Maritime research and innovation for the future
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Table of contents

Lighthouse - a Swedish maritime competence centre ........................................ 2

Challenges and prospects ........................................... 4

Prioritised areas .................................................. 5

Integrated transport systems and business models ...................................... 6

Evaluation and reduction of negative effects shipping has on the climate, environment and public health ...................... 8

Alternative energy for ship propulsion and energy supply .......................10

Energy efficiency within the maritime sector ..............................................12

Financial incentives to support transition to sustainability within the maritime industry ........................................14

Innovative shipping concepts and naval architecture ..............................16

Advanced maritime operations .................18

Maritime safety .........................................................20

Sustainable working conditions within the shipping industry ...............22

Maritime informatics ...............................................24
Lighthouse - a Swedish maritime competence centre

Lighthouse gathers leading maritime stakeholders through a Triple-Helix collaboration comprising industry, society, academies and institutes to promote research, development and innovation within the maritime sector with the following vision:

Lighthouse – for a competitive, sustainable and safe maritime sector with a good working environment

Long term goals of Lighthouse:

• Implement ground-breaking changes in the maritime sector; in the entire logistics chain as well as in separate divisions.
• Reduce any negative effects on the climate, environment and health by increasing energy efficiency, reducing the discharge of harmful emissions and improving working conditions within the industry.
• Provide the maritime sector with scientific recommendations with regards to policy making and changes in legislation within and outside of Sweden.
• Promote export and increase job opportunities within the Swedish shipping and maritime industry.
Lighthouse facilitates collaboration of interdisciplinary research, development and innovation by:

- Creating collaborative research and networking platforms
- Providing support and resources for maritime research
- Creating interest in maritime research

Lighthouse areas of focus to achieve the vision:

- Competitiveness through innovation
- Climate and environment
- Maritime safety and working conditions
Challenges and prospects

Shipping - for a sustainable society

Approximately 90% of all goods today are transported by sea. The entire transport industry faces the challenge of an ever increasing demand for transportation and the need to develop a long-term sustainable transport system, a prerequisite for the continued advancement of public services. Faster renewal and development of different areas of the transport system is required within the shipping industry, as well as the role and function of the shipping industry in a cohesive transport system.

Lighthouse is focusing on long-term development, research and innovation and is supported by platforms for demo projects, such as the Zero Vision Tool. Access to skilled and highly qualified people in all areas is important to achieve a competitive and sustainable maritime sector, both in the short- and long-term. Research and education are closely linked. First class research is essential to providing cutting edge educational opportunities. Research, innovation and enhanced expertise require higher education and illustrate why education is central to making the maritime industry sustainable.

Shipping and marine technology – an area of Swedish advancement

The Swedish shipping industry, marine technology companies, as well as academia and institutes within the maritime sector are renowned worldwide for being progressive, having adapted to international demands and being at the forefront of maritime research and innovation.

The opportunities for innovation, shipping and marine technology companies, universities and public services are significant in the growing global market. The collaborators within Lighthouse aim to develop the industry further; from research and innovation in different areas such as industry terms and business models, to innovation in logistics, navigation, energy efficiency and alternative fuels. For instance, close collaboration between industry and academia presents opportunities for success within the EU Framework Programme Horizon 2020.

With continuous focus on reinforcing the expertise within the industry, the Swedish shipping industry will strengthen its position and establish itself as pioneers in developing the shipping industry of the future.

Together we join forces for a sustainable future.
Prioritised areas

The following pages introduce areas prioritised by Lighthouse to achieve our vision and reinforce the position of the Swedish maritime industry, through innovations and endeavouring to find solutions to any climate, environmental, shipping safety and working condition challenges. These areas are:

- Integrated transport systems and business models
- Evaluation and reduction of negative effects shipping has on the climate, environment and public health
- Alternative energy for ship propulsion and energy supply
- Energy efficiency within the maritime sector
- Financial incentives to support transition to sustainability within the maritime industry
- Innovative shipping concepts and naval architecture
- Advanced maritime operations
- Maritime safety
- Sustainable working conditions within the shipping industry
- Maritime informatics
The focus of “Integrated transport systems and business models” is operation and innovation to establish a competitive and sustainable shipping industry within the context of trade, logistics, business finance and law. Shipping is essential for globalisation and prosperity, and fundamental to the international transport system.

In the past, shipping predominantly involved shore-to-shore trade. Today, shipping is being integrated into the public domain through processing, logistics and transport chains, as well as trade, capital markets, policy making and legislation. However, competition between different transport modes remain and the shipping industry increasingly carry the socioeconomic costs compared to other transport modes, whilst the industry is losing its competitive edge.

Shipping is part of an integrated transport system that supports efficient logistics. The demand for innovation from current stakeholders is high, whilst giving them the chance to streamline the industry and find new business.

The scope for new stakeholders, with new ideas and technology, is the potential to support as well as challenge existing stakeholders to take advantage of the potential of current information technology.

Shipping is essential for globalisation and prosperity

Important areas:

• New and improved means of handling the flow of door-to-door freight. New roles, business models and support systems to streamline the handling of goods, money and information.

• Enhanced synchronisation, planning and communication to facilitate speed reduction at sea whilst maintaining profitability and satisfied customers.

• Expertise and methods to analyse the effect any changes to legislation and support has on logistics and commercial interests.

• The role of shipping in national and local transport.
Sea freight generally generate less carbon dioxide emissions per unit transported goods compared to other transport modes, although negative environmental and public health effects still remain due to different marine and air pollution. Both the Swedish and the international shipping industry face vast challenges in reducing pollution from nitrogen and sulphur oxides, particles, oils, chemicals, sewerage, scrubber water, and harmful antifouling paint substances, as well as the task of reducing the proliferation of invading alien species and underwater noise pollution. Development and installation of new emission reducing technology are essential to meet environmental objectives, but can also increase the competitiveness of the Swedish shipping industry and benefit Swedish merchant fleet subcontractors.

Research quantifying the effects shipping pollution has on the environment and public health is a prerequisite for the incorporation of new legislation, financial incentives and innovations in the environmental area. Research should define the time scale and what geographical impacts can be expected of any work undertaken to promote protecting the environment. Environmental and socio-economic advantages and disadvantages of any environmental measures must be weighed against each other since measures to reduce one type of effect can lead to an increase in different types of emission.

An increasing number of stakeholders take advantage of the sea as a resource, whilst the need to protect the marine environment is increasing. Today, some of the most heavily trafficked shipping routes in the vicinity of Sweden cross protected and vulnerable marine areas. Research assessing future shipping routes are needed in Sweden as well as globally, in the ongoing marine planning process.

Both Swedish and international shipping industry face vast challenges in reducing pollution.

**Important areas:**
- To quantify any negative climate, environmental and public health effects of shipping pollution in the air and water.
- Evaluation of environmental and economic benefits of different measures of pollution reduction.
- The role of shipping in marine spatial planning processes and evaluation of shipping routes.
The challenges faced by the shipping industry related to the propulsion of ships include stricter legislation to reduce sulphur dioxide and nitrogen dioxide emissions within the Emission Control Area (ECA) in Europe and North America, to reduce emission of particles and black carbon in polar areas, and to achieve a fossil fuel free shipping industry. Stricter emission legislation is also expected in Japan and the Mediterranean. By 2020, introduction of stricter shipping fuel sulphur regulations will be in force (max. 0.5% sulphur levels) within the entire European Union, and globally latest in 2025.

Additional ECA areas are also expected in Japan and the Mediterranean, including reducing such emissions as particles and black carbon. There is demand for solutions to be implemented in the near future (2020 perspective) as well as long-term solutions (2050 perspective).

Alternative fuels thus need to have minimal negative environmental effects with regards to combustion emissions or accidental spillage. All new technologies and energy carriers must be evaluated from a sustainability perspective, such as life cycle analysis or other environmental system analysis methods.

**Important areas:**

- Alternative fuels and fuel production for combustion engines, including evaluation of the fuel chain with regards to methanol, liquefied natural gas (LNG), etc.

**All new technologies and energy carriers must be evaluated from a sustainability perspective**

- Production of electro fuels and its role in the energy chain as energy storage.

- Development of energy and emission efficient engine concepts for alternative energy carriers.

- Electricity as an energy carrier, through diesel-electric operation, hybrid operation, electric power in local applications, energy storage in batteries and solar cells.

- Development of alternative propulsion fuels and saving energy through wind propulsion.
Energy efficiency within the maritime sector

The growing demand for transportation results in increased energy usage and emissions, affecting public health and the environment. It is essential to extend short-sea shipping in the EU in order to reduce the pressure on existing onshore infrastructure and to achieve emission targets. There are no simple solutions for reducing shipping pollution – a radical energy efficiency approach is called for.

The area of energy efficiency aims to implement alternative shipping designs, order processes and operation methods, as well as increase knowledge of energy efficiency measures within all the different parts of the global logistics chain.

There are several effective techniques for energy savings that reduce fuel consumption. To improve accuracy in the design of these techniques, it is important to develop trustworthy and experimental computation methods that lead to real energy efficiency gains in order to avoid unnecessary expenditure through inadequate conversion of vessels.

Important areas:

- New and innovative measures improving energy efficiency, including everything from ship design, technical modifications to improved logistics solutions, contracts and legislation.

- Methods for verifying measures to minimise any doubts with regards to costs, possible savings in actual operation and other environmental effects. Development of measures within this area is required.

- Improved practice. Research into the practice and organisation of energy efficiency is needed.

- Climate control. The transition to reducing any negative effects on the climate by the industry must be governed through legislation, standards and indexing, etc. Research is needed to obtain knowledge on which actions should be taken and facilitation of the transition.
The Swedish shipping industry has demonstrated in projects, such as the demonstration platform Zero Vision Tool, various technical opportunities and solutions to meet a broad range of sustainability challenges. There are still unexplored solutions and existing techniques can be developed further. However, a significant challenge is that large-scale commercial utilisation is not in demand until legislative requirements are in force and the market is free. Hence, development of new techniques is a financial risk for shipowners and ports, who carry the initial investment costs, as well as for technology suppliers. Consequently, users wanting to be at the forefront end up carrying the immense costs of development. Some technologies are also reliant on a surrounding system or infrastructure to be introduced on a large scale.

To date, knowledge needed to correctly evaluate any socioeconomic benefits and costs from shipping, and the gap between societal and business profitability is lacking for several fuels and technologies. An evaluation of alternatives based on current knowledge of the effects on businesses and society can be made before developing a structure for incentive. Examples of tools include indices as a means to measure and to communicate sustainability performance, differentiated fairway- and port fees, allowances and loans for “green investments”, bonus-malus systems and trading with emission rights from a wider perspective.

**Knowledge needed to correctly evaluate socioeconomic benefits and costs from shipping is lacking**

**Important areas:**

- Socioeconomic calculations highlighting benefits and costs of freight transport and of shipping for a wider use and implementation.

- How different types of incentives can support step-by-step management control measures to facilitate faster and continuous transition towards sustainable shipping.
The development of ship systems for sustainability in future transport system calls for lightweight structures, well-tuned to their role in the system. Ship system development and the transition towards legislation based on functionality put new demands on knowledge and understanding of classical Naval Architecture topics, such as hull structural design and choice of construction material, stability, seakeeping and propulsion. Furthermore, system issues, such as the life cycle of the ship system and its impact on the complete transport system, society and the environment must be addressed concurrently.

Today, methods to technically assess and evaluate new concepts; e.g. unconventional hull shapes, designed in untried materials or equipped with novel propulsion systems, are limited. There is, for instance, a great need to improve methods to effectively predict erosive propeller cavitation, since propeller design is fundamental for optimisation of ship design and successfully achieve better performance.

A great potential exists to improve the entire efficiency of a ship by adopting a comprehensive view of ship design, where consideration is taken to operational profile, sea state and working conditions for the crew. Research is needed to generate concepts and evaluate concepts from a system perspective. Technical research is very important, although due to the system and sustainability aspect, research and sharing of information between disciplines is equally essential.

Important areas:

- System modelling including how ship concepts impact the entire transport system; its efficiency, function and impact on the environment.
- Ship design comprising expertise from both technology and the operator.
- Control system and propulsion.
- Stability and seaworthiness.
- Lightweight materials, structures and production methods.

There is a great potential to improve the entire efficiency of a ship by using a comprehensive view of ship design.

Innovative ship concepts and naval architecture
Advanced maritime operations are commonly featured in shipping today. New areas for the use of natural resources are being made available and offshore operations are becoming increasingly important. Ship sizes are increasing at the same time as the area in which they operate is being limited; mainly because of increased traffic, increased competition for space or geographical limitations due to size. Higher demands are put on the crews of the ships and the different operational systems for manoeuvring and propulsion. As rapid technical advancement to ease operations through various instruments is taking place, reliable systems are needed.

This area of interest is related to the development of robust positioning systems, operational and manoeuvring support, as well as research related to communication between humans/technology/organisation. Also included are development and innovation activities, including but not limited to, the development of advanced navigational assistance, streamlining through traffic and route optimisation, including dynamic route separation, anomaly detection and predictions. The link to international initiatives such as e-Navigation, e-Maritime and intelligent transport is clear. The programme will also contribute to the development of maritime activities in harsh climates; arctic and cold climate technology and the development of icebreaking technology, including new models and processes supporting safe and environmentally friendly winter navigation. Ice has a major impact on transport and trade within the EU, hence ensuring efficient and safe shipping all year round is a challenge for the Baltic Sea region.

Important areas:

- Robust and redundant positioning systems with high positioning accuracy.
- Methods and decision making support systems for manoeuvring in complex operations.
- Solutions for increased safety and cost reduction in ice navigation and icebreaker management.
- Advanced offshore navigation assistance.
- Human/machine interaction aspects when introducing automated technology.
- Communication solutions including reliable connections and access to an onshore IT infrastructure.
Maritime safety

Shipping faces a number of challenges, one of the most important being safety. A shipping accident can have major consequences, not only loss of human lives but also impacts in terms of environmental and financial after-effects. Maritime safety covers a broad spectrum of topics, divided into legislation, organisation, education and training, construction of ships and equipment, and operations.

In maritime operations, safety can be divided into different proactive measures, that all aim to mitigate and reduce the impact of accidents. Fire prevention is an example of a pro-active action, while other measures to reduce negative impacts of an accident includes fire fighting and rescue operations.

Development of methods to identify safe nautical behaviour is important for maritime safety and includes the requirement for onshore and shipping surveillance, verification, optimisation and forecasting. Risk analysis is fundamental for development of maritime safety and development is also needed in the historic static level and dynamic processes.

Design of ships and equipment require continuous back-up by research activities, in order to maintain required safety levels. Research can advise in the development and interpretation of new legislation. The activities can be divided into thematic areas such as arctic shipping, design of future ultra-large vessels, design of specialised vessels, ship motion and stability. Maintenance issues related to corrosion and fatigue which influence the design and safety level of aged ship structures is a field of growing interest world-wide.

It is also important to include operational aspects such as navigation, search operations as well as leadership and education. Simulators and field tests are important tools for this type of research.

Important areas:

- Development of methods, organisation, training and procedures for Search and Rescue, Evacuation and Escape.

- Applied safety, including safety culture, operating standards and regulatory systems to be integrated in complex maritime operations.

- Operator performance, examining physical and cognitive capacities.

- Proactive user friendly design, integrating human performance into the design of complex socio-technical systems in order to prevent accidents, onshore and ship based surveillance and decision-making support.
Sustainable working conditions within the shipping industry

Sustainable working conditions contributing to a long and continued working life is a strategic challenge on a national as well as a global level. Demographic development has led to the workforce having to continue stay in employment to a higher age.

Simultaneously, technical development and administrative systems are becoming more and more complex and demanding more attention by the operator, who needs to monitor, control and handle new situations.

Important areas:

- Effects of working conditions, working tasks and organisation of work and the characteristics of safe, healthy and effective working conditions on board.

- Interaction between management, executives and staff in a multicultural environment with geographically distant working sites and how the leadership relates to gender issues and equality.

Design of the working environment, systems and tools affect the performance of staff as well as their health and well being. Such aspects also affect the efficiency and competitiveness of organisations, as well as costs for bad health and production losses on a socio-economic level.

- The design, implementation and maintenance of technical and administrative systems to increase usability and minimise the risk for sub-optimisation, malpractice, accidents and bad health.

Research for a safe, healthy and effective workplace on-board
Maritime Informatics studies the usage and utilisation of digital systems within the maritime sector and how it can lead to increased efficiency of operations, safer shipping and greater profitability for the industry. Shipping is based on the interaction between different stakeholders and digitalisation has facilitated integration between different maritime stakeholders, such as shipping companies, ports and purchasers of transport. Maritime informatics can facilitate for other prioritised areas, the entire transport system and for different areas of maritime operations.

Two important aspects of the maritime transport system, where digitalisation creates opportunities, are efficiency and safety of maritime activities. New stakeholders have been introduced, creating opportunities for improved integration between different systems in different parts of the digitally connected ship, between ships, with onshore assistance (e.g. remote operation and detection of route deviation) as well as between different onshore devices.

Digital platforms must provide an environment that facilitates sharing of information based on trust among involved stakeholders. By providing information from various sources, opportunities for innovation by new and existing stakeholders are created as well as opportunities for third-party developers, who could offer innovative services and increased safety. Thus, Maritime Informatics addresses safety issues for maritime operations and collaboration in information.

**Important areas:**

- Distribution and recovery of data streams from various sources (such as sensors, Automatic Identification System (AIS), future AIS systems, crowd sourcing).

- Analysis of large amounts of data from various data sources (sensor fusion), which can be used to identify and create new, more or less technology influenced innovations (decision support systems, streamlining of management, etc.).

- Digital platforms for information and service interaction.

- Legal and commercial conditions for increased information collaboration between maritime stakeholders.

- Maritime safety – to understand and overcome the challenges that exist for different data owners to share such information that has previously been considered a competitive advantage.