European Technology Platform of the Waterborne Industries

Maritime Europe Strategy Action

SEVENTH FRAMEWORK PROGRAMME

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THEME 7: Transport (including Aeronautics)

TTG4 e-Maritime: Publication on e-Maritime for shipping and port operations

Maritime Europe Strategy Action

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Description of the Task:

Task 4.5: Publication on e-Maritime for shipping and port operations

Objective:

To produce a booklet summarising the state-of-the-art in e-Maritime, outlining the main opportunities for implementation, and highlighting some of the most promising activities.

Description:

To secure good visibility and prominence for the work of the e-Maritime Thematic Technology Group, and to assist in the promotion and acceptance by the wider industry of its conclusions, a booklet will be produced, summarising the state-of-the-art in this area, outlining the main opportunities for implementation and highlighting some of the most promising activities, in clear, business-oriented language.

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1 Executive Summary

The aim of this deliverable is to produce a publication summarising the state-of-the-art in e-Maritime, outlining the main opportunities for implementation in shipping and port operations, and highlighting some of the most promising activities in clear, business-oriented language. This publication will also provide visibility for the recommendations of MESA's e-Maritime Thematic Technology Group, for the promotion and acceptance of its conclusions by the wider industry.

A number of EU and nationally funded research and development projects have addressed the issues of automation, information and communication technologies in maritime transport, port operations and logistics (**Annex 1**). But what are the main opportunities for innovation for connected and automated maritime transport in order to meet future challenges? The MESA project was launched in order to address this question, in parallel with other specific areas of technology.

Connected and automated maritime transport is the future for the European maritime industry. Digitalisation and communication technologies will create new services to support the shipping sector and logistic chains will become more integrated for all modes of transport.

The direct benefits that are expected to be delivered are:

- Optimisation of operations and processes.
- More efficient use of fuel.
- Reduction in human errors leading to improved safety and quality of service.

This publication identifies key ICT innovations that will address future maritime requirements and affect almost all aspects of connected and automated maritime transport processes. Opportunities for improving competitiveness, safety, and security are also identified.

Information and Communication Technologies (ICT) for Maritime Connected and Autonomous Transport

The European Commission have been actively promoting competitiveness of the European maritime transport sector and a more efficient use of resources through increased automation and better use of Information and Communication Technologies (ICT). The core vision is to enable a seamless information exchange in the sector to streamline transport operations, increase safety, improve competitiveness and reduce the environmental impact.

In recent years, advances in information and communication technologies have created a demand for new forms of surveillance and information management systems; these are increasingly driven by policy and governance addressing safety, security, and sustainability. This is reflected in the emergence of the IMO's e-navigation concept and the more embracing European Commission's e-Maritime framework established for measurable economic, social and environmental benefits.

Despite recent progress on the EU's e-Maritime initiative and the IMO's e-navigation concept, more still needs to be done to achieve the stated objectives for improved competitiveness and reduced administrative burden for the European maritime transport sector; and for improved vessel safety and security, operation, and traffic management.

Future Challenges

The challenge is to create solutions for connected and automated maritime transport that address future requirements and have a significant impact across a broad range of stakeholders,

ship, port and logistic operators, so as to ensure industry take-up and long-term user driven developments. In the maritime transport sector, vast amounts of data are available that could support new business opportunities to improve the logistics and ship operation. Value added services for better freight transport management could be developed for intermodal transport and data on vessel traffic and for e-navigation could improve safety, environmental performance and competitiveness.

Key ICT Innovations

There are a number of key ICT innovations that will address future maritime requirements and affect almost all aspects of connected and automated maritime transport processes: robotics and autonomy, autonomous vehicles, simulation and optimisation, open system integration, the Internet of Things (IoT) and Big Data Analytics, Cyber-physical systems, Internet of Services, Cloud-computing, Augmented and virtual reality simulation, and cybersecurity.

The next generation of connectivity between ship and shore will be dominated by a variety of new communication technologies, including most importantly, satellite communications. These technologies will help to reduce costs by enhancing operational efficiency, automating processes, improving safety and security, and reducing environmental pollution.

ICT Maritime Opportunities for 2030

The rapid development in information and communication technologies will significantly increase digitalisation in all waterborne sectors and lead to data-driven services such as optimising energy use and fuel efficiency, vessel performance and condition monitoring, and weather routing. A higher degree of systems automation, the availability of smart sensors and global networks for data transfer between ship and shore will promote remote controlled, and semi or fully autonomous operation of assets.

The requirements for maritime and connected and automated transport, (which includes e-Maritime and e-navigation), to address future impacts and challenges were based on forecasted trends and trend interdependencies. These requirements took into account market intelligence, predicted societal trends and the future regulatory framework, for all waterborne sectors. The principal outcomes from these trends represent the likely demands on the maritime industry through to 2030.

Research Priorities for implementing ICT Maritime Opportunities to 2030

Four research priority topics for future research, development and innovation, that are needed to address the impacts and challenges for Maritime Connected and Automated Transport, and for implementing the main ICT opportunities for Maritime Connected and Automated Transport, are indicated below:

- **Smart and Autonomous ships:** vessels with reduced manning levels, real-time monitoring of ship performance with automated information management and surveillance. Improved

integration with shore support centres for technical operation and remote maintenance with systems carefully protected from cybersecurity risks.

- **Smart and Connected Ports:** Smart ports with Digital infrastructure and ICT innovation: Robotics and automation, autonomous vehicles; the IoT and Big Data Analytics, simulation and virtual reality, and cybersecurity. Integration of national single windows with trade portals and port community systems: providing one entry point for all logistics, operational and administrative information.
- **European Marine Digital Highway:** Integration of navigation technologies with shore based data networks and centres with the corresponding navigational and communication facilities aboard ships to provide accurate, safe and secure "e-Navigation-based" ship traffic and transport management system for a marine digital highway.
- **European Integrated Transport Information System**: Improved interconnectivity and integration between transport modes based on sematic interoperability or common reference models and established systems. Open, reliable and transparent access to transport and trade information can also create new or change existing business models.

2 Information and Communication Technologies (ICT) for Maritime Connected and Automated Transport

The European Commission has been actively promoting competitiveness of the European maritime transport sector and a more efficient use of resources through increased automation and better use of ICT. The core vision is to enable a seamless information exchange in the sector to streamline transport operations, increase safety, improve competitiveness and reduce the environmental impact.

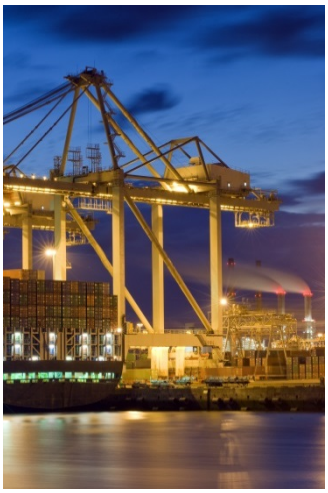
A number of EU and nationally funded research and development projects have addressed the issues of automation, information and communication technologies in maritime transport, port operations and logistics (Annex 1). But what are the main opportunities for innovation for connected and automated maritime transport in order to meet future challenges? The MESA project was launched in order to address this question, in parallel with other specific areas of technology for the maritime sector.

Connected and automated maritime transport is the future for the European maritime industry. Digitalisation and communication technologies will create new services to support the shipping sector and logistic chains will become more integrated for all modes of transport. The direct benefits connected and autonomous maritime transport is expected to deliver include: optimisation of operations and processes, more efficient use of fuel, and a reduction in human errors leading to improved safety and quality of service.

This publication identifies key ICT innovations that will address future maritime requirements and affect almost all aspects of connected and automated maritime transport processes. Opportunities for improving competitiveness, safety, and security of European shipping are also identified to address future challenges.

3 Introduction

Maritime transport is a major economic contributor in the EU as well as a necessary component for the facilitation of international and inter-regional trade on which the European economy is fully dependent. Improving competitiveness, safety, and security of European shipping is a major objective of the EU Maritime Transport Strategy, which in turn shapes the requirements for upgraded maritime transport information management.



In recent years, advances in information and communication technologies have created a demand for new forms of surveillance and information management systems; these are increasingly driven by policy and governance addressing safety, security, and sustainability. This is reflected in the emergence of the International Maritime Organization (IMO) e-navigation concept and the more embracing European Commission's e-Maritime framework established for measurable economic, social and environmental benefits.

Despite recent progress on the EU's e-Maritime initiative and the IMO's e-navigation concept, more still needs to be done to achieve the stated objectives for improved competitiveness and reduced administrative burden for the European maritime transport sector; and for improved vessel safety and security, operation, and traffic management.

Maritime and transport industries worldwide have developed specific systems and applications of ICT technologies for exchanging information in the maritime domain and many of which are comparable to what has been developed in Europe. European applications for ship operations and maritime transport are nevertheless considered to be state-of-the-art and more advanced in some areas such as in the logistics domain and Port Community Systems.

European shipping must remain at the forefront of innovation to stay competitive and sustainable. There is therefore a need to integrate shipping into the overall transport system and to improve vessel safety. More efficient ports and their connection to the hinterland are also needed as well as the provision of real-time data for ship operations from shore-based services. Digital information exchange technologies between the different actors involved in maritime transport, including automated data exchanges, have undoubtedly the potential to deliver huge opportunities and benefits.

The use of advanced information and communication technology in the maritime transport sector is not a new concept and although many of the existing systems are effective, most are not interoperable. The current priority has been to foster the use of advanced information technologies for working and doing business in the maritime transport sector in a seamless way, and to implement the necessary systems for the various domains and applications.

The need for waterborne transport will continue to grow towards 2030 and beyond, primarily driven by population growth and rising prosperity. More raw materials, finished goods, fuel, food and water will need to be transported globally and waterborne transport will remain the most cost efficient means of achieving this. Infrastructure and links to all other transport modes will grow and adapt in response.

Growth in global waterborne trade and activity will create significant new opportunities for the EU maritime industry, with its expertise in delivering high added value, sophisticated and inovative products and services. Waterborne transport will be an integral part of an efficient logistic chain. Connection with other transport modalities, or inland-waterway transport, will be seamless. Smart vessels will communicate with smart ports to limit congestion, waiting time and thus costs. Smart vessels will adapt their sailing speed to match harbour slots automatically.

4 Future Challenges

The challenge is to create solutions for connected and automated maritime transport that address future requirements and have a significant impact across a broad range of stakeholders, ship, port and logistic operators, so as to ensure industry take-up and long-term user driven developments. The EU's Integrated Maritime Transport Strategy opens new horizons for digital information exchange technologies; for example, the SafeSeaNet system is a core platform to contribute "upgraded EU maritime transport information management" linking other established systems such as e-Freight and e-Customs, the National Single Window, Port Community Systems, transport logistics management systems, and Galileo, as well as e-navigation developments for improved vessel safety and operation from shore-based management.

In the maritime transport sector, vast amounts of data are available that could support new business opportunities to improve the logistics and ship operation. Value added services for better freight transport management could be developed for intermodal transport and data on vessel traffic and for e-navigation could improve safety, environmental performance and competitiveness. There are numerous potential advantages in better exploiting available data and the use of information and communication technologies in transport and logistics, such as improved traffic management in ports and at sea, and reduced administrative cost of regulatory compliance.

The importance of smooth information flows is reflected in the development of tools to simplify access to maritime traffic and transport data. These tools are at different stages of development and implementation for waterborne transport, including inland waterways, as well as multi-modal transport.

4.1 Key ICT Innovations

There are a number of key ICT innovations that will address future maritime requirements and affect almost all aspects of connected and automated maritime transport processes: Robotics and autonomy, autonomous vehicles, simulation and optimisation, open system integration, the Internet of Things and Big Data Analytics, Cyber-physical systems, Internet of Services, Cloud computing, Augmented and virtual reality simulation, and cybersecurity.

The next generation of connectivity between ship and shore will be dominated by a variety of new communication technologies, including most importantly, satellite communications. These technologies will help to reduce costs by enhancing operational efficiency, automating processes, improving safety and security, and reducing negative environmental impact.

The improved maritime connectivity will have a significant effect on how the maritime industry manages information. Most ship systems, shore based support centres, ports, and integrated transport systems will be linked to the Internet. This will enable data streams from multiple sources to be combined for real-time decision making, leading to more efficient operations, as

well as more automated ships and guided vehicles. This will also have a positive impact on the safety of life at sea, and bring many benefits, such as reducing fuel consumption, remote condition monitoring, and more efficiently organised supply chains.

The emerging enabling ICT technologies for waterborne transport and logistics are similar to those found for multimodal transport[1] and some of the emerging ICT technologies have already been used in recent EU waterborne transport and logistics related projects:

- ***Cloud computing:*** With the rapid development of web technologies a new concept has emerged called: "cloud computing". In the maritime domain, the Cloud connects all maritime stakeholders with maritime information services of all kinds. This offers greater flexibility and enables both large and small companies to use the system.
- ***Wireless communication technologies*:** There is also an increasing use of wireless communication technologies (such as smart mobile phones, QR code, RFID and telematics tracking). As computer power is increasing exponentially and smart devices are getting more affordable and capable, this will allow people to be connected anywhere at any time. Such ubiquitous connectivity and network services enable real-time and extended visibility across the entire waterborne transport and logistics sectors, which is essential to handle increasing complexity.
- **Internet of Things (IoT)*:*** Web 3.0 provides the infrastructural framework supported by a new set of languages making use of the Maritime Cloud Technology to allow intelligent, contextual decisions of the sematic Web with the IoT to connect devices to connect an informative stream of data. The IoT can support the intelligent cargo concept for sustainable global logistics operations where goods are self-context and situation aware and connected to a range of services. The IoT is also essential for increased complexity of technical systems onboard, which is a prerequisite for increased automation, remote services and autonomy.

[1] Harris, I, Wang, and Y, Wang H. ICT in multimodal transport and technological trends: Unleashing potential for the future, Int. J. Production Economics, 2015.

- **Big Data Analytics:** The technological developments mentioned above will allow an increasing volume and detail of information to be captured from a variety of sources. These large data sets (so called "Big Data") will need to be processed using sophisticated analytics to significantly improve the decision making. Future decision support systems for managing ship and port operations and freight logistics are expected to utilise the developments of all the technological trends identified. Bid Data Analytics will optimise operational efficiency, traffic, and transport management, and improve competitiveness.
- **Augmented Reality (AR):** AR technology, where interactions with the real world environment are augmented by virtual images, graphics or other data is a potential application for managing ship's bridge operations or port resources. Future applications will connect the virtual world with reality to assist in more efficient decision making, such as navigation or improving the awareness of threats from pirates.
- **Robotics and Autonomy:** Systems automation, the availability of smart sensors and global networks for data transfer from ship to shore will promote remote controlled and autonomous ship operations. The development of remote-controlled and new types of robots that could be used to replace human-operators on board ships is closely linked to the development of other technologies such as sensors, Big Data analytics, and the IoT. New types of robots, called "SmartBots", will have the ability to carry out specific tasks autonomously.
- **Cyber-Security:** Increased communication between systems on board a vessel, leading to ships becoming a "system of systems", together with critical infrastructures becoming ever more interconnected, will require resilience to be built into those advanced technology networks, to reduce the risk from cyber-crime etc. Low connectivity and fragmentation within the supply chain have helped to protect shipping from cyber threats, but with a fourfold increase in the adoption of satellite communication on board vessels over 10 years, the issue is becoming much more critical. For example, if automated ports and automated guided vehicles (AGVs) were to become the dominant mode for transporting food supplies, this would pose significant risks, both in terms of supply security and the risk of introducing harmful substances in food.

5 What exactly is e-Maritime and e-navigation?

A longstanding problem in the shipping industry is the complexity and time involved in submitting reports when arriving in and departing from ports. Ship operators, masters, agents are still burdened with having to fill in paper documents which include similar information and to distribute them to different government authorities, including ports, maritime safety, security, customs, boarder control, and health authorities. This increases the cost and causes delays, reducing the competitiveness of maritime transport.

The European Commission has been actively promoting the competitiveness of the European maritime transport sector and a more efficient use of resources through the better use of ICT, with a core vision to enable seamless communication in the sector. The European Commission's e-Maritime initiative introduced in 2009 will lead to a paperless, streamlined and optimised logistics industry, leading to cost savings in administration and improved planning and scheduling of logistics activity.

e-Maritime can therefore be defined as the use of digital information exchange technologies between the different actors involved in maritime transport, including the ship's master and onshore stakeholders, and the interfaces with other modes of transport, in order to facilitate sustainable maritime transport.

IMO's e-navigation concept, which encompasses all aspects of ship operation, provides a global perspective for the European Commission's e-Maritime initiative, which is wider in scope covering logistic integration, in addition to purely nautical issues, which is the mandate of IMO. However, both make use of the same ICT technologies, processes and services and are considered complimentary in geographic scope and overlapping in objectives and technology.

5.1 The EU's e-Maritime initiative

Europe's e-Maritime initiative focused primarily on the shore-based facilitation and on the development of electronic technology, processes and services to facilitate the flow of goods over sea, and consequently the ships that carry these goods to and from and around Europe

The objective of the e-Maritime initiative was to promote "coherent, transparent, efficient and simplified solutions in support of cooperation, interoperability and consistency between member States, sectors, business and systems involved in the European Transport System"[2]. This objective is fully compatible with the Lisbon Agenda, the mid-term review of the Transport White Paper[3], the Blue Book[4] on an Integrated Maritime Policy, the information society and a range of other policies inspired from electronic means of communication.

The e-Maritime objectives are particularly relevant to the "Maritime transport strategy for 2008-2018[5], through supporting improved efficiency and quality of maritime transportation services to meet European economic, social and environmental needs in line with the Integrated Maritime Policy. e-Maritime is also closely related to the European Agenda for Freight Logistics[6], the European maritime transport space without barriers[7], and the e-Customs initiative[8]

5.2 e-navigation

IMO's e-navigation concept is primarily based on improved digital communications between ship and shore and ship and ship. The aim of e-navigation is to provide needed information, in electronic format, to a ship's bridge team to enhance the safety and efficiency of marine navigation. If the IMO's envisaged e-navigation solutions are realised then the concept of a Marine Digital Highway (MDH) can be achieved.

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[2] European Commission (EC) Green Paper "Towards a future Maritime Policy for the Union": a European vision for the oceans and seas COM (2006) 275

[3] Communication from the Commission to the Council and the European Parliament - Keep Europe moving - Sustainable mobility for our continent - Mid-term review of the European Commission's 2001 Transport White Paper COM/2006/0314

[4] "Blue Book" - An Integrated Maritime Policy for the European Union, COM(2007) 574-

[5] Specified in the Blue Book, which is the evolution of the Green Paper on "A Future Maritime Policy for the Union: a European Vision of the Oceans and Seas". COM (2006) 275

[6] The EU's freight transport agenda: Boosting the efficiency, integration and sustainability of freight transport in Europe, COM/2007/0606.

[7] Communication and action plan of 21 January 2009 with a view to establishing a European maritime transport space without barriers COM(2009) 10

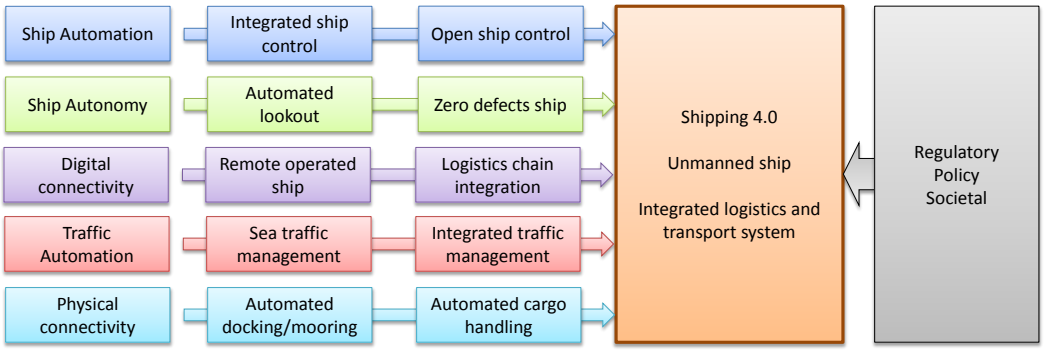
[8] European Commission Communication: A simple and paperless environment for Customs and Trade COM/2003/452

e-navigation encompasses all aspects of ship operation for safe navigation, including weather routing, minimising fuel consumption and emissions, and maintenance of onboard nautical information, as well as effective Vessel Traffic Services (VTS) and ship-port communication for optimised port entry and cargo handling. The key technologies involved relate to the navigation (e.g. ECDIS electronic charts, radar, and sonar), vessel performance monitoring, vessel tracking, (e.g. AIS, LRIT), satellite imagery and communications, and computer software.

6 ICT Maritime Opportunities 2030

6.1 Maritime Connected and Automated Transport

Improving competitiveness, safety, and security of European shipping is a major objective of the EU Maritime Transport Strategy, which in turn shapes the requirements for upgraded maritime transport information management. Advances in ICT have created a demand for new forms of surveillance and information management systems and these are increasingly driven by policy and governance addressing safety, security, and sustainability. This is reflected in the emergence of the IMO's e-navigation concept and the more embracing European Commission's e-Maritime framework, established for measurable economic, social and environmental benefits.



The rapid development in information and communication technologies will significantly increase digitalisation in all waterborne sectors and lead to data-driven services such as optimising energy use and fuel efficiency, vessel performance, condition monitoring, and weather routing. A higher degree of systems automation, the availability of smart sensors and global networks for data transfer between ship and shore will promote remote controlled, and semi or fully autonomous operation of assets. Interconnectivity between sea-based operations and shore-based operation centres will enable increasing support and control from the shore. This will require secure systems and operations against cyber-attacks.

The requirements for maritime connected and automated transport, (which includes e-Maritime and e-navigation), to address future impacts and challenges are based on forecasted trends and trend interdependencies. These requirements took into account market intelligence, predicted societal trends and the future regulatory framework, for all waterborne sectors. The principal outcomes from these trends represent the likely demands on the maritime industry through to 2030.

The selected priority areas to address future maritime requirements for connected and automated maritime transport are as follows:

- Improved port and logistics infrastructure and operations
- Improved littoral management and development
- Improved crew working conditions and health and safety requirements on board
- Improved ship security systems/Improved protection against hacking
- Greater shore based monitoring and surveillance
- Continuing drive for greater energy efficiency/Better design codes and modelling
- Flexible and adaptive ship operations/ Improved ship handling and survivability/ Improved vessel routing
- Greater ship autonomy/More autonomous ship operation
- Greater integration of the logistics chain/Displacement of paper systems

6.2 Technological developments to address maritime requirements

The anticipated technological developments to address future maritime requirements in the selected priority areas are presented below:

1. Improved port and logistics infrastructure and operations

Over the next decade the ports and logistics sector will witness automation becoming more widespread and operations being increasingly directed and optimised in real-time by sensors and intelligent software, including the use of IoT, Big Data Analytics and robotics. Simulation software will be used for planning new terminals or assessing existing ones, as well as for training staff. Virtual and augmented reality will also be used for this purpose.

Up to now, container ports have been slow to fully utilise the IoT, but there are many commercial opportunities present in using the IoT, with smart and connected ports moving to a more integrated solution via improved wireless infrastructure. The IoT is an important driver for the Big Data concept, making it possible to create a rich perspective on how a business actually performs.

2. Littoral management and development

Now that a marine and maritime policy framework has come into being at European level[9], there is an opportunity for European Territorial Co-operation (ETC) maritime cross-border programmes to investigate, as part of their situation analysis, how they can link to this framework, and so cooperate more closely. The principal policy areas with the potential for such cooperation are Integrated Maritime Policy; Marine Strategy Framework Directive; Common Fisheries Policy; Integrated Coastal Zone Management; Maritime Transport; Ports; e-Maritime; Maritime Safety; Water Framework Directive.

3. Improved crew working conditions and health and safety requirements on board

There is a need for an investigation of minimum manning levels for different types of ships trading on different trade routes and carrying different cargo types, to determine whether and how these need to be reviewed, and better understood for their implications to safety and efficiency. While the human role will evolve, a ship may remain fully controlled from on board, but changes will be necessary to the skillsets of crew members as systems are increasingly ruled by software and shore-based support being increased. The benefits of improved connectivity and Internet access need to be made more widely available to all seafarers.

4. Improved ship security systems/Improved protection against hacking

Further developments in the range and performance of Global Monitoring for Environment and Security (GMES) services will bring greater situational awareness, with faster data collection and dissemination contributing to more effective early warning systems. Increased communication between systems on board a vessel, leading to ships becoming a "system of systems", together with critical infrastructures becoming ever more interconnected, will require resilience to be built into those advanced tech networks, to reduce the risk from cyber-crime, terrorism, etc. Low connectivity and fragmentation within the supply chain have helped to protect shipping from cyber threats, but with a fourfold increase in the adoption of satellite communication on board vessels over 10 years, the issue is becoming more important.

5. Greater shore based monitoring and surveillance

Remote operation of ships may be introduced for safety reasons in busy shipping lanes, to pass control of a vessel to a shore-based pilot with local knowledge, or in niche areas for other reasons.

[9] Commission Green Paper: Towards a future Maritime Policy for the Union: a European vision for the oceans and seas [COM (2006) 275 final

6. Continuing drive for greater energy efficiency/Better design codes and modelling

With improvements in the speed, scale and volume of operational data that can be collected from on-board vessels, and the increasingly real-time sharing of this information between ship and shore using marine broadband services, more economical and less environmentally-harmful ship operations will become possible. The entry into force of the Monitoring, Reporting and Verification (MRV) regulation from 1 January 2018, requiring ship-owners and operators to annually monitor, report and verify fuel consumption for vessels 5,000gt or over which call at any EU port, is providing a strong motivation for technologies to facilitate compliance with these requirements.

Greater possibilities for, and willingness to, share ship data with third-party technology firms will lead to improvements in ship energy efficiency. Data analytics and vessel management software will give operators better reliability and control over maintenance costs at sea and in dock, even as more sophisticated systems reduce the environmental strain caused by the sector. In the future, it will allow extended periods between dry-docking, with vessel milestones based on vessel condition, rather than according to a fixed schedule. Big data/data analytics will also permit optimised deployment of vessels on trades, seasons and regions etc., based on individual vessel performance.

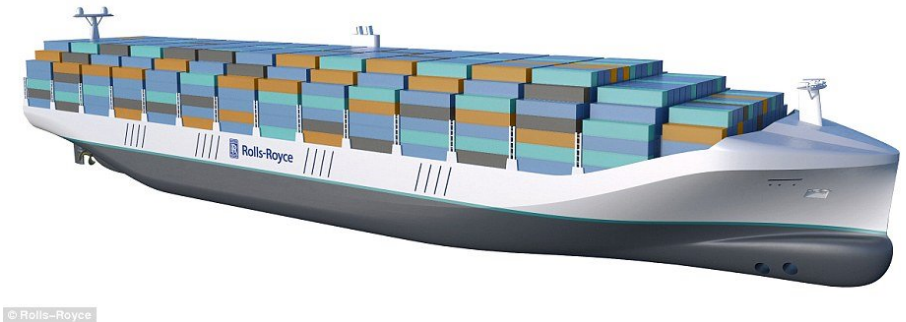
Real-time data collection in ports will also lead to greater efficiency and less environmentally-harmful operations, as improvements are needed for the development of both smart and green port concepts.

7. Flexible and adaptive ship operations/ Improved ship handling and survivability/ Improved vessel routing

There will be a greater connection between maritime navigation systems in operation and their designers, offering benefits in safety, efficiency and continuous improvement of system usability.

8. Greater ship autonomy/More autonomous ship operation

Drone cargo ships, known colloquially as 'ghost' ships, are unlikely to start operations within the coming decade and an intermediate step of partially automated ships, or Smart ships, with much reduced crew levels should be expected beforehand. Smaller and more specialised craft may be deployed on a shorter time scale, e.g. for inland waterways.



Courtesy of Rolls-Royce

9. Greater integration of the logistics chain/Displacement of paper systems

Although efforts to create and transfer title documents electronically, such as the bills of lading, they have so far met with limited success; the electronic exchange of information on cargo, crew and passengers is now advancing. Over the next five years, more on-board activities will be systemized to reduce duplication and provide single points of data entry, enabling greater on-

board and onshore analysis services in a real-time environment. Developments aimed at reducing the amount of paperwork officers and their crew have to undertake while at sea will accelerate, with the ultimate ambition to realise “the paperless ship”.

At present, much shipping and logistics data that is generated is not being exploited beyond its narrow purpose. This situation could be addressed by harnessing the power of big data and developing real-time big data handling capabilities.

In order to integrate EU maritime transport with competitive intra-European door-to-door transport services, it is imperative that an integrated ICT infrastructure is used for all modes of transport. This will require a single reference model and framework to addresses different facets of transport and logistics, such as collaboration, digitisation, and security etc. However, the important issue is semantic interoperability, rather than using the same systems or standards for all transport modes. In this context it would be inappropriate for the maritime community to define its own standards in areas that relate to other transport modes as long as existing standards satisfy all the important maritime requirements.

6.3 Research Priorities for implementing ICT Maritime Opportunities to 2030

Four research priority topics for future research, development and innovation, that are needed to address the impacts and challenges for Maritime Connected and Automated Transport, and for the implementing the main ICT opportunities, are indicated below:

The maritime requirements for Maritime Connected and Automated Transport needed to address the opportunities and activities identified are:

Smart and Autonomous ships: vessels with reduced manning levels, real-time monitoring of ship performance with automated information management and surveillance. Improved integration with shore support centres for technical operation and remote maintenance. As data networks, data management, and sensors become more vital for ship operation, these systems will need to be carefully protected from cybersecurity risks.

Smart and Connected Ports: Smart ports with Digital infrastructure and ICT innovation: Robotics and automation, autonomous vehicles; the IoT and Big Data Analytics, simulation and virtual reality, and cybersecurity. Integration of national single windows with trade portals and port community systems: providing one entry point for all logistics, operational and administrative information.

European Marine Digital Highway: Integration of navigation technologies with shore based data networks and centres (SafeSeaNet, (AIS, LRIT), GNSS, National Single Window, VTS, route planning etc.) with the corresponding navigational and communication facilities aboard ships to provide an

accurate, safe and secure “e-Navigation-based” ship traffic and transport management system for a marine digital highway.

European Integrated Transport Information System: Improved interconnectivity and integration between transport modes, based on sematic interoperability or common reference models and established systems, such as: Maritime national Single Windows, RIS, e-Customs, TAF, ERTMS, rail one stop shop, "access points", "data pipelines"; digitalisation of transport documents and acceptance of e-transport documents. Open, reliable and transparent access to transport and trade information can also create new or change existing business models. The new models can be based on using the increased opportunities for transparent risk and profit sharing. This is a prerequisite for full optimisation of the transport and trade systems.

Annex: ICT Research for Waterborne Transport

A number of EU and national funded research and development projects have addressed the issues of ICT in waterborne transport and logistics, including its application to port and shipping operations and e-navigation. The MESA project was launched to establish the state-of-the-art in e-Maritime research and development, to outline the main opportunities for its implementation, and to highlight some of the most promising activities for the future.

EU-funded projects have focussed on improving the interoperability of ICT systems in transport and logistics and several projects have contributed to the development of tools for streamlining maritime operations, including the transmission of legally required information, such as the IMO FAL Forms. Several projects have worked on applications to transmit information seamlessly to all relevant stakeholders in an automated and smart way; others have dealt with improved traffic management in ports and at sea, and unmanned ships.

Ship Operations

The EU has co-funded several research projects aimed at fostering a holistic and integrated approach in sea transportation. These projects have focussed on the development of commercial services in all aspects of a ship operation, such as crew training and performance optimisation, energy efficiency, operation risk management and assessment and technical management. Other projects have helped establish an EU framework for safe, efficient and environmentally-friendly ship operations as well as EU competitiveness.

Recent projects have aimed to empower the European maritime sector by offering efficient quality shipping services fully integrated in the overall European transport system using an upgraded information management infrastructure. Upgraded e-Maritime solutions will help facilitate decision making and information exchange between different stakeholder groups involved in:

- Improving the safety and security of maritime transport services and assets and environmental protection.
- Increasing the competitiveness of the EU maritime transport industry and strengthening the EU presence on the international scene.
- Integrating sustainable waterborne transport services into efficient door-to-door transport services in Europe and beyond.
- Reinforcing the human factor, particularly supporting competence development and welfare for seafarers.

EU research has produced most useful results for ship operation, including: Strategic Fleet Management, Personnel management and training systems, Chartering, Ship condition monitoring, maintenance and emergency support systems, Loading planning and optimisation,

Voyage management systems. Electronic documentation, e-compliance, e-recruitment, e-drawing, e-purchasing, and e-voyage planning have also been covered within the innovative single window architecture.

e-navigation

IMO's e-navigation concept is based on the harmonisation of marine navigation systems and supporting shore services driven by user needs. It encompasses human factors, standards, and procedures etc. and is more than a system composed of integrated subsystems and equipment. The European Commission has considered e-navigation in parallel with IMO, but from the European TEN-T programme[10] point of view and in the context of the priority 21 initiative: *Motorways of the Sea* and its future needs.

Although IMO's e-navigation was conceived to improve safety and security of navigation, it can also be interpreted with a broader remit to increase efficiency and performance of ship operation. This includes some services that are the main considerations for ship-owners, port operators, and regulatory authorities.

EU research and development related to e-navigation have covered eight main areas: e-navigation architecture; human element; conventions and standards; position fixing; electronic navigation charts (ENC); equipment standardisation; and scalability.

EU research has produced very useful results for the realisation of e-navigation concept to facilitate safe and secure navigation of vessels and vessel traffic management from shore/coastal facilities. It can be argued that EU research has been critical for the development of e-navigation. The research has also included communications and data exchange between ships and ship-to-shore, the integration and presentation of information onboard to minimise the risks of confusion or misinterpretation, and for legislation and standards for information and for ship to shore reporting. Research has also taken place for unmanned vessels.

Port Operations

Over the last 10 years, EU research and development projects related to ports have focussed on three main areas: port management and operations, infrastructures, and multi-modal traffic in port terminals. The common objective was to help achieve higher levels of efficiency in ports. More recently, research has focussed on port security and environmental issues, including port noise and use of energy. The concept of "green ports" is also receiving more attention, together with issues of marine environment protection, global climate change and rising sea levels.

EU research has provided important information for logistics and multimodal transport operations and processes, or how they can be improved, through the application of new support technologies, such ICT and simple data exchanges. Recent EU research focused on integrating web-based systems for multimodal transport logistics and port networking within the e-Maritime framework.

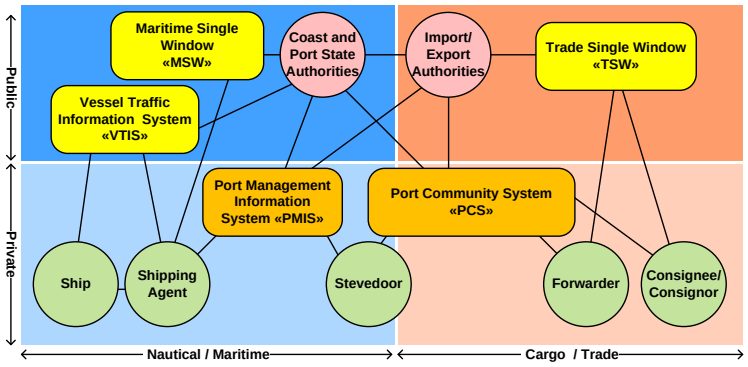
The European Ports Policy[11] has influenced on the advancement of modernisation measures of the European Ports. These measures include the adoption of Directive 2010/65/EU on reporting

[10] European Commission, Tran-European Network: TEN-T Priority axes and projects 2005, Luxembourg: Office for Official Publications of the European Communities.

[11] COM (2007): "Communication on a European Ports Policy", Commission of the European Communities. COM (2007) 616 final.

formalities for ships arriving in and/or departing from ports of the member States, the e-Maritime initiative, and the development of Port Community Systems (PCS) and the Modernised Customs Code. The application of these measures can reduce waiting times at ports, secure processing of data, simplify formalities, and provide timely information to transport operators.

The use of advanced ICT in areas such as Customs automation, electronic documentation and advance information in logistics is expected to continue in the future.



The intelligent use of data and advanced ICT technologies, such as IoT, Big Data Analytics, augmented reality, robotics, etc. will further develop port community systems for optimising daily operations. The use of real-time monitoring, improved management and optimisation of traffic in port areas will also help facilitate the intermodal logistics chain.

Logistics Chain

The main challenges that the European and the Global Transport and logistics service providers face, which are already reflected in the related research projects, are that the transport and logistics services sectors are heterogeneous and fragmented. This prevents integration of services and combination of resources, especially in "door to door" logistic chains. As opposed to Trade companies, Transport companies have not traditionally invested in information systems primarily because ICT is not viewed as important compared to other industries; furthermore, the transport sector is heavily regulated in many different areas e.g. safety, security, environmental protection, competition, customs and labour laws etc.

European research and development in transport and logistics services sectors have mainly addressed the issues of information flow in the supply chain. The modern business operations require an unbroken logistics chain from production to consumption, where all relevant information is available throughout the chain. Current research effort has gone beyond simple information exchange as the requirements include full scale profiles, risk based management and efficient flows of cargo with minimised downtime and waiting. The research also attempted to capture information and exchange throughout the chain, based on specific rights and on specific terms.

Recent European projects have focused improving the efficiency of the transport interfaces, the Logistical planning throughout the value chain, the inland port interface, and improving the monitoring of the cargo flows. Furthermore, the research has aimed to develop and implement decentralised ICT infrastructure for new planning services, including CO2 calculation capabilities and for existing systems to co-exist and co-operate efficiently.