, the centre has been developing high-level research involving technology, business and design in a true interlinked environment. The award-winning (METEX scholarship & Aalto University reward)

Figure 1. **Multi-use space concept for cruise ship, from Triad – joint Master's theses project (Ahola, 2010)**

Triad joint Master's theses project executes theses in the passenger ship context. The project is organised annually and connects three Master's candidates from the above-mentioned fields in a multi-disciplinary research environment to research a common current topic from three different perspectives.

Topics investigated range from multi-use space to a real-time feedback system for passenger ship service operations. For example, the interchangeable module system for passenger ships (see figure 2) was first developed in Antti Kauppi's (2012) thesis, and further investigated in several other theses, e.g. Parmasto, O. (2012); Jõgeva, M. (2013); Ahola, A. (2011); Wu, Y. (2013); Tulimaa, P. (2012); and Yliriku, V. (2012) (see figure 2).

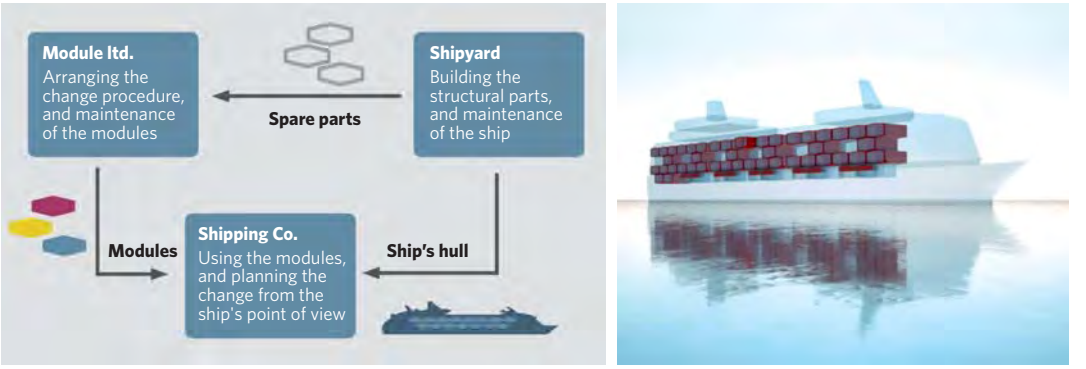


Figure 2. **The m²cell concept – an interchangeable module system for passenger ships (Kauppi, 2012 & Ylirisku, 2012)**

Apart from the Triad programme, the centre also conducts individual research. The virtual design environment enables the communication of different disciplines within real time and scale. The tool can be used for user testing, for educational purposes and as a communication tool in decision-making. The first Master's thesis and working demo (Magica, 2013) for the new research direction will be published in 2013. The centre's post-graduate research concentrates on user experiences. M.A. Markus Ahola investigates the passengers' perception and how cruise experiences can be seen through actor-network theory (ANT). The research outcomes can be utilised in strategic passenger ship design.

Cruise & Ferry Experience –study module

Responding to the project nature of work within the international community, involving people from different professional backgrounds, the centre's education is based on problem-based learning and the importance of interdisciplinary communication skills, as opposed to gaining massive amounts of knowledge. Lectures for the business, design, and marine engineering students are given by marine industry professionals. In addition, student groups develop passenger ship concepts of the future from a comprehensive perspective, considering user trends, business model, manufacturability and other aspects.

In the first course (Cruise & Ferry 1), students are introduced to marine industry and design. The students define their individual learning objectives and select optional courses from the different fields (see figure 3). Learning is implemented in conceptual design (see figure 4) which is then upgraded during the final course (Cruise & Ferry 2) based on knowledge gained. Outcomes are presented at the shipyard. During the module the student learns to:

- formulate, analyse and synthesise complex design problems and carry out small scale research on these
- carry out design work in multi-disciplinary and international teams and communicate the results within and outside the group
- act professionally and understand the ethics and impact of his/her work on society
- manage large projects including the planning of lifelong learning
- use some of the basic consumer research, design and engineering tools.

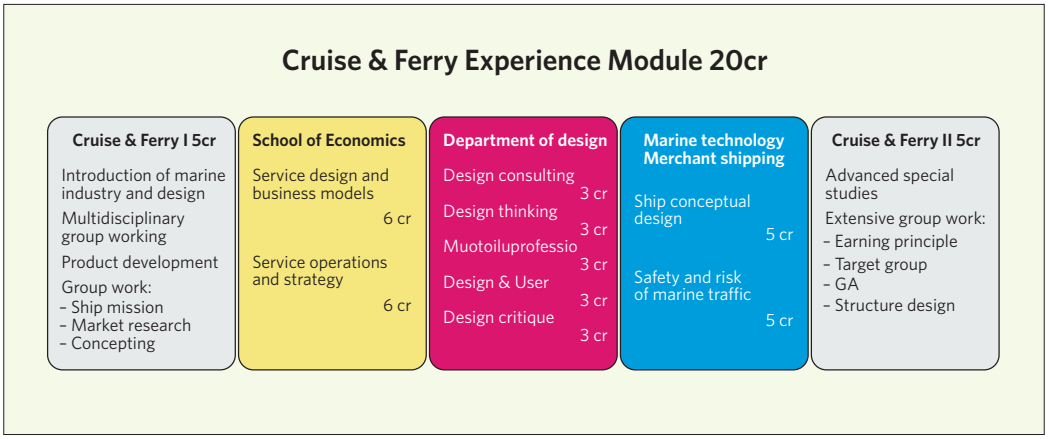


Figure 3. **Example course curriculum of Cruise & Ferry Experience study module**

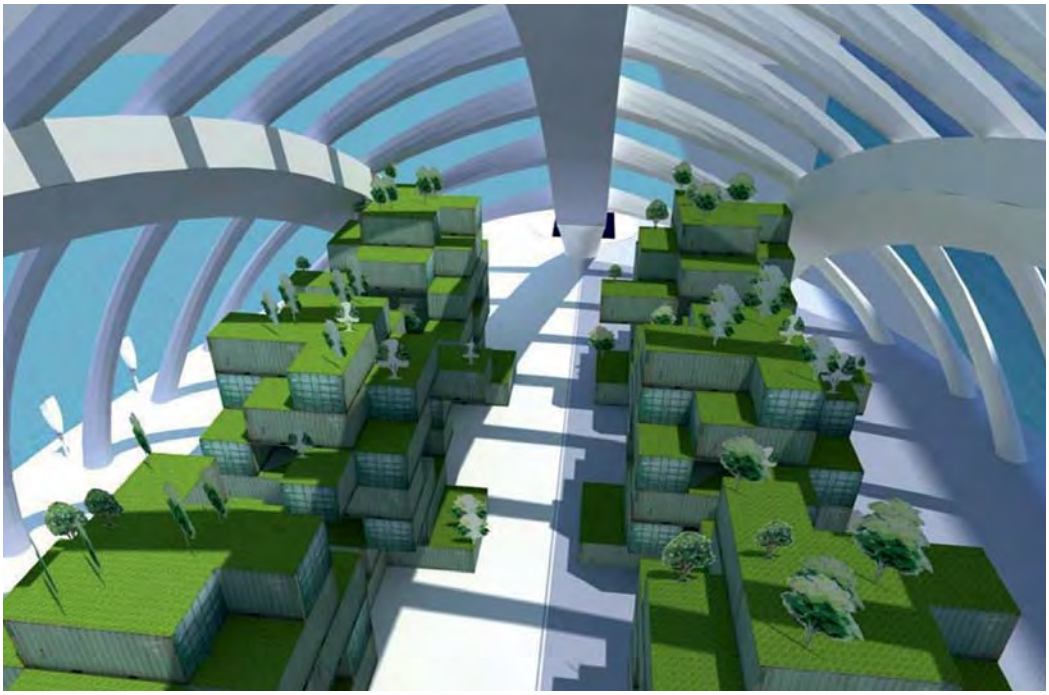


Figure 4. **Example of Cruise & Ferry Experience study module outcomes: 'Biosophy' catamaran cruise vessel with its own ecosystem (Kulaots, Pollak & Prieto, 2011)**

PROJECT NAME
WP 8
Design Drive

Task 5

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
PENTTI KUJALA AALTO UNIVERSITY	**AALTO UNIVERSITY** **ROYAL CARIBBEAN INTERNATIONAL** **STX FINLAND OY**	**2009 – 2014**	**0.653 MILLION**

Cruise & Ferry Experience Centre

Main targets & motivation

The original objective of the project was to integrate user-centric design and multi-disciplinary activity with passenger ship research and education. This is implemented through a multi-disciplinary research and education programme at the Marine Technology research unit of Aalto University School of Engineering's Department of Applied Mechanics.

The programme aims to educate professionals in mastering communication between technology, economics and design factors in passenger ship design. The present focus is on education at Master's level. The programme is based on a modular structure where students can direct the curriculum towards their own field of specialisation. At the end of studies the programme offers an opportunity for the most promising students to participate in the inter-linked Master's theses programme Triad, in which three students investigate a common research question from three different perspectives, i.e. technology, economics and design. Research is also carried out at doctoral level. Programme activity is guided by a steering group consisting of industry representatives, i.e. STX Finland, Royal Caribbean International, Archtech and Foreship, with Aalto University professors from the fields of marine technology, industrial design, and business.

Although the programme is still young, the results have been extremely promising, with participation in various events attracting great interest in a unique programme in the field of marine technology. The programme is constantly being developed, aiming for ship design and user testing in virtual reality as well as internationality.

Novelty & added value brought by this work vs. state-of-the-art

The programme has developed a novel and globally unique approach to research and education in passenger ship design. Remarkable research results and innovations on passenger ships have been delivered in a multi-disciplinarily manner, and multi-talented professionals educated in communication and collaboration between different disciplines to add to their own expertise within the ship design context.

Research problems solved

How do we integrate user-centric design and multi-disciplinary activity with passenger ship research and education?

Results

The programme's numerous studies – research on the modular ship concept from various perspectives and on business models for attending to new market areas, together with the creation of user-centric design approaches – have resulted in multiple new suggestions for passenger ship structure, functionality, business model, service design, and architecture. In addition, doctoral studies conducted within the programme have resulted in a strategic approach for collecting, analysing and implementing user experiences in ship design.

A multi-disciplinary study module, equal to 20 ECTS (540h), has been established in the programme, aiming to develop collaboration and communication skills between students from different disciplines in project-based courses. Although developed around passenger ship design, the programme can also be used for any other multi-disciplinary application.

Key publications

1. Ahola, M., Murto, P., Kujala, P & Pitkänen, J. (2014), Perceiving safety in passenger ships –User studies in authentic environment. Safety Science.
2. Ahola, M. & Salovuori, H., to be published, Actor Networks of Cruising Experience. Journal of Travel Research.
3. Ahola, M., Romanoff, J., Kujala, P., Remes, H. & Varsta, P. (2011), Cruise and Ferry Experience – program for Future Passenger Ship Designers. Proceedings of the International Conference on Education and Professional Development of Engineers in Maritime Industry, December 7th–8th 2011, Newcastle, UK, pp. 35–40.

4. Kauppi, A. (2012), m²cell concept -an interchangeable module system for cruise ship hotel space, Aalto University School of Arts, Design and Architecture, Helsinki.
5. Parmasto, O. (2012), Mechanics of the passenger ship structure with non-longitudinal-load-carrying accommodation decks, Aalto University School of Engineering, Helsinki.

Number of publications: 29
Number of Master's Theses: 16

Networks and international co-operation

The programme is part of the Nordic Five Tech Master's education programme, where its responsibility is to offer education on passenger ships for international students. The multinational research has been published in international publications.

Applications & impact

The industry need for educated professionals capable of working in a multi-disciplinary project environment has led to the establishment of a new programme for research and education on passenger ship design. The programme is multi-disciplinary, taking account of design, economics and technology. Students learn to communicate and act in a community of people from different backgrounds. The concepts created as student work are extremely innovative and well received by the industry. The developed approach has received extremely positive feedback internationally among marine technology education and other disciplines. Learning under the programme has also been reported as a positive experience.

The programme is closely related to the industry, keeping research topics current and beneficial for both academia and industry. By their very nature, the research and research topics are in the form of a forecast, and evaluation of the real impact of the results lies in the future. In the meantime, the programme will shortly extend to doctoral education. Teaching facilities will also be modified for project-type working, one outcome being the inclusion of Virtual Prototyping.

Future Accommodation System

New markets for the cabins industry

STX Cabins has found promising new markets worth tens of millions of euros annually. The new market areas are in hotels, flats, trains and refurbishment of passenger vessels.

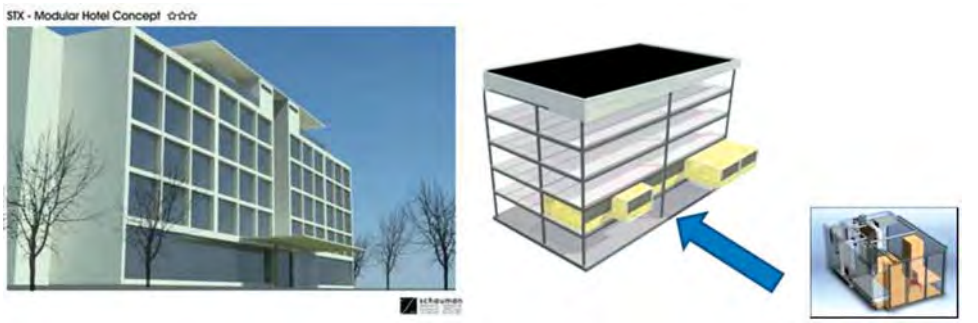


Figure 1. **Modular hotel concept**

The modular hotel concept is a comprehensive package for modular building. The concept combines conventional building methods, using steel frame and concrete slabs, with modular accommodation rooms. The focus is on hotels in the lower middle-class range, where price level and execution time are especially critical.

One of the most interesting applications is in old office buildings, which can be converted into hotels or student houses. In Central and Western Europe the business potential is over EUR 100 million within the next 5 years. Accommodation for athletes at Olympic Games sites can also be built quickly and economically using the concept.

Several technical panels were developed for use in refurbishment of bathrooms in passenger vessels. The panels are feasible in many other applications, such as offshore accommodation units and trains.

Figure 2. **Technical panel wash basin**

Figure 3. **Technical panel toilet seat**

Figure 4. **WetRef Vanity Unit**

There is significant potential for refurbishment projects implementing the Vanity Unit or Wet Ref solutions. For instance, currently over 100,000 ship cabins are in the age range 11–20 years, and over 60,000 in the age range 21–40 years, and therefore facing the need for refurbishment. In offshore structures, the value of refurbishment projects has already exceeded the value of newbuildings. The oldest rigs were built in the 1960s and are now in need of an extension of life span. One Wet Ref delivery project is currently in progress at STX Cabins.

PROJECT NAME
WP 8
Design Drive

Task 6

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
KARI HENTUNEN	STX FINLAND CABINS OY	2009 – 2011	0.098 MILLION

Future Accommodation System

Main targets & motivation

The original objective of the project was to identify the needs of future cruise passengers, with portfolio analysis and passenger segmentation as the intended methods. More specifically, the aim was to identify new possibilities for services, i.e. usability of the cabins, in order to develop new generations of passenger vessel cabin concepts. In the course of research work, however, the shipbuilding aspect was reduced, with increased emphasis placed on finding new market areas e.g. in hotels, flats, trains and refurbishment. The target here was to identify the trends and possibilities for modular accommodation in different business areas. Special effort was put into developing solutions suitable for trains. The success of new solutions was to be demonstrated with mock-ups, either physical or virtual.

New and improved applications for modular cabins and accommodation systems were developed as a result. The project also provided an opportunity to make a comprehensive market study, identifying new possibilities and analysing the solutions in a wide variety of accommodation in all types of vehicles, such as trains, aeroplanes, yachts and trailers. Finally, new products for the market were anticipated.

The research problem consisted of finding ways of improving and expanding the use of modularity in cabins, hotel rooms and bathrooms within the perspective of new business opportunities, serviceability and sustainable solutions. A further problem for research lay in how to implement current common shipbuilding solutions in other business areas, incorporating lessons learnt from current trends e.g. in hotel solutions.

Results

The study of the history of cabin concepts finally resulted in two new concepts: Future Cabin and Retro Cabin. Future Cabin answers the question: What features could cabins have in 20 years from now? Retro Cabin, embodying a historical perspective, brings back the luxury and comfort of "old times". A virtual mock up was made of these concepts.

An important result of the R&D work was the introduction of three patent applications: one for a cabin installation method, a second for a new concept of bathroom design, and a third for an integrated cast mould for the cabin.

The modularity and exchangeability of cabins was improved remarkably by a train toilet development phase involving the introduction of technical panels for wash basin and toilet. Further development of the technical panels included a highly modularised WetRef shower toilet cabin and vanity unit modules. A solution in response to the demand for refurbishing old office buildings is the modular hotel concept for building low- and mid-range hotels, as well as dormitories using existing building frames and modular cabins.

Figure 1. **WetRef**

Key publications

1. Theses for cabin installation (to be published)
2. Final report: Activities and results of WP 8 Task 6 Future Accommodation system

Number of publications: 2
Number of patent applications/patents: 3/1

Networks and international co-operation

The work was realised in-house.

Applications & impact

The results will be implemented in various cruise liner, refurbishment and construction projects; in the case of the removable ceiling, for example, as soon as possible, in the next cruise liner project. Further research will be carried out on a new version for fire category B-15. There is potential for using the solution in all future cruise liners and car ferries.

Commercialisation of the results looks bright. It has been estimated that within the next 5 years the potential for new solutions in hotels, apartments and student houses is:

- In the Netherlands 15,000–20,000 units for student houses and hotels
- In Norway 5,000 units for hotels
- In Finland 1,000 units for hotels and renovation projects
- In Russia evident potential in onshore-projects, to be further specified.

Total business potential is approximately over EUR 100 million. Furthermore, there is significant potential for refurbishment projects implementing the Vanity Unit or Wet Ref solutions. Regarding ship cabins, for instance, currently over 100,000 are in the age range 11–20 years, and over 60,000 cabins in the age range 21–40 years, and therefore facing the need for refurbishment. In offshore structures, the value of refurbishment projects has already exceeded the value of newbuildings. The oldest rigs were built in the 1960s and are now in need of an extension of life span. One WetRef delivery project is currently in progress.

The results achieved have had a great impact on the competitiveness of the company.

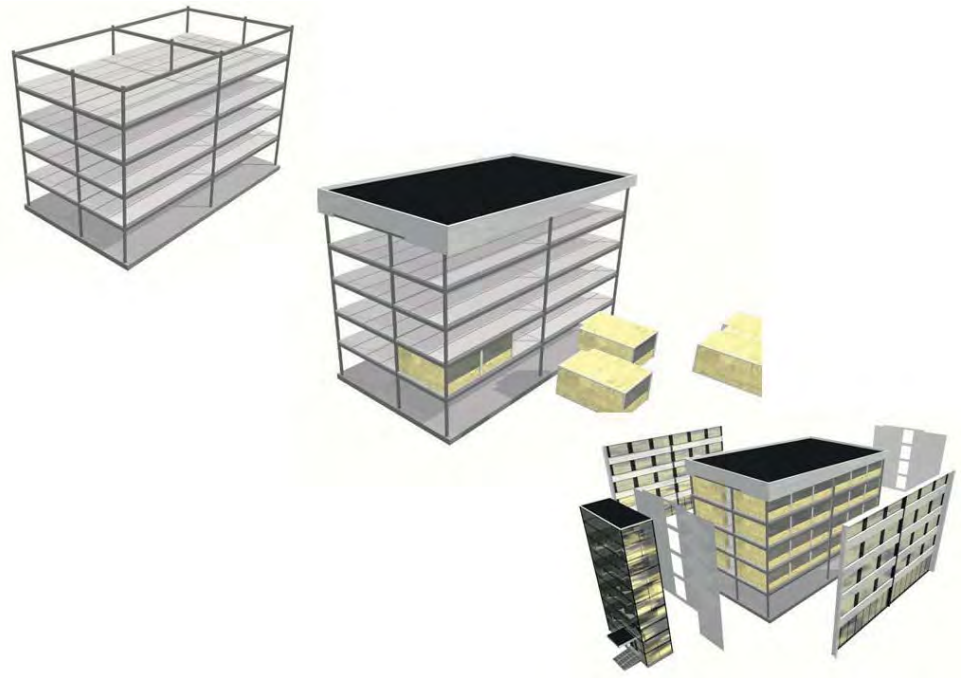


Figure 2. **Modular hotel concept**

Innovation and Engineering Maturity

The Finnish marine industry needs methods for measuring and improving the collaboration potential within dynamic design and engineering networks

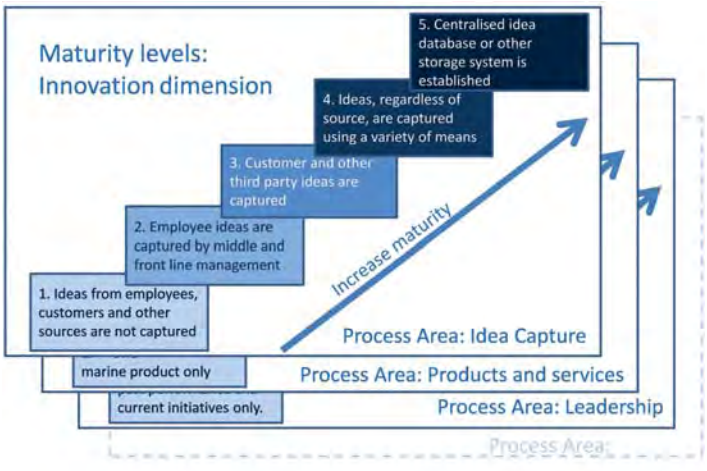


Figure 1. **Your Innovation and Engineering Maturity – Measure and Improve**

Main Results

An Innovation and Engineering Maturity Model for Marine Industry Networks (IEMM).

The developed methodology and free-of-charge IEMM tool can be used by design and engineering companies to

- determine their current maturity innovation and engineering level
- benchmark the maturity level, and monitor progress continuously
- set development targets, and identify a shared vision of development action.

Selected results highlights

1. The Innovation and Engineering Maturity Model for Marine Industry Networks (IEMM), consisting of

- 6 Dimensions
- 4–6 Process Areas for each Dimension
- 5 Levels of Maturity for each Process Area.

2. A user friendly MS-Excel application (the IEMM tool) to be used in companies:

- Current position
- Target position within two years.

3. Results are given graphically and as a "spider web" summary.

4. Reference Benchmarking values for the marine industry.

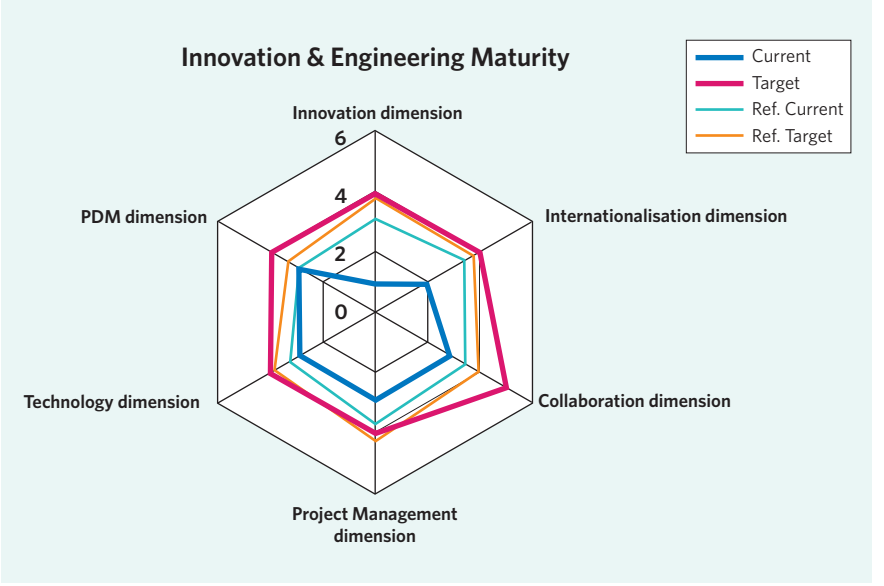


Figure 2. **Results as a "spider web"**

PROJECT NAME
WP 9
Competence Management

Task 1

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
KIM JANSSON	VTT TECHNICAL RESEARCH CENTRE OF FINLAND	2009 – 2012	0.194 MILLION

Innovation and Engineering Maturity

Main targets & motivation

The recent economic world recession and economic crisis has hit the European shipbuilding industry with full strength. Ship orders are scarce, and the yards and the industry now face major restructuring. The Finnish marine industry cluster is networked to a high degree, involving a large number of companies – many of them SMEs – with the local shipyards as the main customer. The companies must now search for international business, and develop their international business processes and delivery logistics operations. The company interviews conducted within the project confirm the opinion within the sector of the great importance of continuous development of innovative offerings to customers and their customers. Only the forerunners are capable of offering something new each time, and this calls for both technical and conceptual innovations.

The Finnish marine industry needs methods for measuring and improving the collaboration potential within dynamic design and engineering networks.

The overall long-term objective of the project was to develop approaches to support efficient operation in **collaborative design project environments** for marine industries. The objective of the research and development of the **Innovation and Engineering Maturity Model** is to deliver methods for measuring and improving networked design and innovation competence. The scope of the work is limited to engineering design projects, product development and innovation activities, and collaborative and networked engineering activities for marine products and services.

Results The Innovation and Engineering Maturity Model for Marine Industry Networks (IEMM) was defined based on company interviews, the state-of-the-art review and international collaboration.

The success factors of tomorrow can be summarised and grouped into:

1. Capability to offer solutions to new markets outside shipbuilding (**Innovation dimension**)
2. Having the courage to act globally, being present in the market close to the customer (in practice, going to Asia) (**Internationalisation dimension**)
3. Networking and collaboration in efficient supplier relations (**Collaboration dimension**)
4. Improving the designers' project management skills and capabilities in supervision of work, and awareness of costs and consequences (**Project Management dimension**)
5. Superior technical knowledge and quality of engineering, and taking environmental issues into consideration (**Technology dimension**)
6. Knowledge management (**PDM dimension**)

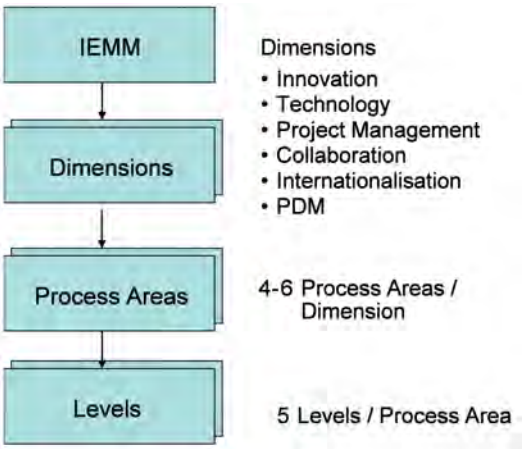


Figure 1. **IEMM structure**

A web questionnaire consisting of 59 questions was established with this model structure. The companies are asked to position themselves for each process area 'Today' and 'Where you want to be in two years from now'.

The questionnaire was then developed further into a user friendly MS-Excel application (the IEMM tool) to be used in companies). The questionnaire results are used as reference values and benchmarking, and are given graphically and as a summary "spider web".

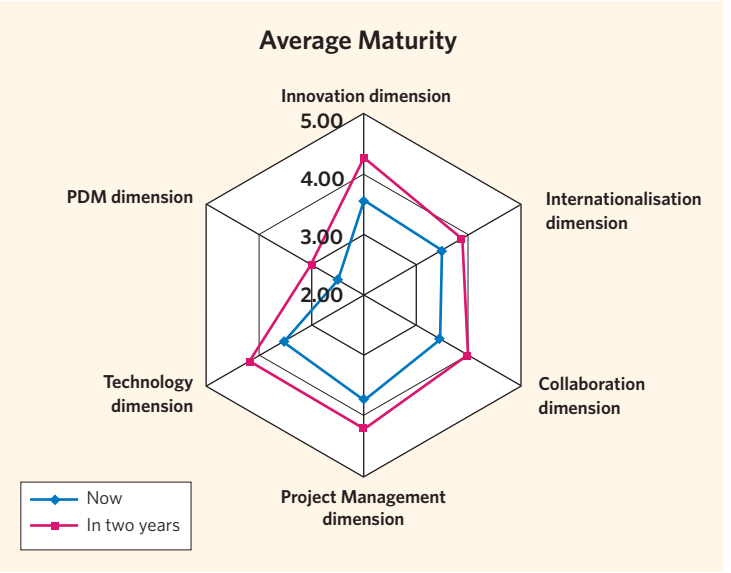


Figure 2. **Results graph with current and target values**

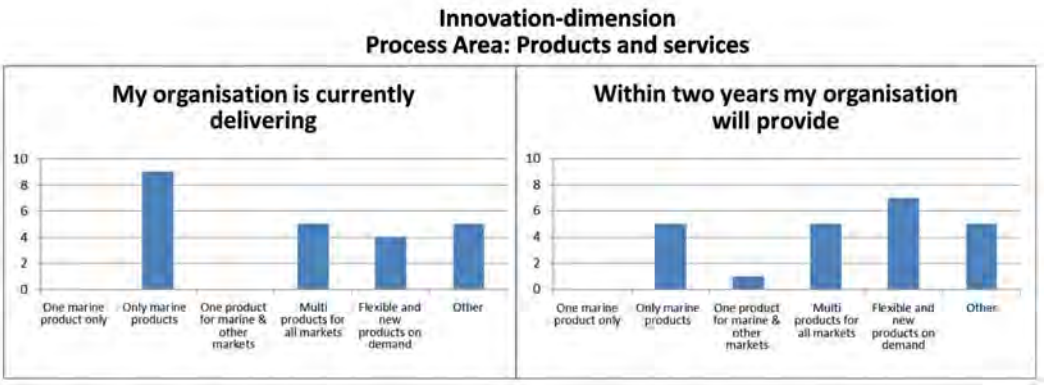


Figure 3. **Current and target values for Innovation dimension, Process Area: Products and services**

Key publications

1. Jansson, K. (2011), An Innovation and Engineering Maturity Model for Marine Industry Networks, ICCAS.
2. Jansson, K. (2011), Developing and using an Innovation and Engineering Maturity Model to Identify Competence Development, PROVE.
3. Jansson, K. & Mattila, V-P. (2010), Innovation and Engineering Maturity Analysis – Increasing Preparedness in the Finnish Marine Cluster, ICE.
4. Määttä, H. (2011), The Challenge of the Retiring Workforce, an Overview of Knowledge Transfer Methods, Report.
5. Mustonen, H. (2011), Knowledge elicitation methodology to transfer operative contexts – CASE: The ship industry, Report.

Number of publications: 5
Number of Master's Theses: 1

Networks and international co-operation

Co-development of Maturity Models with Tecnalia, Bilboa Spain in the EU Project COIN (Enterprise Collaboration and Interoperability). http://www.tecnalia.com/

Applications & impact

The developed methodology and free-of-charge IEMM tool can be used by design and engineering companies to

- determine their current maturity innovation and engineering level
- benchmark the maturity level and monitor progress continuouslyset development targets and identify a shared vision of development action.

PROJECT NAME
WP 9
Competence Management

Task 2

Innovation Meeting Process Management

The transition to globally distributed engineering work also requires a shift to project collaborative working methods and communication: participating and contributing asynchronously to project decision-making – independent of time and location.

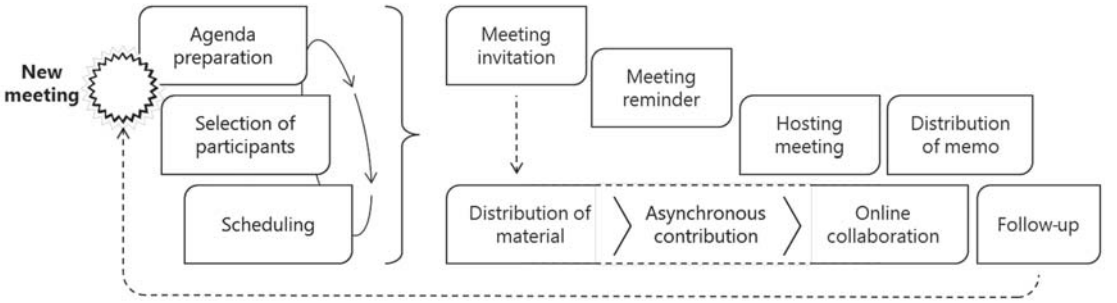


Figure 1. **The figure illustrates the identified long meeting process, extending from planning all the way to finalisation**

Main Results A pilot demonstration implemented on the FIMECC portal, demonstrating project meeting process management using solutions from Inno-W Oy.

Selected results highlights

Pilot demonstration

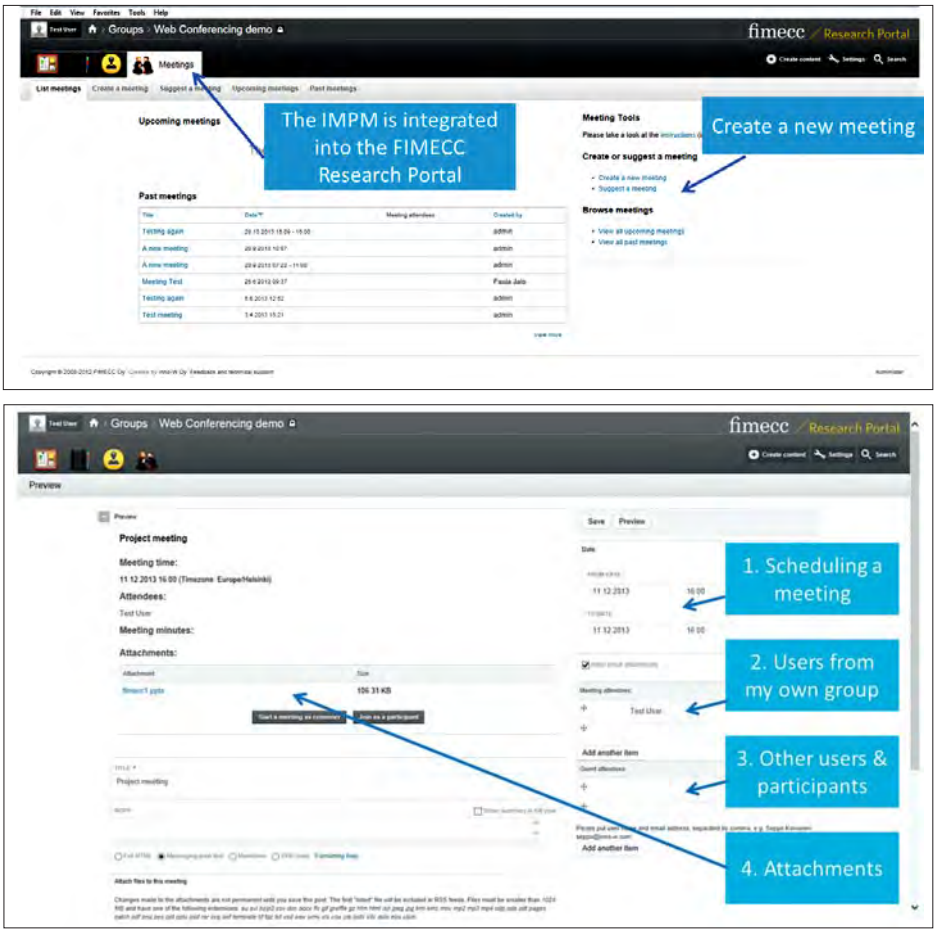


Figure 2. **A pilot demonstration implemented on the FIMECC portal (Inno-W)**

Industry comment

The first feedback has been collected through trial cases between offices in Finland and China. The feedback includes:

- The tool on the FIMECC portal is flexible and provides easy access.
- The user is bound to the Inno-W tools and thus cannot use any of the preferred tools possibly already in use at the company, e.g. MS Lync®, Doodle. (Inno-W tools can be integrated and collaborate with MS Lync and other widely used office tools intentionally left out of the scope of the demonstration. This condition was investigated from the process viewpoint).

There were challenges in implementing the open process, mainly due to information exchange between systems that were not designed to collaborate with each other. Contrary to our original vision, a semi-modular approach was then selected to ensure continuous information flow. Only the meeting invitations and reminders were integrated with email systems, leaving selection of the online meeting tool to the meeting organiser. The system has its own online meeting tool that naturally can also be used.

PROJECT NAME
WP 9
Competence Management

Task 2

CONTACT PERSON
KIM JANSSON
VTT TECHNICAL RESEARCH CENTRE OF FINLAND

PARTICIPANTS (ORGANISATIONS)
VTT TECHNICAL RESEARCH CENTRE OF FINLAND
INNO-W OY

PROJECT DURATION
2013

PROJECT VALUE (EUR)
0.093 MILLION

Innovation Meeting Process Management

Main targets & motivation

Innovation, engineering and design projects are often globally distributed, and involve participants from various geographical locations, time zones and latitudes. Occasionally, not all required participants are able to attend project meetings at the same time. The different latitudes bring variation in the participants' national and local habits with respect to regional holiday patterns. The opportunity to contribute to project management decisions beforehand should therefore be provided. Participants should be able to contribute asynchronously to the meeting – independent of time and location.

There is a need to develop services for the management of these asynchronous and long meeting processes. The meeting process can extend from the planning of the meeting all the way to finalisation – e.g. from agenda preparation to scheduling, through the meeting itself and on to the distribution of meeting minutes and follow-up (figure 1, page 215) Several commercial, free-of-charge and open source software applications and tools are available for each of these steps in the meeting process. However support for overall process control is missing, tool selection uncontrolled, and control and follow-up of meeting progress missing or poor.

Results

To tackle the above-described industrial problem and experienced pain points, the project has further developed the prototype version of a Project Meeting Process Management service that was implemented and industrially evaluated in the EU-funded research project. Based on the experiences and user feedback

the second prototype, the Innovation Meeting Process Management (IMPM) has been implemented in the Task.

Different types of project meetings involve a varying number of mandatory and optional meeting process steps. Figure 1 illustrates typical meeting types used in management of distributed projects. Each step can be supported by a number of IT tools such as teleconferencing, event scheduling, automatic agenda and memo generation, document repositories, document sharing, wikis, application sharing, social media, and many others. It is, however, up to the project organisations to choose the tool most preferable and suitable for each of the steps. What is needed is an overall control and management of the whole meeting process.
With the above-described background, the second implementation of the meeting management service was completed in the FIMECC I&N programme. The software was developed by Inno-W Oy, a company specialised in implementing service concepts, processes and work practices that combine modern methods of communication, intelligence of collaborative networks and online information.

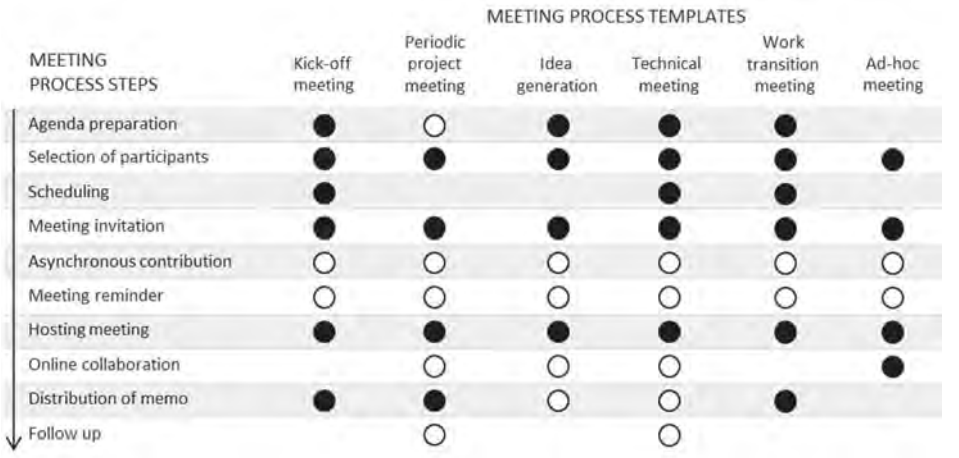


Figure 1. **Mandatory and optional meeting process steps – the black dot indicates the 'mandatory', white 'optional' and blank 'not required' step for the given meeting type**

Key publications

1. Jansson, K., Uoti, M. & Niinimäki, K. (2013), Management of Asynchronous Project Meeting Processes. Proceedings of eChallenges, e-2013 Services and logistics, 9–11 October 2013, Dublin, Ireland.
2. Uoti, M., Jansson, K. & Niinimäki, K. (2013), Managing Long and Asynchronous Project Meeting Processes. Proceedings of Virtual and Networked Organisations: Emergent Technologies and Tools – ViNOrg'13, 20–22 December 2013, Póvoa de Varzim, Portugal.

Networks and international co-operation

The first prototype version was created in COIN, an integrated project funded by the European Community under the 7th Framework Programme (Grant Agreement Number 216256). The consortium consisted of approximately 20 partners. Core co-operating were Pöyry Forest Industry Oy; Txt e-Solutions, Milan (Italy); BIBA – Bremer Institut für Produktion und Logistik Gmbh (Germany); SINTEF (Norway); ATOS Origin, Madrid (Spain); Siemens (Austria); Vienna University of Technology (Austria).

Applications & impact

The developed solutions have some identified minor drawbacks, as well as limitations. The IMPM project participants are nevertheless convinced that development and research work is on the right track. The forthcoming efforts to deliver a combination of the two approaches will lead to a commercial innovative solution that will fulfil the needs of global engineering companies and their requirement for management of long and asynchronous meeting processes.

First Principle Criteria for Sustainable Development

For a better future, act sustainable

The competitiveness of maritime solutions in the global markets of the future will be more dependent on their sustainability. The coming generation of innovations are compelled to be greener, cleaner and safer. Future markets will emphasise the importance of direct and indirect impact and values of maritime solutions in terms of sustainability.

The starting point for sustainable development is the setting of principle criteria. Criteria for measuring sustainability of existing solutions, analysis of the current level, and goals for sustainable development will all become mandatory from the beginning. Acknowledging the current sustainability level and setting the level of ambition enables the forming of a visionary strategy for clean, green and safe innovations.

Competitive edge derives not only from innovations but from development of an efficient innovation process and business methods to manage the requirements.

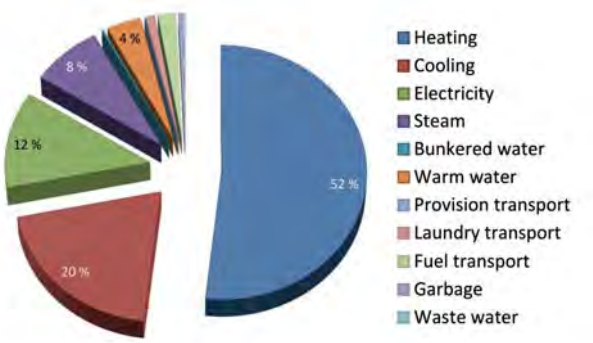


Figure 1. **Carbon footprint distribution of the passenger ship's hotel operations**

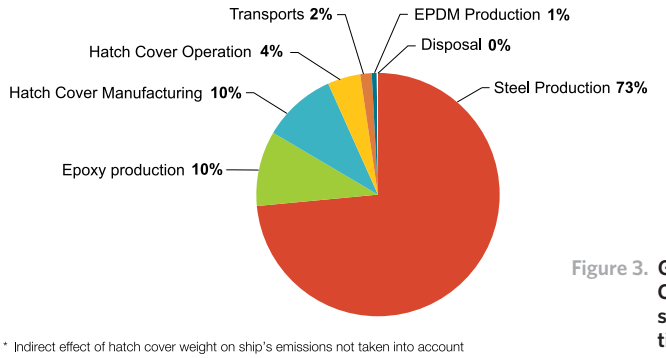
As an example of results in this task, research provided detailed information on the parts of the life cycle phases of a product that most affect the product's energy consumption and emissions. In the passenger shipping research theme, calculation was made of the carbon footprint of a cruise holiday, as well as detailing that of the passenger ship's hotel operations.

Green solutions make economic sense

More than 80 per cent of greenhouse gas emissions in hatch cover manufacturing are generated in the manufacture of materials, primarily steel. On the other hand, steel has the benefit of being fully recyclable when a vessel is decommissioned. Manufacture of a hatch cover generates about 12 per cent of greenhouse gas emissions across the product life cycle. Hatch cover operation generates only around six per cent.

Because the equipment manufacturer has very limited opportunity to affect emissions created during the manufacture of materials, development investments will be directed to where the greatest influence can be achieved: in other words, in developing sustainability of the cargo system and maximising the transported units per used energy, minimising the cargo losses, and improving the safety of equipment. It is clear that the future will bring ever stricter measures for protecting the environment, demanding the compliance of the shipping and shipbuilding industries. However, 'green' solutions are not merely ways of conforming to legislation, or improving a company's image – they make economic sense.

Figure 2. **Development of hatch cover sustainability: reduced use of energy through a more efficient cargo system**



* Indirect effect of hatch cover weight on ship's emissions not taken into account

Figure 3. **Global warming potential in CO2 eq. – direct emissions in side rolling hatch cover lifetime (25 years)**

PROJECT NAME

WP10 Safe Clean and Green Maritime Technology SEA GREEN

Task 1

CONTACT PERSON
KARI SILLANPÄÄ
STX FINLAND OY

PARTICIPANTS (ORGANISATIONS)
STX FINLAND OY
CARGOTEC FINLAND OY
ELOMATIC MARINE ENGINEERING OY
NAPA OY
AALTO UNIVERSITY

PROJECT DURATION
2009 – 2013

PROJECT VALUE (EUR)
0.403 MILLION

First Principle Criteria for Sustainable Development

Main targets & motivation

- Efficient design and engineering in the future will aim towards utilisation of clean and green methods, products, solutions and materials. While the main focus has been on reduction of emissions in daily operation, there has been less research of the whole life cycle of marine products, from raw materials production to disposal from service.
- The main target of this project was to assess the magnitude of different factors affecting a product's sustainability during its life cycle, in order to find the factors that could be rationally developed from the company's sustainability perspective and to formulate these as sustainability criteria.
- An additional target was to develop procedures for carbon footprint calculation.

Results

- Research provided information on which parts of the life cycle of different products is most affecting the product's energy consumption and emissions.
- In the passenger shipping research theme, calculation was made of the carbon footprint of a cruise holiday, as well as detailing that of the passenger ship's hotel operations. New electric balance calculation methods were also created that would take account of complicated passenger ship operation profiles and provide more realistic energy consumption instead of mere dimensioning.

- A specific research theme of hatch covers revealed that while the manufacture of a hatch cover generates about 12% of greenhouse gas emissions across the product life cycle, its use generates only around 6%. More than 80% of these emissions are generated in the manufacture of materials, primarily steel. Excluding the steel producer, and because the equipment manufacturer has very limited opportunity to affect emissions created during the manufacture of materials, the greatest influence can be achieved by maximising the transported units per used energy, minimising the cargo losses, and improving the safety of equipment.

Key publications

1. Kähkönen, T. (2010), The preliminary calculation of the carbon footprint of a cruise holiday, Master's Thesis, Tanja Kähkönen, University of Jyväskylä.
2. Kirsi Lehtilä, K. (2012), Carbon footprint of the ship's hotel operations, Bachelor's Thesis, HAMK University of Applied Sciences.
3. Parkko, T. (2012), Effect of Operation Area on a Cruise Ship's Electric Load Balance Calculation, Master's Thesis, Lappeenranta University of Technology.

Number of Master's Theses: 2
Number of Bachelor's Theses: 1

Networks and international co-operation

- Research and development work was performed in co-operation with several companies, universities and ship owners.

Applications & impact

- Detailed information on energy consumption and emissions at different phases of a product's life cycle, together with developed calculation methods, will provide the opportunity to influence the issues that are most relevant.

PROJECT NAME

WP 10 Safe Clean and Green Maritime Technology SEA GREEN

Task 2

Sustainable Breakthrough Innovations

Competitive edge in sustainable technologies with advanced engineering methods!

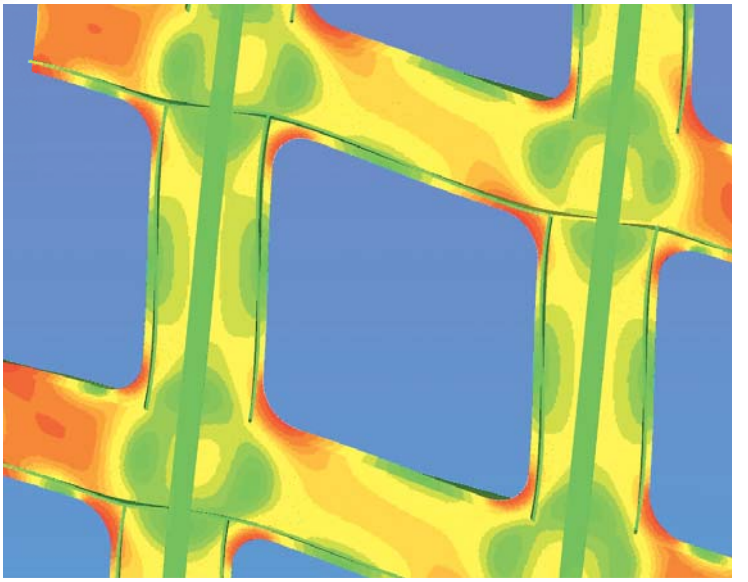


Figure 1. **Novel structures with high-strength steel**

An international breakthrough in the application of high-strength steel was implemented in a cruise ship in 2013. New lightweight structural solutions are needed in order to increase energy efficiency. A potential solution is the use of high-strength steel (HSS). The present rules, however, do not permit the use of HSS because of the existence of crack-like defects. To go beyond the current rules, the influence of surface integrity on fatigue strength was investigated and a post-cutting treatment developed suitable for industrial conditions. The experimental investigations for the large-scale specimens led to a novel class-approved ship structure.

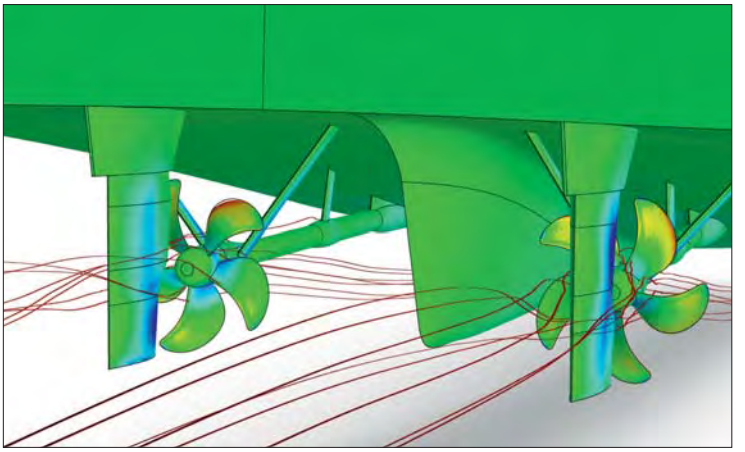


Figure 2. **Computational fluid dynamics**

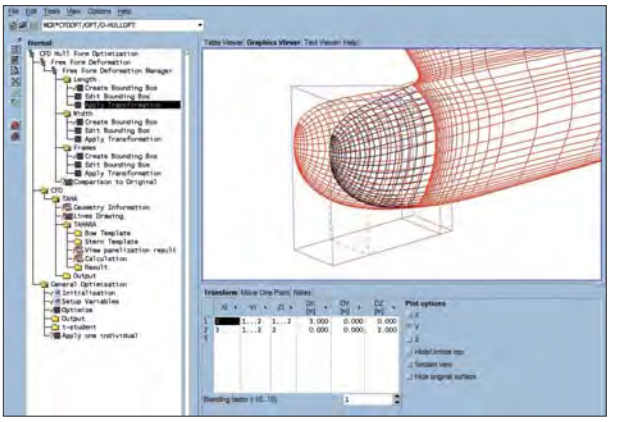


Figure 3. **Hull form modification tool**

Computational Fluid Dynamics

The design process is now faster and more cost-efficient following the introduction of a new Computational Fluid Dynamics (CFD) tool in the practical hydrodynamic design of ships. Research was guided by two simple principles: improved accuracy and a wide scope of problems investigated. Through the use of state-of-the-art simulation tools, significant improvements were possible in both respects. An extensive validation study by STX Finland on a range of existing ships indicated that the estimate for the bare-hull resistance obtained with a modern viscous flow solver is within 2–3% of the model test resistance. At the same time this made significant expansion possible in the range of problems that can be studied by hydrodynamic experts at the shipyard. Such problems include propeller-hull-rudder interaction, sloshing in swimming pools, and wind forces and wind comfort on passenger ships.

Through the research funded in this project, the use of a state-of-the-art flow solver has become everyday routine at the shipyard. The improved accuracy and flexibility has meant that design work is less reliant on model tests.

Hull form modification tool

NAPA have created a new local hull form modification tool which uses the Free Form Deformation (FFD) method for modifying the hull. The designer can use this tool to select smaller or larger areas to be transformed and the magnitude range (blending factor) for controlling the size of the transformation. The advantages of this method are parameterisation of the transformation for optimisation purposes, and retention of the integrity of the original surface. This is then combined with NAPA's CFD tool to set the design target and to judge the relative merits of the new hull variation, and still further combined with the optimisation to automate the work. Here the user is giving the parameters for the modification method and the parts of hull to modify, and setting the inputs, while the NAPA tool creates the desired number of variations and calculates with CFD automatically. To give an example, when using potential flow CFD and producing 250 new hull form variations, calculation took less than 6 hours with a common laptop.

In obtaining design variations using earlier methods the designer has had to modify the hull form and repeat the calculations manually after each new design. This not only takes time, but requires long-gained experience to understand the directions the hull form design should take: which part to enlarge, which to make smooth, and so on. The target of the NAPA Optimisation tool was to ease, and automate, the optimisation process and work flow of hull form design with a view to its use by ship designers generally.

PROJECT NAME

WP 10 Safe Clean and Green Maritime Technology SEA GREEN

Task 2

CONTACT PERSON
SAMI KOUVONEN
STX FINLAND OY

PARTICIPANTS (ORGANISATIONS)
AALTO UNIVERSITY
CARGOTEC FINLAND OY
NAPA OY
STX FINLAND OY

PROJECT DURATION
2009 – 2013

PROJECT VALUE (EUR)
3.340 MILLION

Sustainable Breakthrough Innovations

Main targets

- The main objective of this task was to reduce the environmental impact of a ship by introducing new innovative methods, technologies and material into the designs. The environmental impact, or its minimisation, has become one of the hottest topics in the marine industry. In most cases, the energy saving means increased revenue for the operator. The means to reduce energy consumption were divided into constructional weight saving, improved hydrodynamics, reducing emissions technologies and analysing and reducing total onboard energy consumption. A factor common to all is that more sophisticated analysis methods are required to reach these goals. This has resulted in two targets: more accurate estimation of the real-world performance of ships and ship-borne systems, and an ability to analyse more complex problems efficiently as part of normal design work.
- In terms of hydrodynamics the fundamental research questions have been: 1. Is it possible to integrate state-of-the-art viscous flow simulation tools into the everyday workflow of a hydrodynamics designer? 2. What kind of possibilities do these tools open up for hydrodynamic design?

Results

- New lightweight structural solutions are needed in order to increase energy efficiency. A potential solution is the use of high-strength steel (HSS). The present rules, however, exclude the use of HSS because of the existence of crack-like defects. To go beyond the current rules, this study investigates the influence of

surface integrity on fatigue strength, and develops the post-cutting treatments suitable for industrial conditions. The experimental investigations for the large-scale specimens led to an international breakthrough in the application of high-strength steel and a novel class-approved ship structure, implemented in a cruise ship in 2013.

- FE analyses are an important part of ship basic design, and results from global analyses are often needed at the early stage of the project. It is therefore essential to have powerful tools for generating a global model of the ship. A set of tools were developed to speed up and assist the modelling procedure. The developed tools allow the structures from general arrangement drawing to be used to generate geometry meshing for FE-analysis.
- A new method of FEM analysis was developed and validated. Modelling tools were made in Femap API. With the help of these tools the user can use the general arrangement drawing, extruding bulkheads and decks and setting girder and pillar locations, i.e. generating the geometry for meshing. Idealisation of the global model is also assisted by the tools. The user can define a set of grid points (normally frame and longitudinal) into which the generated geometry is automatically snapped. This enables FEM analysis to be carried out early, as soon as the sales phase of the ship project.
- STX Finland has successfully implemented a state-of-the-art viscous flow solver into their hydrodynamic design process. They have demonstrated through an extensive validation study that with this approach the bare-hull resistance prediction for existing ships of various types is within 2–3% per cent of the model test resistance. This is a significant step, compared to traditionally used tools that neglect the influence of viscosity, and cannot give a reliable estimate of the total resistance for a powering prediction in a ship project. The use of modern tools has also expanded the range of hydrodynamic problems that can be studied computationally at the shipyard. As examples, STX Finland has demonstrated the use of advanced CFD as a design tool for analysing propulsor-hull interaction, sloshing in swimming pools and wind forces on large cruise ships. NAPA's research on the user experience (UX) has resulted in an improved and more user-friendly CFD tool based on a viscous flow solver and associated user interfaces within the NAPA software package. A ship designer can now use the CFD tool, for example, to search automatically for a hydrodynamically optimal design, or to produce resistance curves for different trim and loading conditions.

Key publications

1. Remes, H., Korhonen, E., Lehto, P., Romanoff, J., Niemelä, A., Hiltunen, P. & Kontkanen, T. (2013), Influence of surface integrity on the fatigue strength of high strength steels. Journal of Constructional Steel Research, 2013; 89: pp. 21–29.
2. Romanoff, J., Remes, H., Varsta, P., Naar, H., Niemelä, A., Jelovica, J., Klanac, A. & Bralic, S. (2012), Hull/Superstructure Interaction in Optimised Passenger Ships. Ships and Offshore Structures, published online May 2012.
3. Avi, E., Lillemäe, I., Romanoff, J. & Niemelä, A. (2013), Equivalent shell element for ship structural design. Ship and Offshore Structures.
4. Hämäläinen, R. & van Heerd, J. (2013), Energy Saving Possibilities in Twin or Triple Propeller Cruise Liners, Third International Symposium on Marine Propulsors – smp13, 5–8 May 2013, Launceston, Tasmania, Australia.

Number of publications: 4
Number of Doctoral Theses: 2 started
Number of Master's Theses: 4

Networks and international co-operation

STX Finland Oy, Cargotec Finland Oy, Aalto University, Napa Oy Technical University Hamburg-Harburg, Centre of Maritime Technology (Hamburg), FIMECC Light programme

In terms of education, co-operation has been performed together with the Tallinn Technical University (TTU) and the Nordic Five Tech (N5T) university consortium (Aalto, Chalmers, DTU, KTH, NTNU). Students from TTU have completed their Master's thesis within the project as part of a double-degree master's programme at Aalto University. In addition, one master's thesis was completed as part of the new Nordic Master in Maritime Engineering programme and was jointly supervised by Aalto University and DTU.

Applications & impact

- *Many of the results have already been incorporated into normal practices.*
- *The use of high-strength steel in new applications is piloted in M/S Mein Schiff 3 & 4. Introduction of HSS in cruise ship structures subject to fatigue can be considered an international breakthrough.*
- *Previously laborious FEM tools have been used in the newbuilding project's basic design phase for optimisation work and vibration analysis. The developed FEM-tools enable simplified FEM-analysis as early as the concept design phase.*

- *The advanced CFD tools, taking into account the viscous effect of flow as well as hull-propeller interaction, have been used in the latest hull form designs following validation carried out in the design of M/S Viking Grace*. As a result of this project the designer now has more detailed and accurate information on the flow field to guide the design process towards more energy-efficient designs. At the same time, the tools provide accuracy comparable to model tests, but with more freedom to experiment. Thanks to the improved reliability of the predictions, the design work is less reliant on expensive and time-consuming model tests which have been necessary for confirming findings based on less reliable methods. The combined accuracy and the flexibility will also lower the threshold for studying radically different designs.
- *New design and analysis modules/tools will be included in commercial releases of the NAPA design environment*.

PROJECT NAME

WP 10 Safe Clean and Green Maritime Technology SEA GREEN

Task 3

Novel Environmentally Friendly and Safe Solutions

Competitive edge through responsible thinking!

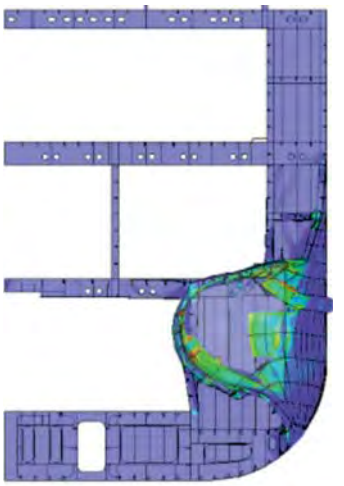


Figure 1. **Of all accident types, collisions and groundings may result in the most catastrophic effects**

The most important objective of the project was to ensure that the Finnish maritime cluster follows the development of safety and environmental trends carefully, and as far as possible leads this development in rational directions. As well as enhancing both safety and environmental aspects, this could also bring the cluster recognition as a leader in the development of new innovative approaches in these fields, while ensuring present market positions and facilitating new business opportunities.

Both procedures and tools for assessing and analysing ships' Safe Return to Port (SRtP) system capabilities were developed and refined by STX Finland and NAPA. The most visible outcome was the "SRtP Manager" software add-on introduced to the NAPA software. These tools and procedures were test driven in conjunction with analysis of the systems of the first large passenger ship built to full SRtP compliance – "Viking Grace" – a ship additionally spiced by its use of LNG as

fuel. It is fair to say that a considerable amount of engineering work could be consolidated, and several bad or erroneous designs spotted and prevented, at an earlier stage than is possible with more conventional design methods.

The NAPA software has incorporated the IMO's draft for the 2nd generation stability rules with multi-level acceptance criteria. This is very useful for shipyards and design offices using NAPA in their daily work. Study was made of methods for estimating the consequences to ship stability in case of collision or grounding, and a numerical simulation tool developed for predicting the sloshing motions of flooded water and the consequent impact on the progression of flooding through the openings. The simulation programme LaiDyn, developed earlier at Aalto University for predicting the motion of an intact ship, was used as a platform for implementing damage simulation methods. Model tests were planned and performed to validate the method, both for a ship flooding case and for internal sloshing in the compartment.

Implementation of the draft Intact Stability regulation in the NAPA programme and the research into simulation of the progression of flooding have given us valuable new tools and important new knowledge, enhancing our understanding of the phenomena of ship stability and subsequently allowing us to design and construct both safer and more efficient ships.

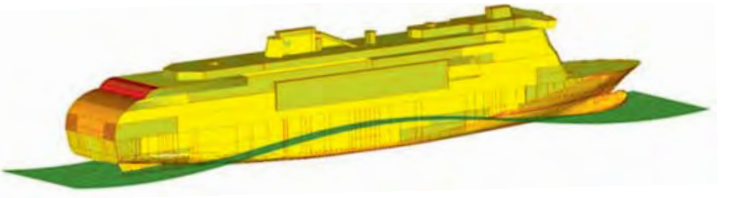


Figure 2. **Waterline variation in waves can have a big impact on the ship's stability**

Figure 3. **An illustration of the Safe Return to Port systems and the outlined logical model based on the 3-D data**

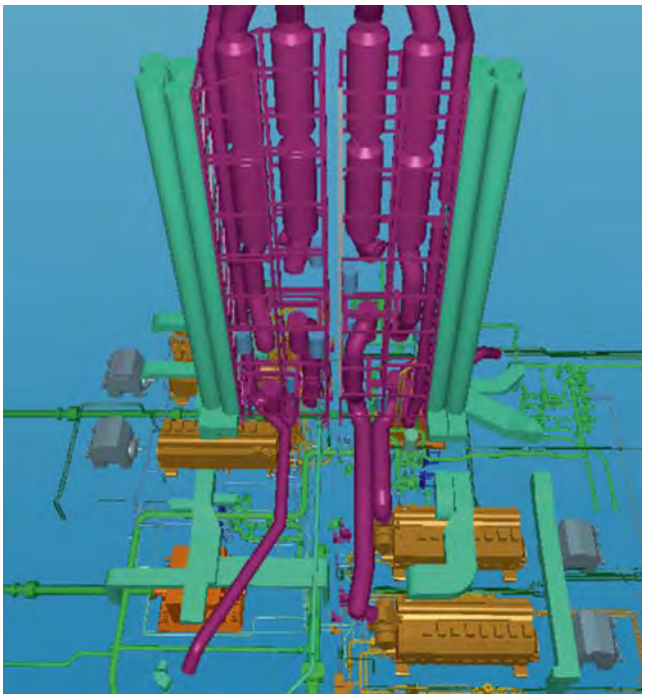


Figure 4. **Evaluation of a ship's SRtP capabilities requires analysis of the combined functions of several systems – a new and very complicated task**

Procedures were created in co-operation with the Finnish Transport Safety Agency Trafi to facilitate the industry's ability to give advice on the most efficient and practical ways of enhancing safety and on environmental considerations. In practical terms, we were able to voice the industry's positions in the IMO's Maritime Safety Committee as well as in the FP and SLF sub-committees. This opportunity has been of crucial importance especially with regard to four different fields: implementation and interpretation of Safe Return to Port and probabilistic damage stability regimes; development of new goal-based regulation schemes; development of energy efficiency requirements (EEDI) for cruise ships and ro-ro ferries; and last – but not least – being able to follow and take part in the course of official discussions and regulatory work following the "Costa Concordia" disaster.

Taking part in international forums has given us extremely valuable silent knowledge on the background of development regulation and standards. This in turn has given us both a step ahead in international competition and, especially, a firm foundation for even further development of our expertise. These can be regarded not only as having high (though difficult to measure) economic value, but as being the essential building blocks for any future business opportunities.

PROJECT NAME

WP10 Safe Clean and Green Maritime Technology SEA GREEN

Task 3

CONTACT PERSON	PARTICIPANTS (ORGANISATIONS)	PROJECT DURATION	PROJECT VALUE (EUR)
MIKKO ILUS STX FINLAND OY	**STX FINLAND OY** **CARGOTEC FINLAND OY** **NAPA OY** **AALTO UNIVERSITY**	**2011 – 2013**	**1.478 MILLION**

Novel Environmentally Friendly and Safe Solutions

Main targets & motivation

The most important objective of the project was to ensure that the Finnish maritime cluster follows the development of safety and environmental trends carefully, and as far as possible leads this development in rational directions. As well as enhancing both safety and environmental aspects, this could also bring the cluster recognition as a leader in the development of new innovative approaches in these fields, while ensuring present market positions and facilitating new business opportunities.

Safety and environmental regulatory frameworks are gradually becoming more and more complicated, as well as advancing towards goal-based approaches. This calls for new tools minimising routine engineering tasks, and for the searching and preventing of bad designs or even sheer errors. At the same time, the knowledge and skills of the personnel, as well as the whole approach to shipbuilding and operation, should be directed from mere compliance to prescriptive regulation or standards towards more pro-active attitudes and design methods.

Results

Both procedures and tools for assessing and analysing ships' Safe Return to Port (SRtP) system capabilities were developed and refined by STX Finland and NAPA. The most visible outcome was the "SRtP Manager" software add-on introduced to the NAPA programme. These tools and procedures were test driven in conjunction with analysis of the systems of the first large passenger ship built to full SRtP compliance – "Viking Grace" – a ship additionally spiced by its use of LNG as fuel.

Working procedures for co-operation with the Finnish Transport Safety Agency Trafi were created to facilitate information flows from the legislators to industry, and also to enable feedback and, especially, advice from the industry on the most efficient and practical ways of enhancing safety and environmental considerations. In practical terms, we were able to voice the industry's positions in the IMO's Maritime Safety Committee as well as in the FP and SLF sub-committees. This opportunity has been of crucial importance especially with regard to four different fields: implementation and interpretation of Safe Return to Port and probabilistic damage stability regimes; development of new goal-based regulation schemes; development of energy efficiency requirements (EEDI) for cruise ships and ro-ro ferries; and last – but not least – being able to follow and take part in the course of official discussions and regulatory work following the "Costa Concordia" disaster.

We were able to forward the topics of safety and environmental considerations as part of work within the Cruise Ship Safety Forum (CSSF), a co-operative body involving shipyards, major cruise ship operators and classification societies that is subordinate to the Cruise Lines International Association (CLIA). The forum works continuously to prepare guidelines for adoption as industry standards for both shipbuilding and operation.

IMO has introduced its draft for the 2nd generation stability rules that will have multi-level acceptance criteria. The first level includes simplified calculation methods, while the second level already requires detailed input and complex computations. The third level calls for accurate modelling of physics as it contains the solution for the motion of the ship in six degrees of freedom. Levels 1 and 2 have been included in the NAPA software as prototype applications. A method for calculating the unintentional motions of a ship in waves (called broaching) has also been outlined. Benchmarking and testing of levels 1 and 2 was performed in close co-operation with the IMO Correspondence Group members, in particular with the University of Trieste concerning the verification of implemented calculation methods. *Preparations for level 3 analysis have also been carried out in close co-operation between NAPA and Aalto University.*

Study was made of methods for estimating the consequences to ship stability in case of collision or grounding. A numerical simulation tool was developed for predicting the sloshing motions of flooded water and the consequent impact on the progression

of the flooding through openings. The simulation programme LaiDyn, developed earlier at Aalto University for predicting the motion of an intact ship, was used as a platform for implementing damage simulation methods.

Model tests were planned and performed to validate the method, both for a ship flooding case and for internal sloshing in the compartment. Flooding tests performed at the Aalto University showed the importance of the first transient roll motion at the start of flooding. Study of the impact of the initial stability of the model and the compartment layout revealed that for a compartment with lateral obstructions, such as non-watertight longitudinal bulkheads, the cross-flooding is slow, and a significant first roll to the damaged side takes place. For a completely open compartment the flooding equalises rapidly, and instead of a roll to the damaged side the first roll can be to the side opposite the damage. The simulation of ship dynamic behaviour under external wave excitations was validated against the model tests for an intact ship performed in the Aalto Marine Technology model basin.

Key publications

1. Manderbacka, T. et al., Model tests on the impact of the opening location on the water motions in a flooded tank with two compartments. Submitted to Ocean Engineering at 8 Nov. 2013, under review.
2. Manderbacka, T. et al. (2014), Sloshing forces on a tank with two compartments, application of the pendulum model and CFD. OMAE2014.
3. Karlberg, D. (2014), Modelling forces on large bodies in sea, Master's Thesis, Aalto University.
4. Manderbacka, T. et al. (2013), Influence of sloshing on the transfer of water between neighbouring compartments considering three different opening configurations, OMAE2013.
5. Manderbacka, T. & Penttinen, E. (2012), Transient Flooding of a Box Shaped Barge, REPORT, Aalto University.
6. Matusiak, T. & Stigler, C. (2012), Ship roll motion in irregular waves during a turning circle maneuver", STAB2012.

Networks and international co-operation

- Working with Trafi in the International Maritime Organisation's Maritime Safety Committee and its sub-committees, where open dialogue can be had with many flag state administrations and other key stakeholders

- Working with the IMO Correspondence Group on intact stability regulations, in particular the University of Trieste
- Working within the Cruise Ship Safety Forum, comprising major cruise ship operators (CCL, RCL, NCL, Disney), major European shipyards (STXFi, STXFr, MW, FC) and the leading classification societies (BV, DNV, LR, RINA)
- Co-operation with the Universidad Federal de Rio de Janeiro in Brazil to provide validation data model tests.

The industry need for educated professionals capable of working in a multi-disciplinary project environment has led to the establishment of a new programme for research and education on passenger ship design. The programme is multi-disciplinary, taking account of design, economics and technology. Students learn to communicate and act in a community of people from different backgrounds. The concepts created as student work are extremely innovative and well received by the industry. The developed approach has received extremely positive feedback internationally among marine technology education and other disciplines. Learning under the programme has also been reported as a positive experience.

The programme is closely related to the industry, keeping research topics current and beneficial for both academia and industry. By their very nature, the research and research topics are in the form of a forecast, and evaluation of the real impact of the results lies in the future. In the meantime, the programme will shortly extend to doctoral education. Teaching facilities will also be modified for project-type working, one outcome being the inclusion of Virtual Prototyping.

FIMECC Oy
Åkerlundinkatu 11 A, 33100 Tampere, Finland

FIMECC Factory, Tampere
Hermiankatu 1, 3rd floor, 33720 Tampere, Finland

FIMECC Factory, Turku
Lemminkäisenkatu 14–18 C, 6th floor, 20520 Turku, Finland

FIMECC Factory, Aachen
Mathieustrasse 30, 2nd floor, RWTH Campus, Aachen, Germany

WWW.FIMECC.COM

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