SMART MARITIME TECHNOLOGY SOLUTIONS

AN UPDATE: A STRATEGIC RESEARCH AGENDA FOR THE FINNISH MARITIME CLUSTER 2017–2025

Meriteollisuus
Finnish Marine Industries

Ministry of Economic Affairs
and Employment of Finland

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Meyer Turku Oy

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Finnish Marine Industries

The Vision

By 2025 Finland will have the most creative, agile and adaptive maritime network known from innovation of customised solutions, services and forms of operation delivered in flexible schedule and with competitive price.

These solutions and services consider the entire life cycle in a sustainable and digitalised setting, which makes the Finnish Maritime Cluster a global role model. The competitiveness and productivity of the network will be supported by long-term, multidisciplinary research and development work integrated strongly with education of future game-changers in a network of internationally recognised universities, research organisations and companies. The competitiveness will be based on high-level competence on integrating latest technology to specialised marine technology solutions and offshore applications including: energy, environmental and sustainability technologies; smart ships and systems; and competence services in the Finnish Maritime Cluster. This leap will happen due to collaboration between experts from different fields.

Picture: Rolls-Royce Marine

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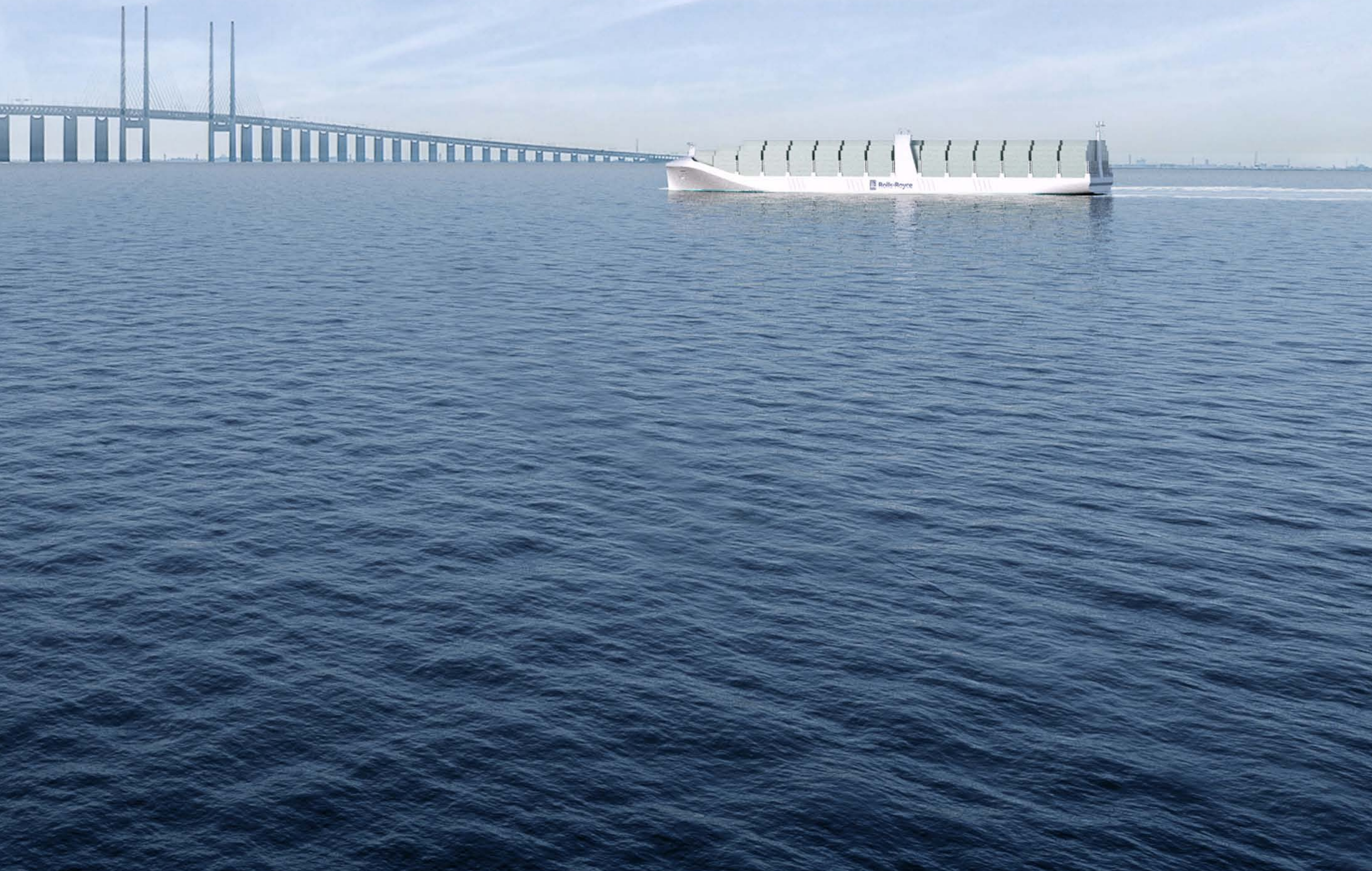


Forewords: Maritime Cluster is shaped by global megatrends

Picture: MacGregor Finland Oy

Global megatrends have a crucial influence on marine businesses. Factors affecting marine industry are growth of the world economy, population growth and unexpected changes in economy, political situation and nature. Climate change, availability of raw materials, food and water create demand for new solutions. Moreover, values of people have a stronger direct impact on their behaviour. Social responsibility and awareness of sustainability have increased as a customer value. The operational environment is changing in accelerating pace as information is distributed faster and the efficiency of all processes is required to be higher. It is significant to be able to adapt fast for the new kind of demands.

Market situation is currently affected by slow economic growth, low cargo and oil prices, which affects the new building business. At the same time cruise industry is booming when a new market in Asia is opening. Marine business is responsive to changes on operational environment, and the balance of the business has changed again. While preparing the Strategic Research Agenda 2025, the Finnish Shipyards' order books of new builds contain highly specialized cruise, ferry and Arctic ships. Meanwhile, the ship systems and equipment producers are keeping their position as segment leaders in global markets. However, shipyards in the Far East are now suffering from low number of orders, and these competitors are looking for new market segments. The low number of cargo ship orders is also challenging to the system and equipment producers. Due to these facts, it is significant to develop our products further, renew them and look for new emerging businesses.

Environmental technologies, digitalization of shipping and intelligent ships and products as well as utilization of oceans' natural resources are seen as necessities for growth. Automation and robotics will be game changers in the production of marine solutions. Circular economy is the rising practise for marine industry. Sustainable business has to use the "reduce, reuse and recycle" (3R) principle. In the future, this is the way to manufacture clean products. It is also important that the regulatory environment is predictable and adjustable, so that there are customers when the innovations arrive to markets. User experience and the needs of the end customer are crucial factors in the today's markets as well as a social responsibility. Safety and risk management are vital and taken in account in all development.

The future of the maritime cluster is seen to be directed by application of new energy sources, sustainable business models, usage of marine resources, international regulation changes, digitalization and automation. Some new opportunities might be found from usage of ocean resources, industrial symbiosis and new innovative ways to shape the production and service chains (Finland's maritime cluster: towards the 2020s, 2016). Sharing economy, collaborative consumption, a class of economic arrangements, in which participants mutualize access to products or services rather than having individual ownership, might create new opportunities and threats to marine industry. Scarce resources directed into RDI, loss of competence, political and economic instability and protectionism create threats for the competitiveness of the marine cluster.

The strength of the Finnish Maritime Cluster is its versatile markets in which the different sectors balance each other. One of the main tasks for the industry in the following years is making a controlled introduction of a new generation of experts to the branch. Investing in RDI and competence developments and sharing the tacit knowledge from experienced professionals are key issues to success. When world is changing fast, the competence gives companies tools to adapt.

Optimized cargo system is essential part of the most efficient container vessels.
Picture: MacGregor Finland Oy

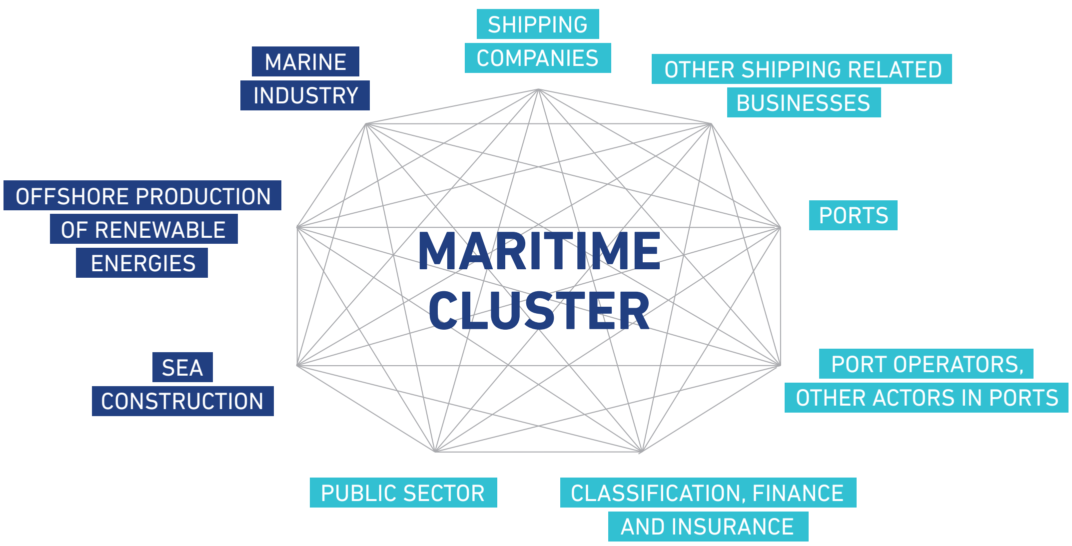
THE PURPOSE AND INTRODUCTION OF STRATEGIC RESEARCH AGENDA

The aim of the Strategic Research Agenda is to create a common vision that will lead to forerunning solutions and give value for customer and society.

The Strategic Research Agenda Smart Marine Technology Solutions has been released in 2014. The agenda is updated every 3 to 5 years as market situations and trends evolve. The agenda presented in this document is based on the work carried out during 2015-2016. The Research Committee of the Finnish Marine Industries has prepared an updated research agenda for the time period 2017–2025. The updated version highlights the themes that are seen vital today in order to achieve success in the maritime cluster. As of 2014, the turnover of the Finnish Marine Industry amounted to around €8 billion and 30,000 people were employed. Finnish Maritime Cluster turnover amounted to around €13 billion, and nearly 50,000 people were employed in maritime cluster operations. Competitive marine cluster creates significant amount of exports, and majority of Finnish trade is transported by sea.

The Strategic Research Agenda aims to identify the main themes and areas of research that the Finnish Maritime Cluster will need in the future. Furthermore, in this process, the industrial, academic and research networks work together to conclude the required skills, knowledge and competences. The members of the Research Committee include representatives from all branches of the Maritime Cluster, including shipyards, suppliers, ship owners, the Finnish Transport Safety Agency, the Finnish Navy, and other actors such as research institutes and universities. The agenda was created by seven task leaders who share long-term experience in the field of marine technology and who represent companies that have long-term impact on maritime network.

The Finnish Maritime Cluster includes marine industries, shipping, ports and port operations in private and public sectors



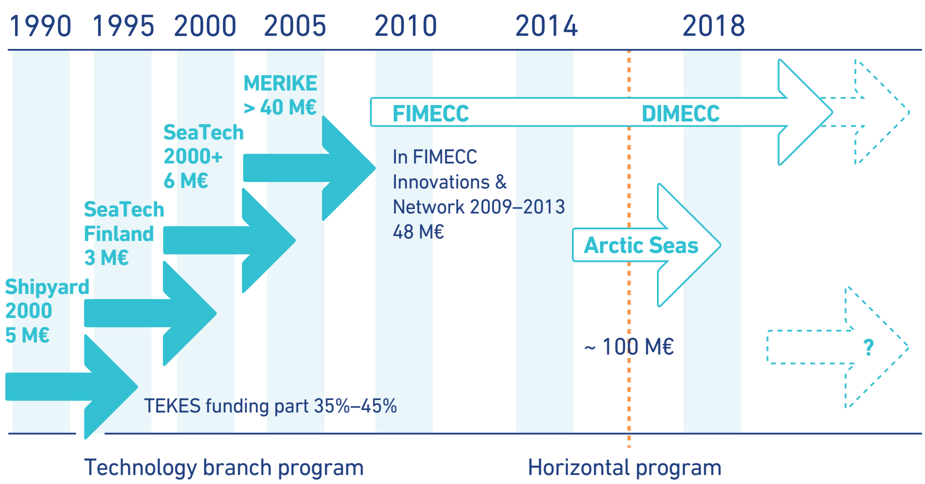
Achieving Vision 2020 and Further Steps Towards 2025

The industry has a long tradition of cooperation in RDI-activities. For instance, a number of TEKES-funded technology programmes have been on-going, starting from Shipyard 2000 (1991, €5 million) and continuing to MERIKE (2004–2007, €41 million). In 2010's, the Finnish Maritime Cluster participated in the Finnish Strategic Centres for Science, Technology and Innovation such as FIMECC (DIMECC from 2016, together with DIGILE SHOK) and the Arctic Seas Programme funded by Tekes (2014-2017, €100 million).

This strong continuation of development is a requirement for the competitiveness of the industry. As the research funding instruments are being restructured, the cluster adapts itself to the changing procedures by utilizing more strongly the EU framework programmes. This also means active participation in preparation of the work programmes.

The Finnish Maritime Cluster is an active developer both nationally and internationally.

National Research Programmes for Finnish Maritime Cluster



The national and international development programmes of the Finnish Maritime Cluster over the years.

THE THEMES AND THEIR IMPLEMENTATION

The agenda is organised into six tasks. Competitiveness and Competence theme starts the agenda and gives an overview on how the competitiveness of the cluster can be maintained and developed. The other crosscutting themes of the agenda are Energy, Environment and Sustainability, and Intelligent Ships and Systems. The product-specific themes are Cruise Ships and Ferries, Arctic Technology and Offshore.

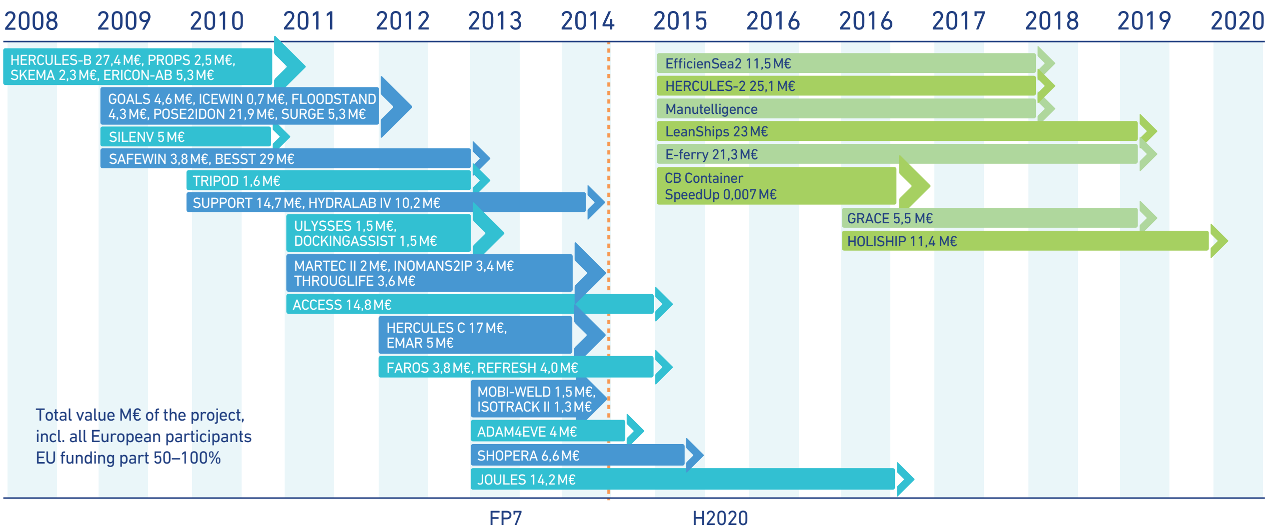
THE THEMES:

- **Competitiveness and Competence Development**
- **Cross-cutting technological segments:**
    - Energy, Environment and Sustainability
    - Intelligent Ship, Systems and Solutions
- **Specific product areas:**
    - Cruise and Ferry
    - Arctic Technology
    - Offshore

The objectives of the tasks include development of **new product or concept (0.5–2 years), integration of innovation (1–3 years)**, **application of innovation (3–5 years)** and **basic research (4–10 years)**; see Figure 2.

These tasks are integrated so that both long and short-term research is carried out at the same time. The key issue is to create an ecosystem in which RDI-activities are carried out with optimal consortiums and funding instruments. The activities are strongly integrated to regulation and competence development.

EU's FP7 & Horizon2020 -funded RDI-projects with Finnish maritime participants



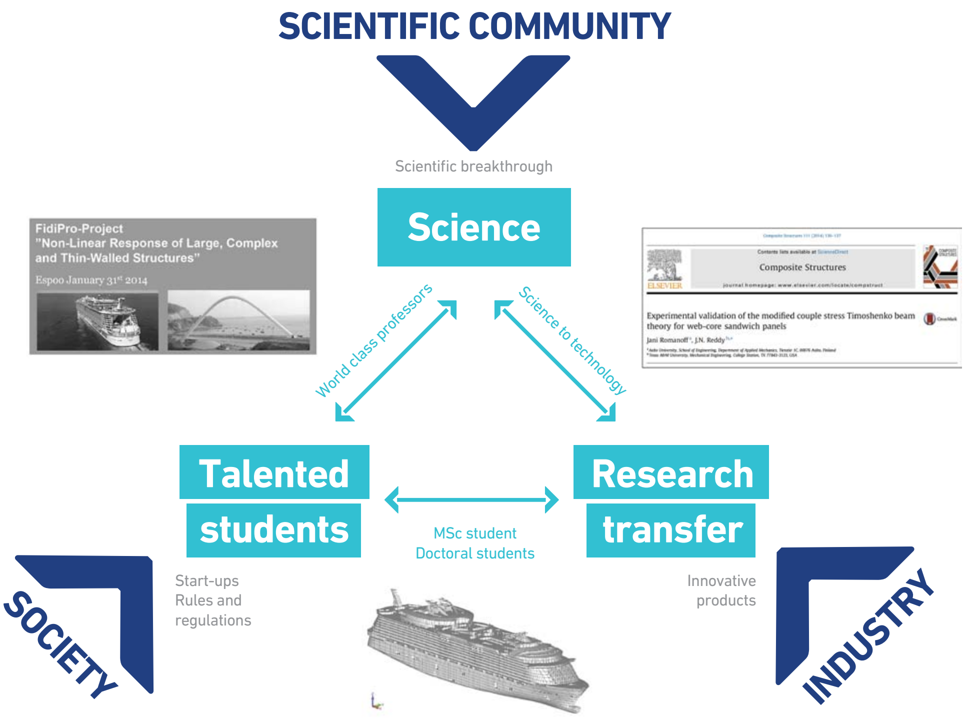
Competitiveness and competence development

Independent from the location of production, companies need to strengthen cost-competitiveness, refine their business behavior and better meet their customers' needs. Competence is a product itself. The global marine sector offers a variety of business possibilities in both existing markets and in totally new ones. The ability to establish the fundamental direction of a business through strategy and to further implement it through a business model and operational plan lies at the heart of business competence.

Picture: Elomatic Oy

Business development needs are largely connected to themes such as value-creation in networks, managing project-based operations, company offering and ecosystems of companies. Future research activities should both deepen academic understanding and provide companies with applied models and solutions to help them to grow and develop. Several key research areas can be identified both at the company as well as the network level. For example, maintenance and service business is becoming more important as society imposes greater requirements in relation to, for example, effectivity, sustainability, energy, and the environment.

The competence of the Finnish Maritime Cluster is high and needs to be further developed in order to outstrip its global competition – the competitors are constantly improving their competence level. Finland is and must be even more positive environment to develop skills and knowledge on various technologies, project management skills and life-long-learning among other relevant work-life competences. Finland is known for innovative concepts and services based on long-term education carried out both within academia and through supplementary courses and seminars on specialised topics organised by the industry.



Development of highly skilled professionals, new products and design approaches, regulations, rules and guidelines simultaneously in co-operation with industry, academia and authorities.

Highly Competent Education and RDI-Ecosystem

Ensuring that competent people receive the education they need is a critical issue. The problems the industry faces are becoming more and more complex, and their solutions require critical thinking and creativity, while the co-operation with experts from other disciplines and various levels of education is a must. This requires strengthening of the already-strong co-operation between industry and academia on development of education towards the needs of ever-changing society. Safeguarding the Finnish maritime research infrastructure is seen as essential in order to retain and further develop competences. Finland has globally unique laboratories and model-testing facilities, which need to be maintained and further developed using the latest experimental and computational techniques.

The imminent retirement of large numbers of personnel and increasing foreign competition are further issues faced by the maritime field, and these can be tackled by education and mentoring programmes inside the Finnish maritime cluster. Thus, the industry needs new competent people with new profiles. This requires both direct international recruitment and proven high-level international education. Finland needs to extend the long-term cooperation with other universities nationally and around the world to guarantee a wide spectrum of education for different fields of expertise. This applies for basic, postgraduate and supplementary education.

Developing education programmes between academia and industry should increase the number of Bachelors, Masters and Doctors of Science and Engineering entering industry. Co-operation between experts from different backgrounds is a must in order to cope with the complex demands of the future. Highly competent people with highly recognised academic capabilities can only develop the rules and regulations for the solutions as this process requires the creation of scientific evidence.

Training and post-graduate education that aims for high-specialization level on certain technologies (i.e. industrial and academic) are key elements in maintaining the edge over competitors. Professionals working in the Finnish marine industry have a wide spectrum of skills and knowledge based on the first principles of marine and other associated technologies. The allocation of qualified personnel is a crucial issue in the development of competence. In geographical terms, people need to meet where the products of maritime industry are manufactured. At the same time, education and basic research is carried out in universities and research organisations located elsewhere. This sets challenges for the system, as people are based in multiple locations. Information technologies and co-operative attitude in the network are believed to overcome these challenges. The competence themes of the products and services on the Finnish Marine Industry network are summarised below, also containing comments on these themes.

Efficient production of tailor-made products

A streamlined building process follows the optimization of network operations. This involves building models for the creation of network profit, risk, IPR-sharing, and cooperation models between network participants. New building processes create new businesses and vice versa. Thus, new building processes based on modularity in design and production should be developed as well as modern ICT-tools for production optimization and simulation. Moreover, automation and robotics are ways to make production process more efficient. In addition, advanced and lightweight materials and the development of new efficient and lightweight structures are important part of making the products more efficient. Utilization of new materials requires new approaches for the manufacturing process, as well.

Modern naval architects need to understand the wide spectrum of technical, design, economic and safety issues related to ships and offshore structures. At the same time they need to be able to assess highly specialised issues, such as the loads generated on complex structures by wind, waves and ice, and to assess their strength and dynamic response. They need to understand modern production technologies and networks and the relation of these to the final product. They need to be able to sell and carry out large-scale projects within the international environment. As the designs are novel, professionals need to be able to work beyond the existing rules and guidelines. This ability supports and further develops Finland's capacity to generate innovative concepts for the marine industry. New academic concepts, such as a systems integration approach, can be further investigated – especially in the shipbuilding networks – and hence support the productivity and optimization of the creation of network value.

THE VISION:
By 2025 Finland has the most competent, adaptive, agile and co-operative network of highly skilled people globally. It is a frontrunner at the current and emerging markets of marine technology.

New business models

Companies need to assess competitiveness from the business model perspective also. International operations and the globalization of the marine industry require companies to assess their business behavior and models in order to succeed in the international business environment. This is especially important in the major emerging markets. Upgrading the value network position is one emerging business possibility for many marine sector companies. This involves management of the change process from, for example, component provider to sub-system provider, from sub-system provider to solutions provider, or from solutions provider to asset management. The traditional form of exporting is challenged by market and political requirements to set up business units, joint ventures and other forms of business physically in foreign locations. Design, operation and maintenance related services for the entire life cycle of the solutions are emerging business opportunity for marine industry companies. Ship operators and shipyards require services such as route and operation optimization, market feasibility surveys and maintenance. Managing project-based business is a key

success factor especially in the marine business. Marine sector end products are usually complex products and systems, which have tight production, lead times, and involve a large supplier network. Thus, the project management skills and competences impact heavily on the success of a project. Moreover, companies operating in a project-based business environment need to find an effective business model to cope with challenges linked to variations in demand, capacity and profitability. These business models should be further investigated, assessed and developed.

Innovative construction, the Burj Al Arab Terrace development. Picture: Admares Oy

Emerging business & Blue Growth

The oceans are the planet's future and seen as one of the biggest untapped business area. Oceans are believed to be the only way to fulfill the growing needs for food, energy, water, organic and mineral resources, etc. There is a need to develop industrial activities at sea. Marine industry can provide engineering and technology solutions to support businesses willing to harness the economy of the sea. These businesses can cover areas as diverse as renewable energies, aggregate mining, shallow and deep sea mining, offshore oil and gas, interdisciplinary survey and research, logistics and ship repair, shipping, yachting and marinas, cruise tourism, coastal tourism, fisheries, maritime security, biotechnologies, desalination, aquaculture, fish-farming, etc.

The maritime cluster in Finland possesses strong basis for emerging businesses due to its adaptiveness and competence. It is important to be a forerunner at emerging business opportunities in which the marine knowhow can be applied. Start-ups have been part of the renewal process of the Finnish maritime cluster for decades, and as new technologies emerge, new start-ups will occur through integration of these new technologies to existing ones.

Foresight

Foresight and business intelligence play a role in the development of business models and in leading companies to adapt themselves agilely to changing business environment and trends. The Finnish Marine Industries aims to make foresight even more established and continuous activity for the whole industry.

Objective	INTELLIGENT SHIP, SYSTEMS AND SOLUTIONS	ENERGY, ENVIRONMENT AND SUSTAINABILITY	CRUISE AND FERRIES	ARCTIC TECHNOLOGY	OFFSHORE TECHNOLOGY
RDI topics for continuous development	• Increased level of internal digital capability (merged ICT- data & tools) • Increasing shared data between companies • Full-scale demonstrator of autonomous systems • Increased capability to derive customer value from data through a cross-disciplinary approach (techno-economical, etc.) • Increased IoT-capability to improve shipbuilding related processes over the entire value chain • Automation in production	• Self-sufficient vessel • Digitalization as tool for environment-friendly solutions and optimization • Renewable energies utilization (wave, tidal, solar etc.) • Electrification of ships, marine traffic and ports • Lifecycle assessment tools to optimise ship systems, ecosystem and supply chain	• More efficient shipbuilding and shorter build time with new cooperation models for network • Customised, energy-efficient and lightweight ships, compact and adaptive products with improved earning potential and added value for the customer • Safe ships with high levels of comfort • Ship concepts with new service and entertainment potential • Development of 3D-tools for design and manufacturing • Use of modular building in production of complex structures	• Creation of new business models and services for Arctic operations (e.g. IT-based services) • Inherently safe, comfortable and economical vessels for transport and offshore operation • Information services for Arctic operators; e.g. route planning, simulator modelling • New models for profit sharing and contracts in the network • Design methods to achieve solutions with low/no 'Arctic extra' cost • Reliable design methods using model-testing and simulation techniques	• Efficient and competitive value adding networks in Finland combined with the use of partners and existing infra in the target countries • Contract models for EPC-business • Weight-, cost-, energy- and time-efficient, sustainable offshore production solutions with enhanced safety • Remote support, control, maintenance, optimization (IoT) • Lifecycle business, modernization of systems and equipment to improve efficiency and comply with new regulations
New openings	• Step change opportunity in process efficiency (from within a yard or factory to the entire ecosystem) • New simulation tools for production process and shipbuilding method • Sharing economy - new business models • Robotics and full automation for shipbuilding • Regulatory framework for unmanned ships and goal-based design • Tools for optimization for entire fleet performance	• Sustainable shipbuilding and ship repair, circular economy: reduce, reuse, recycle • New energy sources: Hydrogen, Syngas, bio gas, Wind, Solar, Tidal, Algae, nuclear, fuel cells • Hydrogen generation	• New main structural concepts based on lightweight materials and structures • Development of intelligent management systems • Advanced production technology applications • Digital services and applications for cruise customers	• Creation of communication networks to the Arctic with applications • Remote controlled solutions for harsh conditions	• Multiuse offshore platforms • Concepts for specialized vessels for different Blue Growth activities • Underwater mining • Ocean farming • Floating energy storages • Floating living structures
Research & education	• Crew training for remotely operated ships • Ship prototyping simulation environment • New design tools considering the operational data • Virtual testing environment for new concepts • ICT-competence, data analytics & algorithms, cybernetics, artificial intelligence	• Development of hydrodynamics and propulsion in different operational conditions using virtual model tests • Lifecycle assessment tools for ships • Energy management in oil and gas production	• Continuous studies of emerging operation areas, markets and consumer trends • Cost- and weight-effective main structural solutions using new materials and structures; e.g. steels and composites and related cost-effective production methods • Development of strength analysis and CFD-methods along with laboratory testing	• Geo-economic analysis and forecasting of transport patterns • Value chain analysis and understanding • Development of risk models for Arctic operations • Methods in ice-water-structure interaction	• Value chains and business success factors in offshore industry • Risk-based tools for HSE-analyses • Ice pile-up around and loadings on offshore structures • Mathematical modelling of ice fields • Full-scale Arctic testing environment (Arctic Center of Excellence)

Summary of the strategic research themes for competitiveness and competence

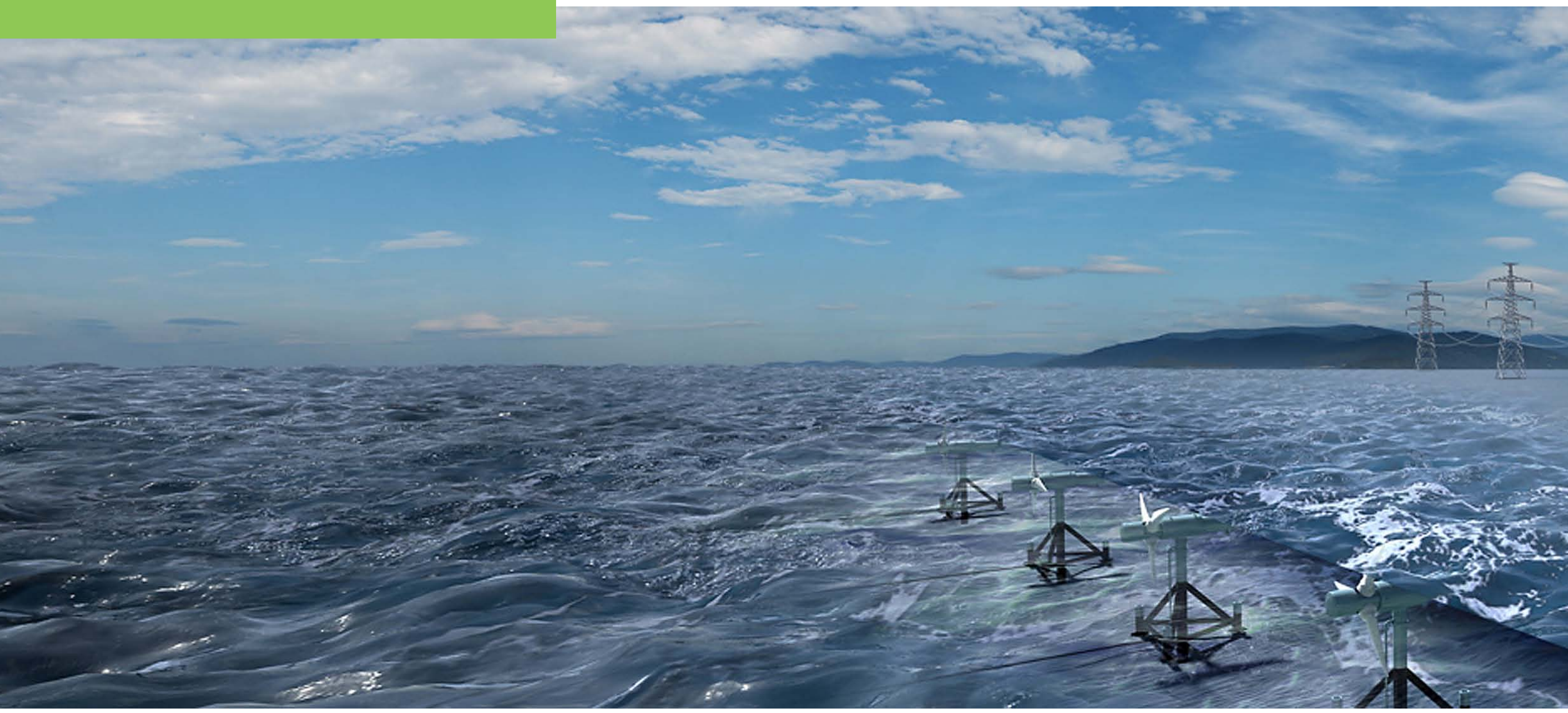
The B.Delta Series represents true eco design in bulk carriers. Picture: Deltamarin Oy

Energy, environment and sustainability

Energy use, sustainability and environmental issues affect all fields of marine industry and all communities. The requirements set for marine technology are becoming increasingly strict. Further research is needed within the industry on issues such as new energy sources (gases, methanol, ethanol, emulsions, condensates, renewables, bio-based etc.); power-generation flexibility (operations, multi-fuel, combustion concepts, transient control); recovery of energy from on-board systems; energy storage; and emissions (gases, particles, noise) and their reduction and energy economics. In addition, performance, maintenance and emissions management need to be improved by operational profiles; reliability prognosis; identification of parasitic losses and fault diagnostics; retrofits and turbo-compounding. The future vision is that maritime would be free from fossil fuels.

THE VISION:
The objective of the Finnish maritime cluster is to produce the cleanest energy solutions in ships and to minimize the environmental impact of shipping globally.

Zero-emission and self-contained ship means that the ship's energy usage and emissions should be constantly decreased through development of its transport efficiency by minimising its own weight and resistance to waves and ice (hull surface and shape, propulsion systems); enhancing energy production systems (diesel engines, fuel cells, nuclear); storage (fuels, batteries etc.) and recovery systems; improving waste material treatment and recycling on and off-board; and by reducing NO_X, SO_X and CO_2. Energy management by information technology has become important future direction of development. Ship systems should be optimised in a design stage for service, holistically to achieve minimum energy usage and emissions in fleet and individual ships. This also means that during ship operation, the systems can be upgraded for better performance according to changing needs.



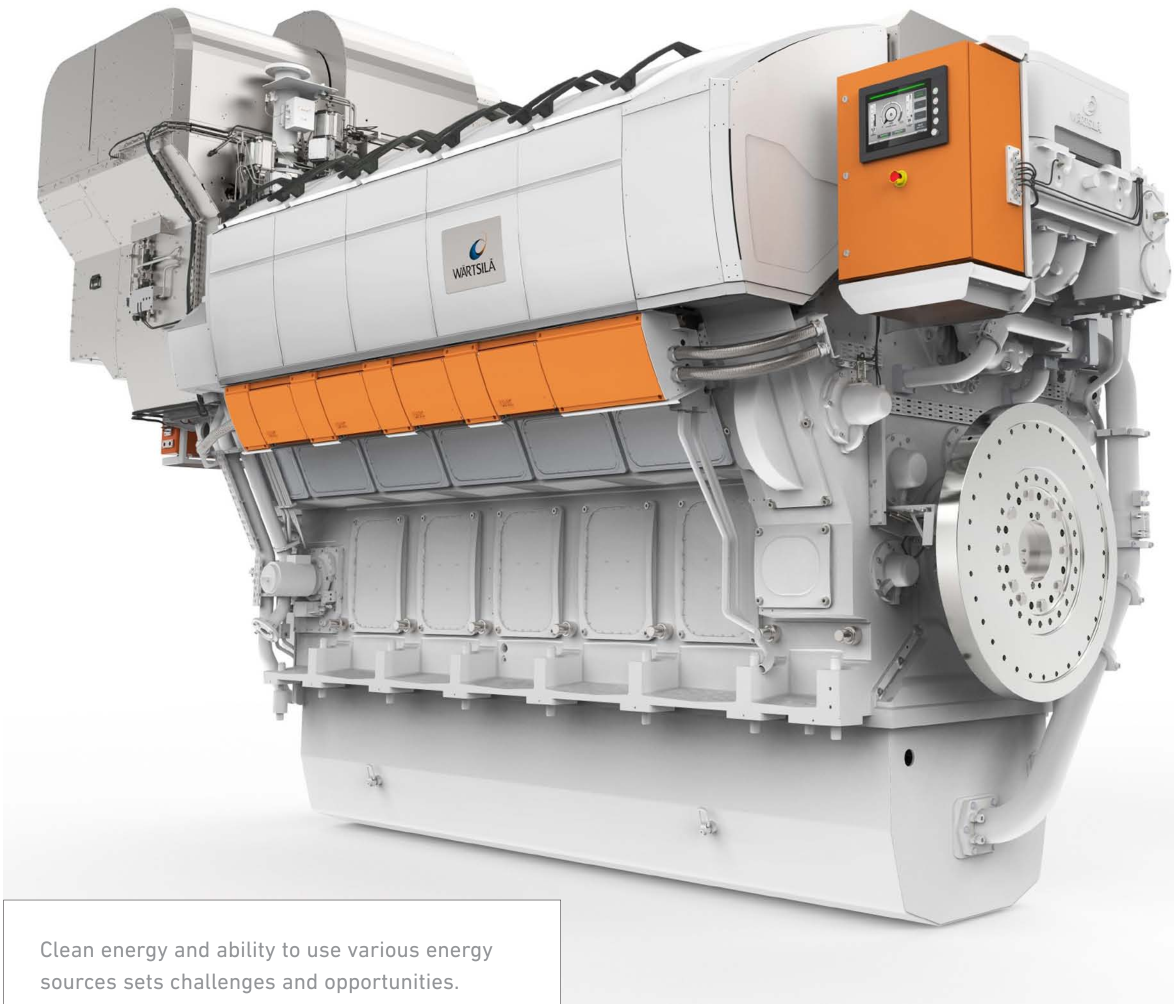
Sustainable marine solutions are needed in order to achieve sustainability in shipbuilding and offshore products (platforms, equipment and subsea technology). Operational periods can be extended and optimised using life-cycle monitoring, big-data and lifecycle management systems for ship systems and hulls; maintenance and retrofits also extend operation periods. Recycling is becoming more important and should be taken into account in the design and building processes when materials and producers are selected. The route optimization based on actual operation conditions is seen as crucial factor to reach environmentally friendly shipping. Better materials are needed in critical components. This requires advanced and modular design methods that take full benefit of computational multi-physics simulation environments, but also operate in the system level in which optimization of the solutions should be carried out.

Renewable energy production based on offshore wind farms, tidal power and wave energy is becoming more required. New concepts are needed for this, and they should take into account the environmental issues related to customer's operations and geographical locations. Ice loads on these energy-production systems should be identified, and management methods should be developed. Methodologies for cost-efficient design, transport, assembly and maintenance should be developed for ice-covered waters. Energy-extraction methods, onshore transportation and optimisation methods for energy economics should also be developed.

Picture: Wärtsilä

Energy, environment and sustainability

Environmental protection is important when energy production and transport are concerned. The associated safety and risk assessment methods should be developed to achieve sustainable energy production. Equipment and technology for risk reduction, such as oil-collection systems in open water and ice, should be further developed and existing systems should be modernised. The noise produced by vessels should be reduced to protect citizens and the environment. This means that the methods used to predict and reduce noise levels should be further developed.



Clean energy and ability to use various energy sources sets challenges and opportunities. The recently launched Wärtsilä 31 engine has achieved a Guinness World Records title for the most efficient 4-stroke diesel engine.
Picture: Wärtsilä Finland Oy

Objective	COMPETITIVENESS AND COMPETENCE	CRUISE AND FERRIES	ARCTIC TECHNOLOGY	OFFSHORE TECHNOLOGY
New product or concept 0.5-2 years	• Towards zero-emission and environmental sustainable ships, with reduction in energy consumption and CO2, SOx and NOx and particle emissions (exhaust gas cleaning) • Digitalization as tool for environmental friendly solutions • Route/Speed optimization according to weather	• Energy efficiency improvements throughout the ship • Utilisation of waste heat recovery technologies, fuel efficiency from 60% to 75% • Increase the use of sustainable materials • Use of renewable energy	• Functional oil spill mitigation systems • Decommissioning and clean-up services for oil spills	• Energy-efficient floating production solutions • Offshore production solutions with enhanced safety and efficiency in decommissioning and recycling • Oil spill response techniques with improved efficiency • Maintenance logistics in offshore wind parks
Integration of innovation 1–3 years	• Electrification of ships, marine traffic and ports • Impact on rules • Renewable energy: waves, wind • Shore supply	• Sustainability, lifecycle assessment tools for ships • Comprehensive optimisation of energy production and waste heat recovery systems • Optimised hull forms for reduced resistance and efficiency in use of materials	• Systems and procedures with reduced environmental risk • Implementation of technologies for zero discharge	• Methods for waste heat recovery in offshore oil and gas production • Methods for renewable energy utilisation in offshore oil and gas production
Innovation and application 3–5	• New emission-reduction methods • New energy sources: LNG, Hydrogen. Syngas, Wind, Sun, Algae • Zero emission and no ballast • Lifecycle assessment tools to optimise ship systems, ecosystem and supply chain	• Development of waste heat recovery technologies, fuel efficiency from 75% to 85% • New waste heat recovery equipment • Improved waste management and energy recovery from waste • Methods for renewable energy utilisation, solar and wind	• Multi-functional and reusable equipment • Oil spill removal based on improved technologies • Technologies for zero discharge ships	• Recyclable materials in equipment and structures • Oil spill removal based on new materials and techniques
Basic research 4–10	• Development of hydrodynamics and propulsion in different operational conditions using virtual model tests • Lifecycle assessment tools for ships • Future energy sources: bio gas, solar panels, nuclear, fuel cells, batteries, energy storage, algae • Better materials for critical components and lean, highly automatized production processes • Modular design methods including, e.g. combined thermo-, chemical, fluid and solid mechanics computations	• Future energy sources, converters and energy storage technologies, e.g. hydrogen, fuel cells, supercapacitors • Material sustainability • Hydrodynamically optimised hull-forms for waves	• Oil-ice interaction • Behaviour of oil in cold water • Alternative fuels and their potential in cold and icy conditions • Underwater acoustics in ice and equipment with low noise levels • Black carbon reduction • Energy-efficient and Zero discharge vessels	• Energy management in oil and gas production • Sustainable use of materials

Summary of the strategic research themes for energy and the environment

Intelligent ship, systems and solutions

The Cluster recognizes vast opportunities with digital technology in maritime business. Finland has ample world-class resources available to make this shift towards digitalization possible, including all areas of maritime activities. Governmental agencies and legislation have practiced an early adaptor mentality – paving the way ultimately towards unmanned shipping.

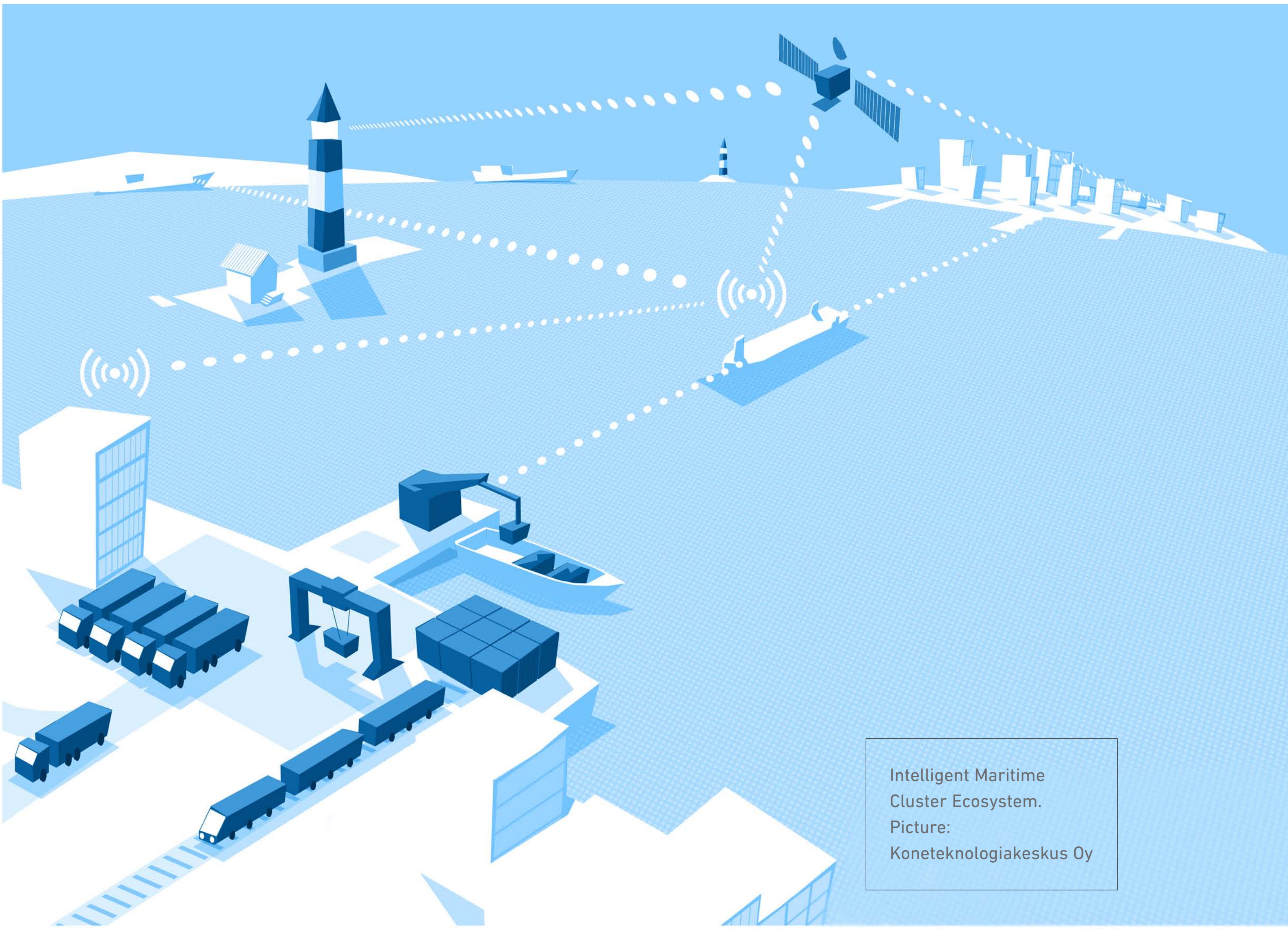
Unmanned cargo ship and network of stakeholders with technologies for Intelligent Ship, Systems and Solutions Picture: Rolls Royce Marine

THE VISION:
The objective is to reach technical, operational and legal readiness to introduce unmanned shipping in Finland – as the first country in the world.

Agility and speed are of the essence when developing new business approaches, highlighting the fact that technical development needs to support commercial aspects. New commercial approaches and digital start-ups need to be in the centre of the new approach. The aim is to be the leading maritime cluster in the world in the field of digital technology in business solutions.

Rapidly developing digital services impact all industries at the moment. People and machines are more and more connected – everywhere and all the time. Smaller and smaller components have their unique IP-address, making it possible to communicate and control over the Internet. Sensors are getting smaller and cheaper to facilitate more extensive monitoring. Cyber security will be most important when machines are controlled remotely. Digitalization is the use of digital technologies to change a business model and provide new revenue and value-producing opportunities that avoid human error, and to enable more efficient operations, user-friendliness and effective and streamlined services.

Legislation typically lags behind technology development. Use of privately owned drones has increased, but there is still no basic legislative framework in place to allow remotely operated vessels. There is the luxury of 4G-networks while there is hardly any functioning means of digital communications when operating in the arctic. Consumers are used to superior Internet commerce services while the industry doesn't provide the same level of transparency and efficiency to our marine Customers. It is time to transform marine business to the digital age by providing world-class Customer service, enabled by digital technology. The Finnish maritime cluster needs to collaborate with national regulatory bodies and the IMO and Class societies in order to improve the regulatory framework – and to take a leading position globally. The Finnish maritime industries is well placed to take a leading role in development due to the high level



Intelligent Maritime Cluster Ecosystem. Picture: Koneteknologiakeskus Oy

of digital capability as a society. Regulatory bodies and governmental entities typically favour the introduction of novel technology whereas commercial companies are starting to differentiate themselves in this area. Training and education needs to build up competencies fast in this area.

Digitalisation can be an enabler to support stakeholders to maintain and strengthen their current position in the value chain – by e.g. increasing operational efficiency or by creating new added value for customers by digital service offerings. On the other hand, digitalization can be a disruptor as well – by e.g. creating new players that can take over the position of current stakeholders with better utilization of data (the "Uber effect"). Digital technologies among maritime industries consist of several different actors and sectors. Activities and actors may vary depending on the sector, but it is essential to form a continuous process from the manufactures to the end user for breakthrough innovations and open-innovation activities.

An open marine data platform would rapidly increase digital collaboration, utilization of big data and creation of new software applications in order to transform data into useful information. It is recommended to start by opening data from public authorities and by developing incentives to open relevant data from all maritime ecosystem stakeholders (shipyards, ship operators, marine technology companies, etc.) in order to open possibilities for new services and technical solutions; the Baltic Sea could serve as a frontrunner as such an ecosystem. The operating environment of the platform will be based on cloud computing. The maritime cluster needs to evolve towards a true ecosystem, and to attract ICT-companies and start-ups. The creation of software applications requires collaboration between maritime business and ICT-experts. User-friendly applications can significantly enhance vessel safety, reliability and efficiency.

Business development for digital services is vital, as the focus will shift gradually from product to service – i.e. from hardware to software. Product development needs to incorporate clear requirements from the digital services viewpoint, eventually considering the product being a service platform rather than building services on top of a product. RDI-priorities need to be evaluated against the status quo – currently with heavy investments in products and factories. Digital services will not require similar infrastructure as today – in fact the inertia of current product-focused competencies and factory infrastructure slows down the development.

Remotely operated and autonomous vessels have already demand. These vessels will be software-centric, involve robotics, cyber security critical, and operating these vessels will represent a new generation in shipping efficiency.

Digitalization will change the traditional marine cluster -specific approach towards agile ecosystems, and it assembles stakeholders from different industries. Ecosystem forms a solid ground for companies to align digital visions, create collaborative funded PPP projects and impact national and international discussion of autonomous shipping e.g. in terms of legislation. The ecosystem is a collaboration platform for independent companies, start-ups and SME's from different industries, research institutes and universities as well as for public authorities. The ecosystem will solidify its functions during the coming years and reach the position of the world's leading centre of digital maritime excellence.

Objective	COMPETITIVENESS AND COMPETENCE	CRUISE AND FERRIES	ARCTIC TECHNOLOGY	OFFSHORE TECHNOLOGY
New product or concept 0.5–2 years	• End-user -driven solution for Customer • Increased level of internal digital capability (merged ICT-data & tools) • Increasing shared data between companies • Full-scale demonstrator of autonomous systems • Increased capability to derive customer value from data through a cross-disciplinary approach (techno-economical, etc.) • Increased IoT-capability to improve shipbuilding related processes over the entire value chain	• Monitoring and demand-based control of different systems • Managing the production and maintenance networks over lifetime with shared information • Fleet and asset management	• Utilization of ice conditions in route and operations optimization • Autonomous operations of specific systems • Fleet and asset management • IT-technologies for Emergency and rescue	• Remote controlled and unmanned operations • Integrated lifecycle models (e.g. shipbuilding material database) • Visualization and simulation techniques improving efficiency of operation, service, maintenance and training
Integration of innovation 1–3 years	• Step change opportunity in process efficiency (from within a yard or factory to the entire eco-system) • Crew training of remotely operated ships • Cybersecurity • Marine open cloud data platform (convergence of big data) that is used by all	• Development of tools for managing the production and maintenance networks • Ship design, operation and life-cycle data in one, complete and up-to-date product model	• Data ownership & sharing • Remote operations	• Systems and procedures with enhanced safety and reduced environmental risk • Maintenance robots
Innovation and application 3–5	• End-user -driven development approach • Unmanned ship designs	• Tools for vessel design and operational optimisation	• Software for optimizing operations in the Arctic based on observed conditions • Communications in the Arctic to enable emergency and rescue operations • Remote support, control, maintenance, optimization (IoT)	• Software to optimize operations in the Arctic based on observed conditions • IT for energy efficiency of operations and equipment • Safety-driven automation and remote control • Safety-driven simulation of operations
Basic research 4–10	• ICT-competence, data analytics & algorithms, cybernetics, artificial intelligence	• Basic research to be directed to support changes in maritime law and regulatory framework • Utilization of ship operational data and end-user experiences in design of new concepts	• Tools for vessel design and operational optimisation • Modelling of ice and met ocean conditions • Basic research to be directed to support changes in maritime law and regulatory framework	• Safety management systems • Modelling of ice and met ocean conditions

Summary of the strategic research themes for digital technology

Picture: Merima Oy

Cruise and ferry

Finnish shipbuilding is well known for innovative and technically demanding cruise ships and ferries. Finland is equally known for many suppliers of advanced marine technologies, highly skilled turnkey area suppliers, design offices and world-class research and education institutes. Together, this marine industry with its customers has developed and built numerous revolutionary and trendsetting ship types. In addition to high volume of new cruise ship orders; emerging Asian cruising and cruise and ferry shipbuilding on location; growing awareness of sustainability; the changing desires of cruise passengers; and ever evolving technical development puts the industry in front of many challenges and opportunities.

Production development must be executed as the record high order book challenge the whole passenger ship design and builder network. A stronger co-operation of the whole network is needed. Building methods must be improved throughout the whole production chain. Modularity in design and modular product architecture can be two of the means with which significant improvements in production could be ensured. Utilisation of new design tools is vital as complex design and production networks work together with complicated products. By modularity, the maintenance, modifications and conversions can be carried out more efficiently during the entire lice cycle of the product.

Cruise ship and ferry operators and shipbuilders are facing a new kind of demand as sustainability awareness is rising among the passengers and other stakeholders. In addition to environmental friendliness, companies have to take account of financial and social aspects that comprise corporate social responsibility. Only that way companies can convey a credible message about the positive values associated with their products.

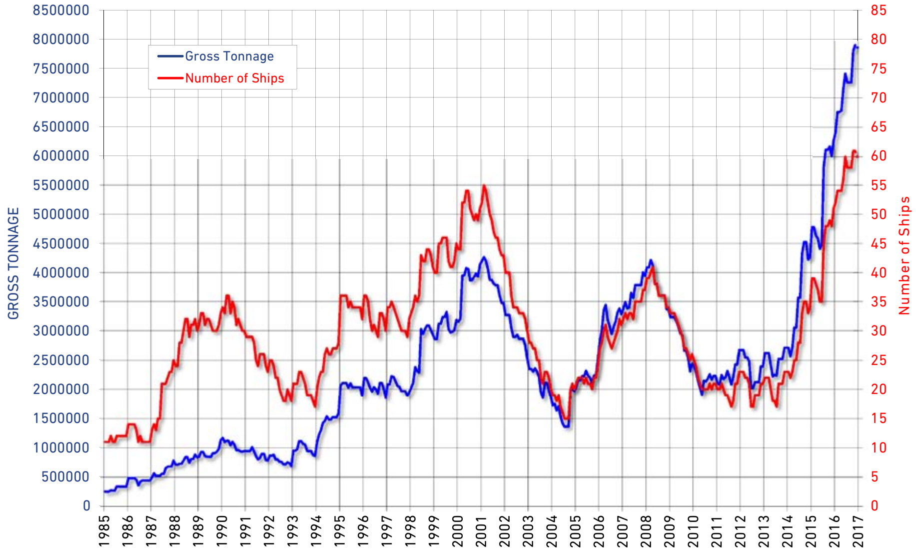
Cruise and ferry

Sustainability development, social responsibility, reduced operation costs and environmental legislation are drivers of energy efficiency. The ever-tightening maritime environmental legislation gives opportunity to shipyards, ship-owners, and system and equipment suppliers to continuously develop energy efficiency to ensure compliance with the applicable and upcoming regulations, and this way gain advantages in the markets. In addition, ship-owners and shipyards collaborate to develop the ships even beyond the applicable regulations instead of contending themselves with compliance only. New energy sources, such as LNG, renewables, energy storage and hybridisation, are also trends for cruise shipping. In ferries, these technologies have already been tested and used, and further implementation and development is continuing.

Safety and comfort are musts in ships transporting passengers enjoying their spare time. Holistic safety assessment in relation to the accidents, such as fires, collisions and groundings, is essential for safe experience. Still, there is room to improve the accident prevention and mitigation systems and risk-control options, such as structural solutions, mitigation of human error, decision-making tools and designing compartments in the hull. Passenger comfort and safety are important issues, which involve continuous reduction of noise and vibration levels inside and outside the vessel, as well as managing the sea-keeping characteristics of intact and damaged ships.

Continuous concept development to meet the new customer desires. Picture: Meyer Turku Oy

CRUISE SHIP ORDERBOOK



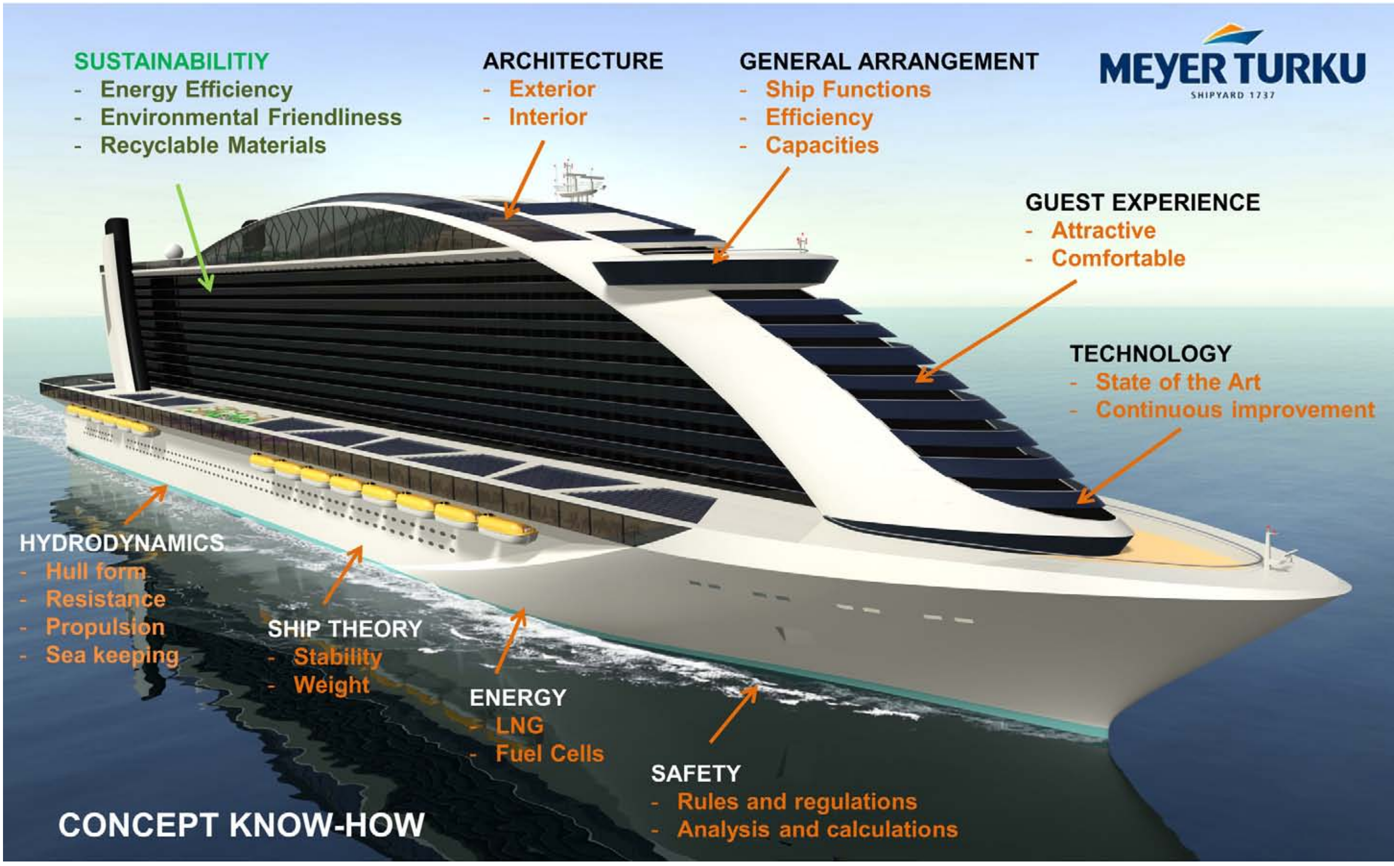
THE VISION:
The Finnish marine industry cluster dominates by its customised, entertaining, efficiently and sustainably produced, green cruise ships and ferries.

Cruise and ferry

Intelligent ship has systems, which monitor and optimise ship operations, assist in preventive maintenance and ensure fluent service. There are systems monitoring energy flows, controlling hotel functions, optimising routes, adjusting trim, etc. In addition, an intelligent ship retains all the necessary design and operational information as to where it is or its parts and systems are on their lifecycle. Maintenance is controlled by product models that contain complete detailed information on the conditions and design principles relating to different ship systems, spare parts etc. In addition, intelligent passenger ships contain the latest entertainment technology available and communicate with the passenger about on-going events and travel information, among other things.

Modern marine sector working with new design tools and technologies requires an increasingly skilled workforce which can be only obtained by education in internationally recognised programmes. Attractiveness of careers in the marine sector has to be ensured in order to get the most skilled young people.

Components of Concept Know-how.
Picture: Meyer Turku Oy



Objective	COMPETITIVENESS AND COMPETENCE DEVELOPMENT	ENERGY, ENVIRONMENT AND SUSTAINABILITY	INTELLIGENT SHIP, SYSTEMS AND SOLUTIONS
New product or concept 0.5–2 years	• New on-board services for passengers and crew • Integration of new service concepts into ship concepts • Products with improved earning potential and added value for the customer • Efficient shipbuilding and shorter building time • Energy-efficient and lightweight ships • Safe ships with high levels of comfort	• Energy efficiency improvements throughout the ship • Utilisation of waste heat recovery technologies, fuel efficiency from 60% to 75% • Increase the use of sustainable materials • Use of renewable energy	• Monitoring and demand-based control of different integrated systems • Development of tools to manage the production and maintenance networks • Fleet and asset management
Integration of innovation 1–3 years	• Testing and implementation of new production methods • Further digitalisation and use of ship data • Utilisation of comprehensive design and manufacturing models • Utilisation of augmented reality in shipbuilding • Utilisation of new strength analysis and CFD-methods along with laboratory testing	• Sustainability, lifecycle assessment tools for ships • Comprehensive optimisation of energy production and waste heat recovery systems • Optimised hull forms for reduced resistance and efficiency in use of materials	• Managing the production and maintenance networks over lifetime with shared information
Innovation and application 3–5	• Sustainable production chain and operation services • Sustainable ships and shipping • Utilisation of high strength steels and lightweight materials • New effective, more flexible and streamlined shipbuilding process • Advanced production technology applications • Digital services for cruise customers	• Development of waste heat recovery technologies, fuel efficiency from 75% to 85% • Improved waste management and energy recovery from waste • Methods for renewable energy utilisation, solar and wind • Self-sufficient vessels	• Tools for vessel design and operational optimisation • Ship design, operation and lifecycle data in one, complete and up-to-date product model • Utilization of ship operational data and end-user experiences in design of new concepts
Basic research 4–10	• Continuous studies on emerging operation areas, markets and consumer trends • Cost- and weight-effective structural solutions and building methods for new materials and structures • ICT-competence, data analytics & algorithms, cybernetics, artificial intelligence • Holistic assessment of safety for future concepts with adaptive spaces	• Future energy sources, converters and energy storage technologies, e.g. hydrogen, fuel cells, supercapacitors • Material sustainability • Hydrodynamically optimised hull-forms for waves	• Basic research to be directed to support changes in maritime law and regulatory framework • Open ship data platforms to support research and development

Summary of the strategic research themes for cruise and ferry.

Arctic technology

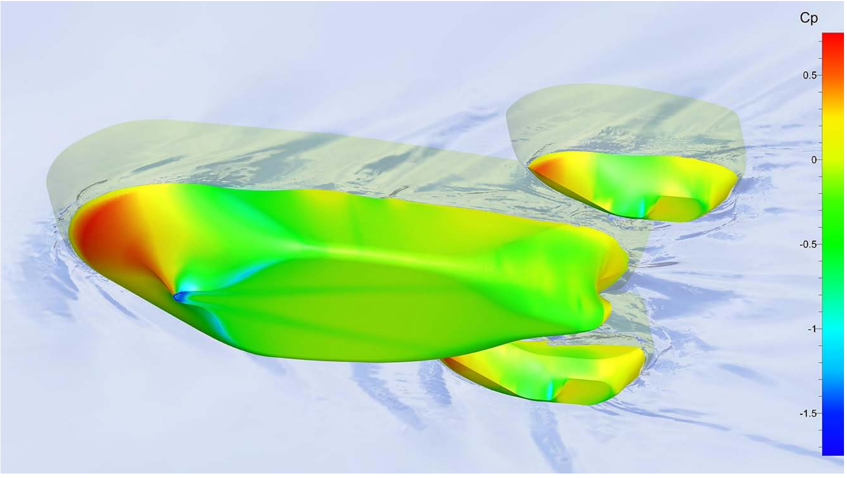
Due to climate change and the reduction of ice cover, it is expected that shipping, fishing and other industrial activities will increase in the Arctic areas. Exploitation of the hydrocarbon and mineral resources from the North, as well as shipping along the North East and North West Passages, could mean significant increase in Arctic operations. The Arctic and Antarctic Seas offer unique opportunities for Cruises, and the ships operating in these areas have to fulfil more stringent requirements than in other parts of the world, even if the cruises happen during open water season. This means that the ships must be specifically designed for harsh conditions (cold, icy, dark, silent), and taking into account the remoteness of the operation.

Finland as an Arctic country can gain global market share on this field of business. Along with Finland, many countries have formulated Arctic strategies. Although Finland during the wintertime is surrounded by 1st-year ice instead of much harsher multi-year ice, the competent Finnish industry has been heavily involved in the development of Russian, Canadian and Swedish winter navigation. Thus, Finland is well positioned to design, build and operate ice-going vessels and to provide products, training and services around these topics. However, Arctic operations involve political issues, such as jurisdiction, sovereignty, economic, fiscal and even military control. It is clear that in this competition Finland needs to focus on its strengths and further develop them. It is also important to maintain and further develop relationships with governmental entities. Finland is known for its solid experience and persuasive references, but also for innovative concepts for ice-operating vessels, offshore and subsea solutions. These vessels must be safe, environmentally friendly, and energy-efficient with optimised ice-breaking and open water characteristics. Ship designs must take into account logistical and production chains as a whole, but also the changing ice-conditions due to climate change. Development of the Arctic requires not only ships, but also establishment of the whole infrastructure for mining, oil and gas, shipping and fishing, including ports, on-shore facilities, aids to navigation, communication systems and equipment, training etc.

Safe operations in remote locations with harsh Arctic environment requires knowledge and knowhow of experienced Finnish maritime network. Picture: Arctech Helsinki Shipyard

THE VISION:
The Finnish Marine Industries enables sustainable, safe and efficient operations in the remote and sensitive Arctic and Antarctic areas.

Environmental, structural and vessel safety are core issues in the planning and execution of Arctic operations including exploration, production (e.g. mining, drilling), and transport (cargo and cruising). Icing of structures requires methods for detecting icing along with new, recyclable materials and coating methods. Even though the Polar Code sets additional limitations above and beyond what is already prescribed by the MARPOL, zero discharge is not required in the Polar Code. This originates mainly due to the lack of reception facilities in the Arctic. Zero discharge means that the ship is designed to hold all liquid and solid waste while out in the sea. It also means that the ships have to be able to treat the waste and garbage on-board and garbage reception facilities are needed in



Pictures: Aker Arctic Technology

the Arctic ports. At the moment there is no ban on using heavy fuel in the Arctic, but this could happen in the future. The risks associated with Arctic operations need to be minimised so that the sensitive environment is not endangered, and lifesaving in these remote locations, should it be needed, can be performed effectively. This requires the development and use of risk models for Arctic operations which are based on observed, up-to-date operational data. Vessels must be energy-efficient and have minimum (zero) emissions. Traditionally, ice operations are energy-intensive, so there is a clear need to develop more efficient designs which are safe with respect to collisions, groundings and ice damages. As ice-conditions become milder, wave conditions typically get harsher, and ice may be more dynamic. Achieving the necessary levels of safety is not in the hands of the designer alone, but requires cooperation with owners, operators, insurers and government authorities.

Ice operations need to consider optimisation of the logistic chain and optimal routes in ice-bound waters. The optimisation must be based on observed environmental conditions. This means that the optimisation of logistical chains, including icebreaker assistance, should take into account the seasonal variations in ice and wave conditions. Services produced for Arctic operations need to be identified and business models created. For the development of the Northern Sea Route and trans-polar shipping, one must consider not only ice-going technology, but also logistical chains and macro-economic transport flows.

Picture:
Arctech Arctic

Building up infrastructure for Arctic operations requires transportation of materials and construction equipment to the Arctic region. Special vessels are also needed for building ports and energy production plants, and for ice-management in ports and around production platforms. Production concepts need to be developed. Development of technology for seismic research is also required in order to establish infrastructure in the Arctic region. Information technologies for these remote areas must be developed as communications are an important part of effective operations and a vital part of the emergency and rescue operations in these remote areas. This is also seen as a possibility for new emerging business.

Ice-breaking ships with optimised ice-breaking process and excellent open water characteristics are needed for energy efficiency, safety and optimised operation taking also into account operation in heavy seas. The same principles apply to offshore structures, which need to be designed differently to these harsh conditions. This means that the icebreaking process needs to be better understood and concepts developed based on this knowledge. New computational analysis tools (e.g. Discrete Element Modelling and Computational Fluid Mechanics including ice) and model tests technology need to be implemented and further developed. These models require accurate information about the ice as a material, how ice fields form, ship-ice interaction etc. Questions related to the behaviour of ships in compressive ice or at high speeds, as well as ice-propeller interaction, structural strength in ice and the manoeuvring of ships in ice need to be resolved.

Subsea operation and remote control are key trends in open water offshore operations. The driving factors are very deep sea wells, long distances, the high cost, technical challenges of surface-based operation, as well as technological advances. In the Arctic, this trend offers certain new possibilities, yet also presents various challenges. It is important to monitor this development and to adapt and apply new technology in ice-covered environments. Seismic survey is one field that may be promising in this regard.

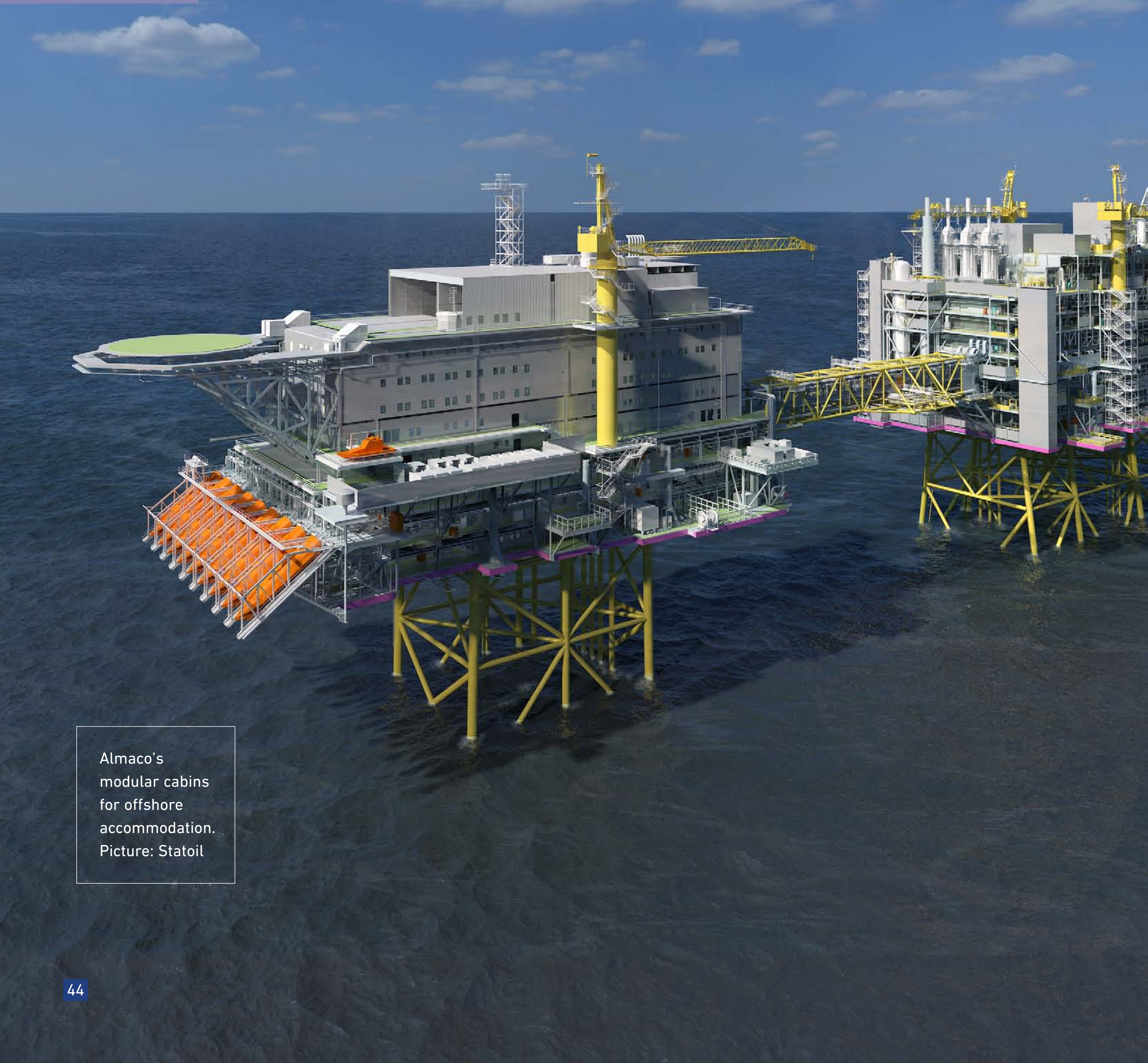
One example of co-operation are common development projects. Here the ice class Aframax tanker developed jointly by Aker Arctic and Deltamarin Picture: Aker Arctic Technology Oy

Objective	COMPETITIVENESS AND COMPETENCE DEVELOPMENT	ENERGY, ENVIRONMENT AND SUSTAINABILITY	INTELLIGENT SHIP, SYSTEMS AND SOLUTIONS
New product or concept 0.5–2 years	• Creation of new business models and services for Arctic operations (e.g. IT-based services) • Service providers and integrators on various levels of the value chain • Efficient and competitive networks in Finland and in the target countries • Inherently safe and economical vessels for transport and offshore operation • Training services for Arctic operators • Information services for Arctic operators; e.g. route planning, simulator modelling	• Functional oil spill mitigation systems • Decommissioning and clean-up services • Light and recyclable materials • Energy efficiency of ice-breakers	• Utilization of ice conditions in route and operations optimization • Autonomous operations of specific systems • Fleet and asset management • IT-technologies for Emergency and rescue
Integration of innovation 1–3 years	• Utilisation of networks in target countries • Development of Arctic fleets • Creation of communication net-works to Arctic with applications • Design methods to achieve solu-tions with low/no 'Arctic extra' cost • Reliable design methods using model-testing and simulation tech-niques including DEM and CFD	• Systems and procedures with reduced environmental risk • Implementation of technologies for zero discharge	• Data ownership & sharing • Remote operations
Innovation and application 3–5	• New models for profit sharing and contracts in the network • Optimisation of logistical chains • Risk-based design methods • Remote and subsea operation in ice • Health and safety as a design factor in the Arctic environment • Improved hull forms and propulsion solutions • Utilisation of operational data in new designs	• Multi-functional and reusable equipment • Oil spill removal based on improved technologies • Technologies for zero discharge ships	• Software to optimise operations in the Arctic based on observed conditions • Communications in the Arctic to enable emergency and rescue operations • Remote support, control, maintenance, optimisation (IoT)
Basic research 4–10	• Geo-economic analysis and forecasting of transport patterns • Value chain analysis and understanding • Development of risk models for Arctic operations • Methods of ice-water-structure interaction, i.e. Discrete Element Method (DEM) and Computational Fluid Dynamics (CFD) with ice • Cost- and weight-effective structural solutions • Cost-effective winterisation • ICT-competence, data analytics & algorithms, cybernetics, artificial intelligence	• Oil-ice interaction • Behaviour of oil in cold water • Alternative fuels and their potential • Underwater acoustics in ice and equipment with low noise levels • Black carbon reduction • Energy-efficient and Zero discharge vessels	• Tools for vessel design and operational optimisation • Modelling of ice and met ocean conditions • Basic research to be directed to support changes in maritime law and regulatory framework

Summary of the strategic research themes for arctic technology.

Offshore technology

Offshore industry is a marine industry sector undergoing renewal in Finland and influenced by changes in global markets. The competencies developed in other marine sectors can be utilised and further developed to create a competitive edge also in the offshore sector. A good example of this is an Arctic technology which in conjunction with offshore can open new possibilities for the Finnish maritime cluster in this segment. Another example is building accommodation on the offshore platforms using technology from passenger ships.



Almaco's modular cabins for offshore accommodation. Picture: Statoil

Mad Dog Spar platform is being transported from Finland to the Gulf of Mexico. Picture: Technip

Increasing the use of FPSOs' (A Floating Production Storage and Offloading) in the production requires ship design knowledge in combination with that from offshore. Potential areas for new business are Norway, Africa, Canada, Arctic Russia and the Caspian Sea area. Competitiveness of the Finnish marine industry could be based on the following new products and concepts: solutions for enhanced safety and efficiency through increased automation and remote controlled and unmanned operations; weight-efficient floating solutions for offshore oil and gas production and renewable energy production; cost- and time-efficient production solutions for large offshore objects, such as substructures and modular living-quarters for the Arctic; energy-efficient floating production solutions; offshore production solutions with enhanced efficiency in decommissioning and recycling; building and maintenance logistics in offshore wind parks (including Arctic conditions); and efficient and competitive networks in Finland and in target countries.

THE VISION:
The Finnish industry delivers value-adding, sustainable technology to extreme offshore conditions utilising global supply chain networks.

Offshore technology

Offshore production solutions with enhanced safety are needed, as safety is an issue of ever-increasing importance in offshore operations. Safety management and the HSE (Health, Safety and Environment) as a design factor utilised through the use of risk-based tools of analysis are topics of new research globally. Improved safety and efficiency of the operations go hand in hand. Unmanned operations and automation are crucial for the future of this business segment. Finland has strong capabilities for this type of research, and these capabilities should also be utilised for the offshore industry.

Weight- and cost-efficient, movable and recyclable floating solutions for offshore oil and gas production are a critical issue in large production facilities. Finland has research pedigree in relation to weight- and cost-saving structural solutions, and new materials for large cruise vessels and this should be expanded to cover floating offshore structures. In the Arctic conditions, understanding potential loading on different types of offshore structures and the resulting strength is key to weight-savings and sustainable solutions. There is considerable expertise in the field of mathematical modelling of ice fields and their dynamic formulations that can be used to study the impact of harsh winters on offshore and marine objects. This combined with decommissioning, reusing materials and recycling can create new business for the Finnish maritime cluster as these are expected to be major cost factors in future offshore business. '

Production technology and utilisation of the network has an impact both on cost and duration of the construction of large offshore objects, and this offers an opportunity to the Finnish maritime cluster to utilise its knowledge on modularisation in design and construction. Both the structure itself and the different operational systems and components can be effectively produced as modules. Efficient operating models and principles, for network of organisations to utilise these, needs to be developed. The Finnish marine industry comprises a network of companies of different types and sizes. This structure is basically suitable to serve offshore operators as it comes to the individual products.

Energy efficiency in oil and gas production gives a competitive edge. The achievement of energy efficiency on board conventional vessels is a research topic that has attracted attention in Finland over the past few years. This research should also be expanded to cover offshore oil and gas production. The processes used in this production offer huge potential for waste heat recovery and energy management in general. Moreover, the offshore conditions give opportunities for the utilisation of renewable energy in the forms of waves, currents, wind and solar radiation. Energy management in general should be a topic for further research.

Maintenance logistics in offshore wind farms is an important opportunity due to the increase in the construction of offshore wind farms. Wind farms and the solutions used in relation to them should remain a topic for research, and maintenance is an issue, which will have a considerable cost impact. There is still plenty of room for innovation, since this issue appears to have been neglected particularly in respect of ice-bound waters. All research that sheds light on the behaviour of ice within a wind farm containing multiple offshore structures is potentially a source of new products and innovations.

Objective	COMPETITIVENESS AND COMPETENCE DEVELOPMENT	ENERGY, ENVIRONMENT AND SUSTAINABILITY	INTELLIGENT SHIP, SYSTEMS AND SOLUTIONS
New product or concept 0.5–2 years	• Efficient and competitive value-adding networks in Finland combined with the use of partners and existing infra in the target countries • Subsea structures construction • Life cycle business, refurbishment, services • Winterization • De-icing, construction of Arctic harbours • Weight -efficient and sustainable offshore production solutions with enhanced safety • Cost- and time-efficient production solutions for large offshore objects • Network-based business models	• Energy-efficient floating production solutions • Offshore production solutions with enhanced safety and efficiency in decommissioning and recycling • Oil spill response techniques with improved efficiency • Maintenance logistics in offshore wind parks	• Remote controlled and unmanned operations • Integrated lifecycle models (e.g. shipbuilding material database) • Visualisation and simulation techniques improving efficiency of operation, service, maintenance and training
Integration of innovation 1–3 years	• Utilisation of local networks in target countries, supply chain management and cost-efficient sourcing, establishing new infra • Use of modules in different pro-duction environments • Risk-based tools for HSE-analyses • Ice pile-up around and loadings on offshore structures	• Methods for waste heat recovery in offshore oil and gas production • Methods for renewable energy utilisation in offshore oil and gas production	• Systems and procedures with enhanced safety and reduced environmental risk • Maintenance robots
Innovation and application 3–5	• New models for risk and profit sharing and contract models in the network • Communications in the Arctic • Remote support, control, maintenance, optimization (IoT) • Lifecycle business, modernisation of systems and equipment to improve efficiency and comply with new regulations • Modular solutions for systems, processes and structures • Solutions for Arctic applications • HSE as a design factor for products and production	• Recyclable materials in equipment and structures, circular economy in concepts • Oil spill removal based on new materials and techniques	• Software to optimise operations in the Arctic based on observed conditions • ICT for energy efficiency of operations and equipment • Safety-driven automation and remote control • Safety-driven simulation of operations
Basic research 4–10	• Value chains and business success factors in offshore industry • Team Arctic Finland development model • Cost- and weight-effective structural solutions • New materials for large structures • Safety management • Mathematical modelling of ice fields • Full-scale Arctic testing environment	• Energy management in oil and gas production • Sustainable use of materials	• Safety management systems • Modelling of ice and met ocean conditions

Summary of the strategic research themes for offshore technology.

Summary

Strategic Research Agenda aims to identify the main themes and areas of research and development that the Finnish Maritime Cluster will need in the future. The agenda also aims at a comprehensive overview of the situation including a list of available research instruments, as well as an understanding of the skills and competence needed. The Finnish Marine Industries and its stakeholders participated in forming the Strategic Research Agenda in order to support the research and development in the Finnish Maritime Cluster. The key research themes are not independent, but will be integrated with innovative interdisciplinary research into larger multidisciplinary programmes. The visions and the main development directions of the selected main themes are:

COMPETITIVENESS AND COMPETENCE DEVELOPMENT:

› **Vision**: By 2025 Finland has to the most competent, adaptive, agile and co-operative network of highly skilled people globally. It is a frontrunner at the current and emerging marine technology markets.

- **Keywords:** Research; Education; Infrastructure; Multi-disciplinary problems; Building Process; Service Business; International Operations; Value Network; Project-based Business; Blue growth; Foresight

CROSS-CUTTING TECHNOLOGICAL SEGMENTS

› **Energy, Environment and Sustainability:**

- **Vision:** The objective is to produce the cleanest energy solutions for ships and to minimise the environmental impact of shipping globally.
- **Keywords:** Zero-emission; Self-sufficient; Sustainability; Renewable energy production; Environmental protection; Circular Economy; Energy Storage

› **Intelligent Ship, Systems and Solutions:**

- **Vision:** The objective is to reach technical, operational and legal readiness to introduce unmanned shipping in Finland – as the first country in the world.
- **Keywords:** Digitalisation as an enabler; Open data platform; Digital services; Remotely operated vessels; Autonomous vessels; Legislation

SPECIFIC PRODUCT AREAS:

› **Cruise and Ferry:**

- **Vision:** The Finnish marine industry cluster dominates by its customised, entertaining, efficiently and sustainably produced, green cruise ships and ferries.
- **Keywords:** Production development; Green Vessel; Sustainability; Energy efficiency; Safety and comfort; Intelligent ship; Education

› **Arctic Technology:**

- **Vision:** The Finnish Marine Industries enable sustainable, safe and efficient operations in the remote and sensitive Arctic and Antarctic areas.
- **Keywords:** Harsh Conditions; Environmentally friendly; Safety and Security; Ice Management; De-icing

› **Offshore:**

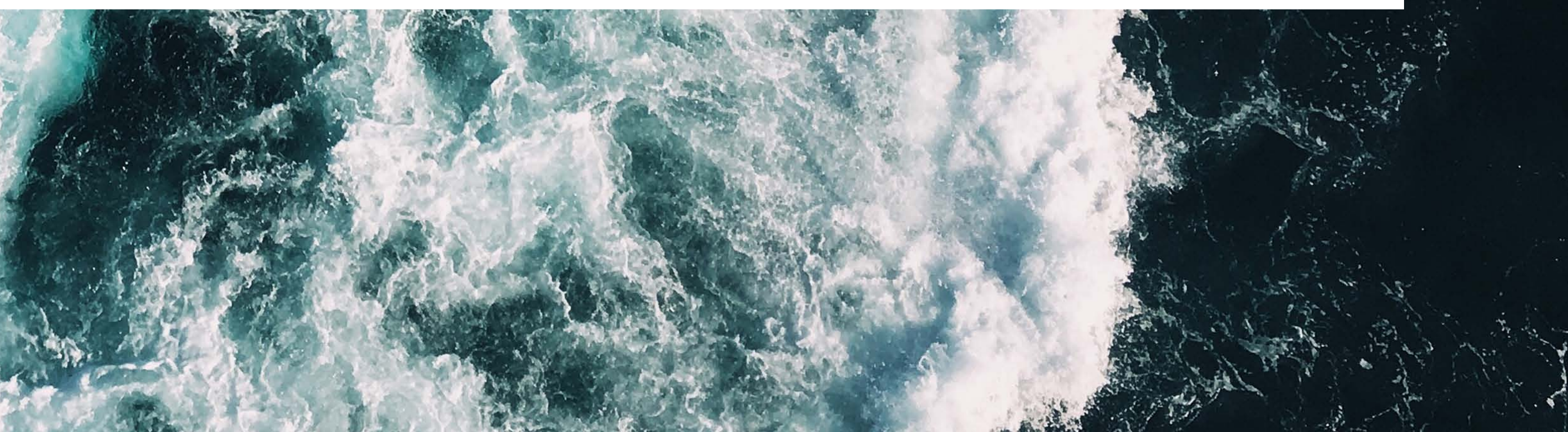
- **Vision:** The Finnish industry delivers value-adding, sustainable technology to extreme offshore conditions utilising global supply chain networks.
- **Keywords:** HSE; Quality; Weight-efficient; Recycling; Production technology; Energy efficiency; Maintenance logistics; Oil and gas production; Offshore wind farms

The goal of the Finnish Maritime Cluster

is to make Finland a leading nation with a high level of competitiveness, competence and co-operation between industry, research organizations, authorities and academia. The most important factors in this competitiveness are innovative products and business concepts based on customer needs and efficient control of value chain processes. Today, the main challenge is to produce tailor-made products based on serial production efficiency. There are three levels of development that must all be running. It is important to develop the current product, look forward in development, and to create totally new innovations. The Finnish Maritime Cluster has to understand the future needs of their customers' businesses and how to increase added value for customers. The Cluster aims to achieve this goal through its vision: Smart Maritime Technology Solutions.

Resources

The projects, which aim to develop new products or concepts, will be funded by individual companies, the Finnish Funding Agency for Technology and Innovation (TEKES), or instruments provided by the European Union Framework Programmes. The same instruments, but with higher public share, will be used to support the integration or application of innovations. Basic research aiming at innovation and new scientific results are to be funded by projects mainly by the extremely competitive instruments of the Academy of Finland and the European Research Council. Funding from local regional development programmes is also to be used to strengthen regions where the Finnish Maritime Cluster is present. In the end, success of a company is depending on their own commitment to develop.



Implemented themes according to SRA Smart Maritime Technology Solutions 2014–2020

Projects started 2013–2016

The table below describes marine related research projects started during or after the year 2013, when the last Strategic Research Agenda 2020 was launched. The list shows how the SRA has been executed and how wide the range of current ongoing research there is. Projects are divided into national and international, and only consortium projects have been taken in account. In addition to the list, there are numerous projects executed by individual companies. During the period there are also some ongoing projects that have been started before 2013.

There are several funding programs for the marine RDI-projects. Arctic Seas is an ongoing programme by the Finnish National Funding Agency TEKES. The aim of the programme is to promote new business from sustainable marine solutions and from sustainable use of marine resources. Horizon 2020 is the largest EU Research and Innovation programme for the years 2014 to 2020. The Connecting Europe Facility (CEF) is a key EU funding instrument in promoting growth, jobs and competitiveness through targeted infrastructure investment at the European level. Although several projects have been ongoing and still continue, the work is not complete and new initiatives with revolutionary ideas for RDI should be executed exploiting the lessons learned from these projects.

NATIONAL PROJECTS

Programme	Project	Start	End	Topic
Arctic Seas	Research of Arctic Fixed Offshore Structures	2013	2015	Interaction between ice and fixed offshore structure
Arctic Seas	LNGinside, planning international growth	2013	2014	Lowering emissions and greater efficiency through intelligent use of alternative fuels. LNG-technologies for marine and heavy traffic applications.
Arctic Seas	SET	2014	2016	Ship Energy Efficiency Technologies
Arctic Seas	ArtEco	2014	2017	Arctic Thruster Ecosystem
Arctic Seas	Smulan II, TP5	2014	2016	Underwater noise monitoring and prevention methods
Arctic Seas	IMOR, LO-ICE	2014	2017	By using the full scale tests and studies to adopt ice management – the manoeuvring of a vessel in ice and use of its hull and propeller flow - as a part of successful oil recovery.
Arctic Seas	Development manager for the Finnish Maritime Cluster to the Tekes Arctic Seas Program	2014	2016	Promoting and Activating the Finnish Maritime Cluster to the Tekes Arctic Seas Program
Arctic Seas	AAWA	2015	2017	Advanced Autonomous Waterborne Applications Initiative. The project develops both autonomous and remote operation for ship navigation, machinery and all on-board operating systems.
Arctic Seas	ARAJÄÄ	2015	2018	Ice loads of arctic structures
Arctic Seas	Arctic oil skimmers	2015	2016	Development of novel bristle material for arctic skimmers
Arctic Seas	SEA-EFFECTS BC	2015	2016	Shipping Emissions in the Arctic (Black Carbon)
Arctic Seas	Subsea 3D Geometry Measurement Device	2015	2017	Fast and Accurate Prototype of 3D Geometry Measurement Device for the Arctic Environment (Subsee)
Arctic Seas	Anti-icing applications	2015	2016	Roll-to-roll fabric of advanced slippery liquid-infused porous surfaces for anti-icing applications
Arctic Seas	GRACE	2015	2015	Integrated oil spill response actions and environmental effects
Arctic Seas	HyperGlobal	2015	2016	The environmental efficiency of maritime and offshore activities - Global service through hyperspectral imaging
Arctic Seas	VORIC	2015	2016	Vessel Operations and Routing in Ice Conditions
Arctic Seas	Arctic Structures	2015	2017	Studying the demands of arctic, cold region environment, directed to structural and corrosion design of high-strength steels utilising the latest research equipment and methodology.
Arctic Seas	SUSTIS phase 1	2016	2016	Sustainability and Transparency in Shipbuilding Networks
Arctic Seas	B.U.S.I.N.E.S.	2016	2018	Business utilising sustainable integration of Novel Energy Systems
Arctic Seas	Ship Recycling	2016	2016	Ship Recycling in Finland
Arctic Seas	Large Arctic Rotor Sail	2016	2017	Large Arctic Rotor Sail Development Project
FIMECC	REBUS	2013	2018	Towards relational business practices. Development of project business networks, logistics networks, R&D networks and value networks.
FIMECC	BSA	2014	2018	Breakthrough Steels and Applications
TEM Meri	Meri- ja teknologiateollisuuden asiakaslähtöinen kasvu	2014	2016	Customer-based growth in the Marine and Technology industries. Focus on offshore opportunities at Norway and Russia.
TEM Meri	Tulevaisuuden teRävin Meriteollisuus Maailmassa – TRIMMI	2014	2016	Analysing the world market and the needs arising from the analysis
TEM Mer	Turku Seas 2020	2014	2016	New, modern operational environments for the marine industry

NATIONAL PROJECTS

Programme	Project	Start	End	Topic
TEM Meri	Team Arctic	2014	2016	Business concepts for Arctic investment projects
TEM Meri	FinBraTech	2014	2016	Business opportunities for SMEs from Brazil and other countries in Latin America
TEM Meri	MerIT	2014	2016	Combining ICT-know-how to marine technology
TEM Meri	Meriklusterin yhteistyöverkoston kehittäminen	2014	2016	Strengthening the Finnish Maritime Cluster's cooperation and integration to ZVT collaboration platform.
TEM Meri	Merien Markkinanäkymät	2014	2016	Establishing a continuous effort to gather, refine and share information about the markets.
TEM Meri	FinTech3DExpo	2014	2016	New presentation platform for Finnish companies in the marine and technology industry: A 3D-fair
TEM Meri	Suomen meriklusteri 2020	2014	2016	Report of the current status and future of the Finnish Maritime Cluster

INTERNATIONAL PROJECTS

Programme	Project	Start	End	Topic
FP7	ISOTRACK II	2013	2014	ISO Shipping Container Tracking and Monitoring System Demonstration Project
FP7	ADAM4EVE	2013	2015	Adaptive and smart materials and structures for more efficient vessels
FP7	MOBI-WELD	2013	2014	Low-force mobile friction stir welding system for on-site marine fabrication
FP7	SHOPERA	2013	2016	Energy-Efficient Safe Ship Operation
FP7	Joules	2013	2017	Joint Operation for Ultra Low Emission Shipping
Horizon2020	Hercules-2	2015	2018	Fuel flexible, near-zero emissions, adaptive performance marine engine
Horizon2020	LeanShips	2015	2019	Low Energy and Near to zero emissions Ships
Horizon2020	HYDRALAB-PLUS	2015	2019	Environmental hydraulic modelling for the upcoming technical challenges associated with adaptations for climate change
Horizon2020	Manutelligence	2015	2018	Product Service Design and Manufacturing Intelligence Engineering Platform
Horizon2020	GRACE	2016	2019	Integrated oil spill response actions and environmental effects
Horizon2020	EfficienSea 2	2015	2018	Efficient, Safe and Sustainable Traffic at Sea
Horizon2021	E-ferry	2015	2019	E-ferry – prototype and full-scale demonstration of next generation 100% electrically powered ferry for passengers and vehicles
Horizon2023	CB Container SpeedUp	2015	2016	Conexbird Wind speed-up containers and prevent damages
Horizon2022	HOLISHIP	2016	2020	HOLIstic optimisation of SHIP design and operation for life cycle
Lloyd's Register Foundation	Scenario based risk management of arctic shipping and operations	2013	2018	The holistic treatment of design relevant features and their identification to advance safe arctic operations and transport.
TEN-T	WINMOS	2013	2015	Efficient maritime transport during winter when sea ice covers large parts of the EU's northernmost waters
TEN-T	Methanol: the marine fuel of the future	2013	2015	Performance of methanol on passenger ferry Stena Germanica
TEN-T	Baltic So2lution	2013	2015	Minimising the emissions by introducing an innovative and environmentally friendly transport model and a generic low-emission, dual-fuel engine technology package.

Programme	Project	Start	End	Topic
TEN-T / CEF	Twinport2	2014	2018	The Action increases the RoPax-capacity and optimises the infrastructure at the Ports of Helsinki and Tallinn.
TEN-T / CEF	Biscay Line	2014	2016	Multiple port Finland-Estonia-Belgium-Spain long distance MoS, relevant to many core network corridors
TEN-T / CEF	The Northern ScanMed Ports	2014	2016	Improve energy efficiency in port operations and shipping, provide onshore power and reception of ship waste and waste water
TEN-T / CEF	Back from Black	2014	2016	Study and deployment of the affordable scrubber retro fitting technology for SME ship owners
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TEN-T / CEF	Back from Black	2014	2016	Study and deployment of the affordable scrubber retro fitting technology for SME ship owners
TEN-T / CEF	Upgrading and sustaining the competitive Baltic MoS-link Germany-Finland (RoRo multiple ports loop)	2014	2016	On one hand, to increase the productivity and capacity of the MoS-link and service related terminal operations, and on the other, to reduce the environmental impact of the ship operations
TEN-T / CEF	Upgrading and sustaining the competitive core Baltic MoS-link Helsinki-Lubeck	2014	2016	Enhanced efficiency and competitiveness of this MoS-link, CO2 emissions reduction and more efficient use of the existing port's infrastructure
TEN-T / CEF	Compliance monitoring pilot for Marpol Annex VI (CompMon)	2014	2016	Voluntary piloting of effective targeting for the enforcement of IMO Marpol Annex VI
TEN-T / CEF	WINMOS II	2015	2019	Winter Navigation Motorways of the Sea II
TEN-T / CEF	DOOR2LNG	2016	2018	Upgrade of the maritime link integrated in the multimodal container transport routes
TEN-T / CEF	Bothnia Bulk	2016	2018	Environmental upgrade of year-round supply in the northern Baltic Sea

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