EMECRID

The R&D group of EMEC

Research Strategy

a contribution to
the **Waterborne** technology platform

Introduction

Marine Value Chain & Stakeholders

The Marine Equipment and Systems industry supports the whole marine value chain and stakeholders. This includes the port infrastructure and operation to the ship/shore interface, shipbuilding and ship repair, through to ship operation and through life support. The size of this market is very large and the marine equipment industry on average contributes 70% of the value of a ship.

Marine Equipment Markets

A study conducted on the behalf of the European Commission estimated the turnover of the European Union and Norwegian marine equipment industries at around €26 billion. From other published data this corresponds to approximately 35% of the entire global market. Of the €26 billion, €12 billion relates to the export market. European equipment industries are world leaders in propulsion, cargo handling, communication, automation and environmental systems. Direct employment in the maritime equipment sector is estimated at more than 262,000 while indirect employment accounts for about 436,000 jobs. The equipment supply industry therefore plays a central role within the maritime economy in Europe. In terms of head count and turnover, it is larger than the European shipyards and may also be stronger than the supplier industries of the two largest shipbuilding nations today - Japan and the Republic of Korea.

Marine Equipment Business Sectors

The contribution by value from the marine equipment suppliers is shared between numerous branches of industry. Setting aside the production of steel and other basic materials the industrial contribution includes; the development and supply of engines, propulsion and electrical power systems, cargo handling systems, general machinery and associated equipment, environmental and safety systems, electronic equipment incorporating sophisticated navigation and control systems, advanced telecommunications equipment, IT, as well as the manufacture and supply of ships accommodation. This industry base is reflected in the structure of the Strategic Research Agenda (SRA), where the research requirements are presented for the 7 business sectors below:

- **Power and propulsion systems**
- **Steering, stabilisation, mooring and anchoring**
- **Control, navigation and communication systems**
- **Electricity, automation and safety**
- **Cargo handling and ship/shore interface**
- **Environmental systems, water treatment, ducting and pipework**
- **Materials, processes and accommodation**

EMECRID Vision

Marine Equipment Research Drivers

The European marine equipment industry is a high value added sector. It competes in a global market, where a leading position cannot be sustained on price alone. The industry derives its competitiveness through innovative and reliable high quality products. Research, Innovation and Development (RID) are the keys to success. The industry strongly supports the three pillars of the Waterborne SRA; Sustainability, Competitiveness and Growth, and has a vision of global leadership. The Marine Equipment Industry must:

- stay at the leading edge in technology
- represent the best choice in performance and costs for the customers
- meet the demands of a new regulatory regime of goal based standards
- cope with the expected growth in maritime traffic
- improve the "green" solution for maritime transport

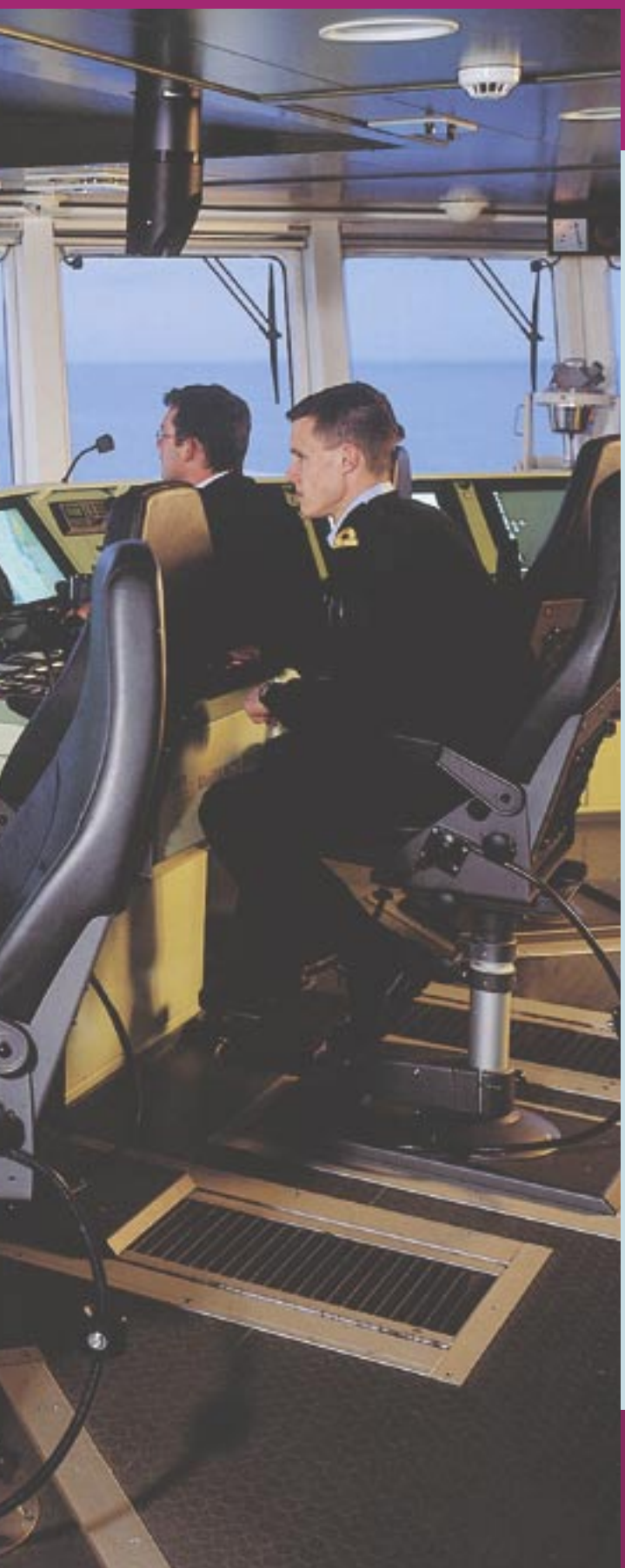
Vision Statement

Increasing European equipment industry global market share by 20% in 10 years time.

- Enhancing worldwide competitiveness through knowledge-driven development and intelligent design and production processes.
- Improving production and integration processes enabling the shipyards to reduce the overall lead-time (ship contract to delivery) by 40%.
- Minimizing safety, security and commercial risk for operators, e.g. by practicing goal based standards in design, production approval and operation.
- Developing advanced system solutions for a new generation of special ships including corresponding landside infrastructure, thereby optimising the inter-modal transport chain.
- Reducing the through life cost of equipment by 30%.
- Increasing the service market share through innovative after sales, maintenance and training concepts.
- Maintaining and improving environmental leadership through technical innovation.
- Reducing loss of life and incidents, such as hull loses, by enhancing equipment safety and security technologies.

EMECRID Vision

Research Agendas



A market focused research priority description is presented to address the EMECRID Vision and research drivers, and contribute to the Waterborne Technology Platform. 'Critical Technology' key research agenda items that fulfil the EMECRID Vision are described below. The SRA is characterised by the objective, research themes and a route map.

- Objective
- Research Themes
  - Technology
  - Tools
  - Process
  - People
- Route Map
  - Research & Development Outcomes
  - 5 Years
  - 10 years
  - 15 years

This report presents an executive summary of the detailed EMECRID Strategic Research Agenda highlighting key contributions to achieving the Vision.

3.1 COMPETITIVENESS

Vision Objective

Enhance worldwide competitiveness through knowledge-driven development and intelligent design and production processes.

Research themes

Maximum efficiency in every part of the propulsion system will be the key competitive advantage to achieve economic and environmental targets. Integrated hull and propulsor design tools will maximise propulsion efficiency for the next generation of ship designs. A range of new propulsion technologies is required to achieve a step change. Large area (paddle wheel, 'whale tail' or bio mechanical) propulsors offer major improvements in propulsion efficiency. Efficient robust actuator technology is required to realise these concepts in practice.

Electric propulsion can offer new propulsion system configurations providing for increased ship design flexibility, lower build and operating costs. Electric propulsion development requires reductions of number, cost, size and weight of the electrical equipments; alternators, transformers, frequency converters, generators and electric motors. High-speed drives and generators offer low weight and size reduction. New permanent magnet and super-conducting motor technology will enable very efficient new rim driven propulsors, thrusters and waterjets.

Whilst prime movers have achieved significant improvements in thermal efficiency further improvements are still possible through the development of more capable materials thereby allowing higher operating temperatures and pressures. Typical applications would include turbochargers and injection systems. Additionally a very significant percentage of the original equipment cost comes from the material costs, better materials and utilisation of materials will yield cost benefits.

Innovative use of alternative materials, such as composites, light alloys and metal matrix composites will facilitate changes in ship construction thereby permitting better utilisation; as well as potentially benefiting production cycle times and hydrodynamics.

Longer term ship level energy optimisation will lead to the use of multiple energy sources such as wind, solar, wave and hydrogen/LNG via fuel cells in addition to a traditional internal combustion engine. This will require the continued development of technologies such as photovoltaics, fuel cells and next generation sails with a particular focus on how to apply these technologies in a marine environment.

Route Map

5 years

Large scale bio-mechanical propulsors demonstrate big efficiency gains

New hybrid electric drive concepts offer increased efficiency, reliability and reduced Life Cycle Costs

New power generation concepts combine prime movers and advanced generators integrated with innovative high voltage dc distribution nets

New high strength materials operate at higher temperatures and increase prime mover efficiency

10 years

Large area propulsors integrated into new short sea ship designs

Integrated power and propulsion systems deliver reduced operating costs

15 years

Europe dominates new bio-mechanical propulsion market

European propulsion systems power an increased proportion of the world merchant fleet

Emerging nano-technology techniques are applied to material in use in the marine environment to further optimise designs and reduce costs

Photovoltaic and wind/wave energy technologies are applied to advanced hybrid propulsion systems

3.2 PRODUCTION AND INTEGRATION PROCESSES

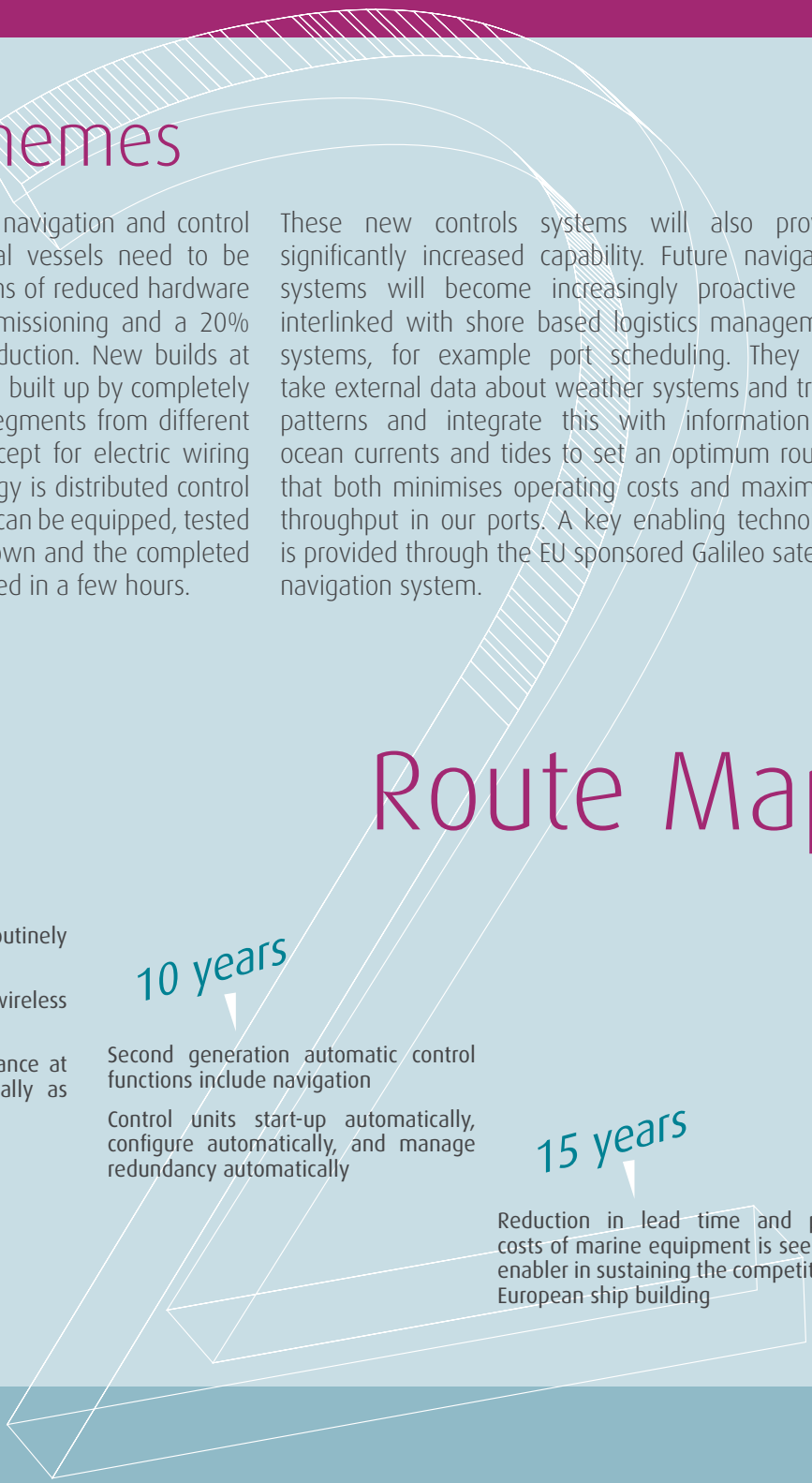
Vision Objective

Improve production and integration processes enabling the shipyards to reduce the overall lead-time (ship contract to delivery) by 40%.

Research themes

Next generation automation, navigation and control systems on-board commercial vessels need to be substantially improved in terms of reduced hardware cost, easier installation, commissioning and a 20% to 30% maintenance cost reduction. New builds at European shipyards, which are built up by completely modular and pre-equipped segments from different locations, require a new concept for electric wiring and control. The key technology is distributed control systems, where one segment can be equipped, tested and set into operation on its own and the completed segments can be commissioned in a few hours.

These new controls systems will also provide significantly increased capability. Future navigation systems will become increasingly proactive and interlinked with shore based logistics management systems, for example port scheduling. They will take external data about weather systems and traffic patterns and integrate this with information on ocean currents and tides to set an optimum routing that both minimises operating costs and maximises throughput in our ports. A key enabling technology is provided through the EU sponsored Galileo satellite navigation system.



Route Map

5 years

Automation control functions are routinely performed on local level

Control units communicate by wireless means

Control functions are tested in advance at local level and merged automatically as segments are put together

10 years

Second generation automatic control functions include navigation

Control units start-up automatically, configure automatically, and manage redundancy automatically

15 years

Reduction in lead time and production costs of marine equipment is seen as a key enabler in sustaining the competitiveness of European ship building

3.3 RISK REDUCTION

Vision Objective

Minimize safety, security and commercial risk for operators, e.g. by practicing goal based standards in design, production, approval and operation.

Research themes

Future generations of passenger ships, such as cruise liners, ferries, RoPax, and specialist vessels such as dredgers and offshore will require enhanced redundancy of drive and control concepts to fulfil the demands of safe, economic and environmental friendly operation of the vessels. The main objective is a holistic approach concerning the complete power part of the propulsion system determined by a goal /risk - based approach over the whole lifecycle of the ship. This encompasses the development and design phase and covers approval, production, commissioning, operation and the logistic aspects including spare parts, maintenance and training of the crews.

Route Map

5 years

Innovation constraints of rule-based design will be replaced by risk-based design of new concepts

10 years

Risk-based design justified by equivalence procedure

15 years

Regulatory bodies approve risk based design standards

3.4TRANSPORT INTEGRATION

Vision Objective

Develop advanced system solutions for a new generation of special ships including corresponding landside infrastructure, thereby optimising the inter-modal transport chain.

Research themes

New control and operation systems will enhance automated dock operations and enable agile port facilities with reduced turn-round times and greater efficiency and throughput. Automated mooring and docking systems will provide safe deck and shore side environments significantly reducing risks to ship and port personnel.

The end-to-end approach to transport logistics will enable fast sea freight to compete with air transport for a more economic and environmental cost effective solution for time sensitive cargo.

European motorways of the sea will take an increasing share of European internal trade as investment in the port infrastructure and automated cargo handling systems significantly reduce trans-shipment costs and ship turn round times.

Real time automatic scheduling systems will take into account navigation, port, authorities and hinterland distribution systems to optimize cargo movements and to minimize congestion and pollution. Fleet management decision support systems will maximize ship cargo capacity to approach the optimum 'full vessel' utilization.

Route Map

5 years

Conceptual design of automated docking systems

First fully automated dock operational

Real time scheduling systems developed

Fast sea freight routes committed

Agreement on standardisation European transport containers

10 years

Automated mooring/docking capability on new short sea ships

Fast sea freight routes in operation across the Atlantic

North-South and Mediterranean sea motorway routes well established

15 years

European short sea shipping fleet transports 50% of European cargo

3.5 THROUGH LIFE COST REDUCTION

Vision Objective

Reduce the through life cost of equipment by 30%.

Research themes

Energy efficient power management and propulsion monitoring system designs are required for multiple engine/drive installations. System modelling tools are required to analyse the performance of a range of propulsion options for different ship designs. The operating characteristics and whole product cycle environmental impact and cost will be used to optimise the design at system level. Case studies of propulsion system LCC will provide operating databases and model validation.

Electric actuation of steering, manoeuvring, deck machinery and other equipment will increasingly replace hydraulic systems with reduced footprint, more flexible installation and longer maintenance free operation. Increased modularity of systems will reduce costs.

Improved modelling of ships and ship systems in a seaway, to better understand the dynamic loading on ships equipment, will support a design capable of meeting the reliability requirements and avoid unscheduled maintenance.

New materials and treatments will be developed to prevent corrosion and marine growth on hulls, to increase the interval between re-treatment and minimise drag/fuel costs. Materials with improved fatigue properties could potentially use the nano-structured approach.

Route Map

5 years

Integrated power management savings demonstrated by validated Life Cycle Cost modelling tools

High torque electric actuation and rim driven electric motors developed for steering gear and deck machinery.

Dynamic models of ships in a seaway increase understanding of the dynamic loading regime on ships equipment, especially the propulsion/drive train.

10 years

All new build ships use integrated power management to reduce LCC

15 years

Nano-structure materials are available with improved fatigue resistance and alternative smart/self repairing materials are developed.

3.6 SERVICE BUSINESS DEVELOPMENT

Vision Objective

Increase the service market share through innovative after sales, maintenance and training concepts.

Research themes

European leadership in the world equipment market is the platform for service business expansion. Technology investments are required to deliver innovative service improvements. All high value equipment needs to have Equipment Health Monitoring (EHM) systems embedded into the design. Equipment through life reliability models will be required to provide the prognostic capability to deliver condition-based maintenance. Development of in service performance databases and innovative intelligent pattern recognition tools will deliver robust maintenance planning information. This will maximise the availability of the ship and its asset value.

As part of monitoring there is a new research stream exploring self-monitoring materials that announce that they are nearing failure, this needs to be evaluated and utilised where appropriate within the marine equipment industries.

EHM systems should simplify operation and allow reduction of staff and engineers onboard. This functionality should be integrated with the ships automation and control system and use common monitoring and communication systems. Remote shore based EHM control centres need to be developed and linked to fleet operators.

Consistent with the risk/goal-based approach to design, approval and production it will be necessary to develop risk/goal based techniques and tools to create maintenance schedules. The acquisition of data from operation will assist the application of 'risk based design' by providing a very much enhanced understanding of how equipment is being operated as well as facilitating active risk management.

Route Map

5 years

EHM embedded in all major new ship systems

System suppliers provide total care services to operators

New tools and techniques deliver risk/goal based maintenance schedules

10 years

Increased intelligence in on-board EHM provides on line reconfiguration and performance optimisation

15 years

No in service failures of critical systems.

Service EHM data feeds back into designs with increased lifetime and operating efficiency

3.7 ENVIRONMENTAL PROTECTION

Vision Objective

Maintain and improve environmental leadership through technical innovation.

Research themes

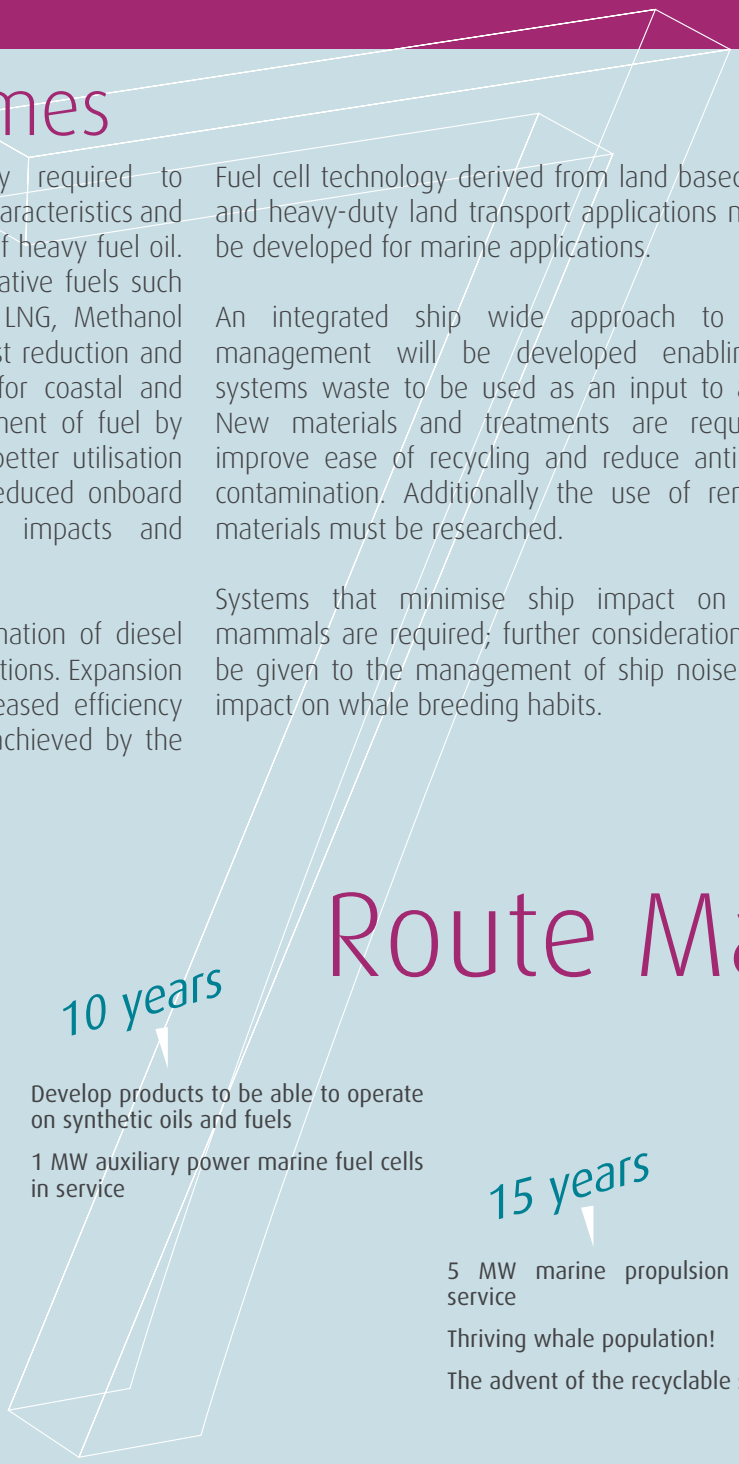
Expensive measures are currently required to improve fuel handling, combustion characteristics and emissions that negate the low cost of heavy fuel oil. Fuel processing and supply of alternative fuels such as Rapeseed Methyl Esters (RME), LNG, Methanol and LPG, must be researched for cost reduction and environmental benefits, especially for coastal and short sea shipping. Improved treatment of fuel by the fuel supply chain would bring better utilisation of vessel design for cargo space, reduced onboard workload, reduced environmental impacts and improved engine life.

Research is required into the reformation of diesel fuel for future marine fuel cell applications. Expansion of electric power options with increased efficiency and environmental benefit will be achieved by the adoption of high power fuel cells.

Fuel cell technology derived from land based power and heavy-duty land transport applications needs to be developed for marine applications.

An integrated ship wide approach to energy management will be developed enabling one systems waste to be used as an input to another. New materials and treatments are required to improve ease of recycling and reduce anti fouling contamination. Additionally the use of renewable materials must be researched.

Systems that minimise ship impact on marine mammals are required; further consideration should be given to the management of ship noise and its impact on whale breeding habits.



Route Map

5 years

Operate on low sulphur fuels

Prototype 250 kW marine fuel cell at sea

Improved low environmental impact anti fouling treatments

Fully integrated and energy optimised ship systems

10 years

Develop products to be able to operate on synthetic oils and fuels

1 MW auxiliary power marine fuel cells in service

15 years

5 MW marine propulsion fuel cells in service

Thriving whale population!

The advent of the recyclable ship

3.8 SECURITY

Vision Objective

Reduce loss of life and incidents, such as hull loses, by enhancing equipment safety and security technologies.

Research themes

Maritime security will be an increasing priority for both cargo and passenger protection. A range of new technologies provide solutions and benefits that need to be researched and integrated into the Maritime transport chain. The following technology areas have been identified:

- **Modelling of complex security systems**
- **Standardised, maritime Intel communication and database technologies**
- **Data fusion and threat analysis based on Intel and complex multi-sensor systems**
- **Global tracking and reporting of vessels/Vessel Traffic Management systems**
- **Coastal surveillance with high-definition radar sensors**
- **Protection of particularly sensitive locations against underwater intruders**
- **Autonomous underwater vehicles for survey operations**
- **Efficient none-lethal measures to deter intruders**
- **Mobile CNRN sensors for on-board cargo inspection at sea**

Whilst sharing some similarities with security systems safety management can be enhanced through improving sensor technologies and alert algorithms used in monitoring systems. This will result in earlier and more dependable warnings. Where possible the alert systems should be married to automatic counter measures such as fire suppression. New technologies such as smart valves should be developed to create self-healing systems.

New materials and innovative applications will increase safety and decrease commercial risk by e.g. guaranteeing intrinsic fire survivability.

Automated mooring and docking systems will provide safe deck and shore side environments significantly reducing risks to ship and port personnel. Improved equipment health monitoring and predictive tools will prevent failure of critical systems at sea.

Route Map

5 years

Automated docking

EHM on critical systems

Marinise security technologies developed in other transport sectors (e.g. aerospace) for wholesale use in marine applications. Where necessary to be integrated with the ship management systems.

Develop the procedures necessary for the successful deployment of these security and safety technologies.

10 years

Agile port facilities with no docking accidents or injuries

Develop ambient intelligence for security applications

Develop advanced simulations and models to enable the derivation of improved incident management plans

'Smart sensor' technology in use

15 years

Intelligent models and algorithms are capable of interpreting the growing volume of intelligence specific to maritime security

Strategic Research Agenda

Ship Systems	WG A Power & Propulsion Systems											WG B Steering and Stability				WG C Control, Navigation and Communication Systems	
Sub systems and sub divisions	Diesel	Gas Reciprocating	Gas Turbine	Fuel Cells	Propellers & Thrusters	Waterjets	Pods	Large Area Propulsors	Jet Propulsion	Mechanical Drive	Electric Propulsion	Steering	Stabilization	Mooring	Anchoring	Navigation	Communication
Critical Technology	Alternative fuels & fuel treatment				Blade hydrodynamic design							Dynamic positioning				Collision avoidance	
	Alternative cycles				Propulsor/hull structure interaction							Rudder stabilisation				ECDIS & routing decision support	
	Engine management systems				New materials strenght and lifetime							Ride control				Satellite navigation & communication	
	Exhaust gas treatment				Rim driven motors							Automatic mooring systems				Goal based control system design and risk analisys	
	Compact, efficient, marinised heat exchangers				Superconducting and permanent magnet motors												
	Component design				Systems integration design tools							System integration design tools					
	Fuel cell marinisation																

Matrix

WG D Electricity, Automation and Safety Systems							WG E Cargo Handling/Ship Shore Interface			WG F Environmental Systems, Ducting & Pipework				WG G Materials, Processes and Accomodation		
Power Generation & Distribution	Automation	Data Management	Fire	Evacuation & Rescue	Pressure Containment & Relief	Flood Control	Caro Handling Systems	Ship Design	Port Facility Design	Noise & Vibration Control Systems	Ballast Water	Exhaust Emissions	HVAC, Duct & Pipe Systems	Materials	Processes	Hotel / Accomodation Services
Condition monitoring & asset data management			Systems analysis				Guided vehicles			Exhaust treatment				Light metal alloys		
Availability, reliability & maintainability modelling			Risk analysis				Transport unit design			Ballast water treatment				Polymers and composites		
Life cycle cost & integrated logistic support tools			Damage control				Automatic lashing			Environmental accident management system				Nanostructure design		
Power converters			Security and passenger/ goods tracking system				Automated storage and retrieval systems							Environmentally friendly and renewable materials		
Superconducting and permanent magnet generators & components							Optimisation of cargo storage							Fire survivable materials		
System integration design tools							Unmanned deck			Noise & vibration isolation				Fatigue resistant materials		
Automated operations							Decision support system for loading/ unloading									

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