Activity 2 – Defining Sea Traffic Management

The Target Concept

Document No: MONALISA 2.0_D2.3.1

Co-financed by the European Union
Trans-European Transport Network (TEN-T)
Document Status

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Document History

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<th>Version</th>
<th>Date</th>
<th>Status</th>
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<tr>
<td>1.0</td>
<td>2015-12-11</td>
<td>Approved</td>
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TEN-T PROJECT NO: 2012-EU-21007-S

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1 General Information

MONALISA 2.0 is a project with 39 private, public and academic partners from 10 different countries. Its overall objective is to strengthen efficiency, safety and environmental performance in maritime transportation. Coordinated by the Swedish Maritime Administration, the project is co-financed by TEN-T under the Motorways of the Sea Programme and is part of the EU’s e-Maritime initiative. MONALISA 2.0 follows on from the MONALISA project (2010-EU-21109-S) and also incorporates results and experiences from the SESAR (Single European Sky Air Traffic Management Research) programme in the aviation sector. MONALISA 2.0 is divided into four Activities: Activity 1, STM Operations and Tools; Activity 2, STM Definition; Activity 3, Safer Ships; and Activity 4, Operational Safety.

This report is a deliverable from Activity 2 of the MONALISA 2.0 project. The objective of Activity 2 is to outline a framework for Sea Traffic Management (STM), elaborate its target concept, and develop a plan for further development and deployment. Activity 2 is divided into 7 sub-activities:

- **SA2.1 Current Situation Analysis** describes today’s maritime transport industry, focusing on information sharing. It highlights its strengths, weaknesses, and current development, as well as its needs. The results of this analysis are presented in report D2.1.1 STM - The Current Situation.

- **SA2.2 STM Performance Target Development** is an analysis and elaboration of a performance framework including: performance targets, key performance areas, vision and goals. Its results are presented in report D2.2.1 STM Performance Framework.

- **SA2.3 STM Target Analysis** develops the target concept(s) of Sea Traffic Management based on the current situation analysis and performance targets. The results of this work are summarised in this report, D2.3.1 STM - The Target Concept.

- **SA2.4, 2.5 & 2.6 STM Strategic Roadmap and Master Plan Development and Work Programme for Development Phase** is a combination of three sub-activities that together establish a shared vision of the overall transition sequence for implementing the STM Target Concept. Results are described in report D2.4.2/D2.5.1/2.6.1 STM Master Plan.

- **SA2.7 Port CDM Demonstrator** developed and demonstrated initial versions of some information sharing services used in the Port CDM concept. Results are presented in the report D2.7.1 Port CDM Report.

This is the STM Target Concept Report.
2 Executive Summary

Maritime Transport is a key link in the global intermodal transport chain. However, it lacks effective information sharing practices that result in imperfect common situational awareness and a lack of process integration. Both can lower overall competitiveness and efficiency and increase the likelihood of accidents and environmental problems. Without a holistic approach to the maritime transport processes, it is impossible to undertake the overarching improvements that will make maritime shipping much more effective and efficient.

Overall, the digitisation of shipping information is still very much in its infancy. At present, a ship's voyage data is produced, as well as held, by a number of institutions, organisations, and individuals, and is often proprietary to a particular technology vendor. Optimising individual processes by themselves will likely suboptimise the whole maritime transport chain because although a single process may increase its efficiency, it is likely to do this at the expense of overall transport performance.

For this reason the MONALISA 2.0 project takes a holistic view of Sea Traffic Management (STM). STM has the potential to overcome many of the challenges of communication and information sharing between maritime stakeholders and to create significant value as a result. Its goal is to bring shipping into the future and to create a more sustainable industry with reduced environmental impact and improved safety and efficiency.

The STM Target Concept is facilitated by a common information framework with standards for information and access management and interoperable services. It enables authorized stakeholders to securely share real-time information about their intentions and actual actions on a continuous basis. The proposed vision of STM conforms to existing practices and initiatives within e-navigation, e-maritime, and the collaborative port, and incorporates both private and public services across a berth-to-berth voyage.

The proposed Sea System Wide Information Management (SeaSWIM) acts as a common framework for information sharing and service distribution for maritime activities and enables four STM concepts, each consisting of a specific set of operational services:

1. Strategic Voyage Management (SVM) to improve route planning and route optimisation before a voyage.
2. Dynamic Voyage Management (DVM) to improve route re-planning through continuous monitoring, route exchange and route optimisation during a voyage.
3. Flow management (FM) to support land organisations and ships in optimising overall sea traffic flow through areas of dense traffic or those with particular navigational challenges.
4. Port Collaborative Decision Making (PortCDM) to make arrival and departure processes more efficient through information sharing and process enhancement.
The MONALISA 2.0 project undertook five studies to assess different aspects of the value of STM. Their results were integrated to derive a holistic value proposition incorporating both quantitative and qualitative analyses that describe STM’s impact on its nine Key Performance Areas (KPAs) and present a holistic cost-benefit analysis. Key findings are:

- **Safety**: Accidents and groundings will be reduced 50-70%.
- **Efficiency**: Port costs will be reduced by 2-15% and anchoring time by 18%.
- **Environmental Sustainability**: Emissions costs will be reduced by 4-34%.
- **Cost Effectiveness**: Bunker fuel costs will be reduced by 4-34%, turnaround times improved, and administrative costs reduced by 15%.
- **Predictability**: STM will make ATAs and ATDs more predictable.
- **Capacity**: STM will decrease the need for buffers in the voyage planning, improving capacity.
- **Interoperability**: Common information standards will enable increased interoperability and make many port services more efficient.
- **Flexibility**: Optimised sea voyages and efficient port operations will enable shipping companies to be more reliable and flexible, adjusting routes to avoid problems, and adapting more smoothly to changes.
- **Security**: STM will improve secure electronic information exchange.

Figure 1 summarises these net positive benefits.
However, the most significant long-term impact on maritime shipping will probably be much more than monetary. The introduction of an ‘ideal’ STM is likely to make a significant and beneficial re-engineering of the overall maritime ecosystem. Accordingly, one can say that the biggest advantage of STM is exactly this – a reinvention of the maritime shipping industry.

Sea Traffic Management is an idea whose time has come. Shipping has fallen significantly behind other modes of transport and the lack of digital integration of the processes and information involved in maritime transport has created inefficiencies, increased costs, and resulted in unnecessary risks to safety and the marine environment. STM is an opportunity for the EU to offer world-class leadership in this field and to build a solid platform that will not only deliver significant benefits to all stakeholders, but also act as a foundation for innovation within the maritime transport industry as well as between it and other modes of transport.

Figure 1: Range of Expected Cost Savings from STM implementation
Relative to Analyses of Current Costs (from lowest to highest)
3 Introduction

Maritime Transport is a key link in a global intermodal transport chain. Moving a ship from A to B is not an exclusively navigational process, and has never been so.¹ In the future, greater integration with other processes will be required in order to improve and optimise it.

There are several processes involved in shipping: nautical; cargo handling; financial; safety; and control, including customs, immigration, regulatory, environment and security. Too few of these processes are integrated with each other or even compatible in terminology or technology and this often results in unnecessary delays, extra expense, a lack of predictability, and poor situational awareness across the entire ecosystem leading to potential accidents and environmental hazards. Without a holistic approach to these processes, it is impossible to undertake the overarching improvements that will make maritime shipping a much more effective and efficient actor in intermodal transport.

Overall, the digitisation of shipping information is still very much in its infancy. At present, a ship's voyage data is produced, as well as held, by a number of institutions, organisations, and individuals, and is often proprietary to a particular technology vendor. A ship’s master typically facilitates the information flow between these stakeholders while the ship is at sea (see Figure 2). As a ship nears its port of destination, responsibility for information flow moves to a shore-based ship agent. In both cases, most information is typically retrieved and distributed manually by the use of emails and phone calls.²

The Problem

Maritime transport lacks effective information sharing practices, which lead to imperfect common in situational awareness, and result a lack of process integration that can lower overall competitiveness and efficiency, and increase the likelihood of accidents and environmental problems.

Figure 2: Information Flow to and from a Ship

¹ To learn more about how the maritime transport ecosystem currently operates, see “Understanding the Maritime Transport Ecosystem”, Appendix A.
² To learn more about how information is currently used in the maritime transport ecosystem, see “Finding Information in the Maritime Transport Ecosystem”, Appendix A.
Over the past 13 years, shipping has been introduced to automated data exchanges through the adoption of an Automatic Identity System (AIS). One of AIS’ major purposes is to increase navigators’ situational awareness through the automatic exchange of ship data. However, although it provides data about ships’ current positions and destinations, AIS does not provide details on their intended routes, and few maritime stakeholders actually know the intentions of the ships in their domain of interest\(^3\).

Optimising individual processes by themselves will likely sub-optimise the whole maritime transport chain because although a single process may increase its efficiency, it is likely to do this at the expense of overall transport performance. For this reason the MONALISA 2.0 project takes a holistic view of **Sea Traffic Management** (STM), on-going initiatives within the IMO’s e-navigation Strategy Implementation Plan (SIP), e-maritime, and other electronic processes that are emerging on a national, regional, international, federated and cross-sector basis.

STM has the potential to overcome many of the challenges of communication and information sharing between stakeholders in the maritime transport industry and create significant value as a result\(^4\). Its goal is to bring shipping into the future and create a more sustainable shipping industry with reduced environmental impact and improved safety and efficiency (see box).

3.1 Report Structure

This report defines the STM Target Concept by showing how it addresses many of the current challenges of the maritime transport ecosystem. Its first section presents the vision for STM from a holistic point of view and then describes the information-sharing framework (SeaSWIM) that enables it. This ensures the secure, just-in-time exchange of information between actors in the maritime domain. The four major concepts envisioned for STM and their benefits are then described: Strategic Voyage Management, Dynamic Voyage Management, Flow Management and Port Collaborative Decision-Making (PortCDM).

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\(^3\) The maritime transport ecosystem is data-rich, in that it produces much data, but information-poor in that it is difficult to connect pieces of data in context on a just-in-time basis to provide information that is useful to any of the stakeholders involved.

\(^4\) To learn more about collaboration and coordination in the Maritime Transport Ecosystem, see "Collaboration in the Maritime Transport Ecosystem", Appendix A.
The next section presents the STM value proposition describing the impact of STM on nine key performance areas. Following this, it describes STM costs and benefits. The final section examines the legal, human, and technical dimensions of implementing STM. It considers: the legal environment that would be needed to make STM a reality; how STM will affect individuals and change practices related to people (e.g., training); and how STM would operate technically, the risks involved, and risk mitigation strategies.

4 A Holistic Approach to Sea Traffic Management

4.1 STM: A Holistic View

Maritime transport is a key component of the international ecosystem that transports goods and people from door-to-door (see Figure 3). There are many competing autonomous actors operating in maritime transport, each emphasising their own systems/solutions, most of which are vendor-specific and proprietary. This results in an inability to share information and that in turn leads to many inefficiencies and challenges. In addition, this creates very high barriers to entry for new service providers, jeopardising the innovative capability of the industry as a whole. There is thus a need for improved information sharing and common information services that will connect key actors in the maritime ecosystem to enable safe, efficient, and sustainable sea transport.

Figure 3: The Sea Voyage as an Integrated Part of a Larger Inter-Modal Transportation Chain

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5 See “Sea Traffic Management: A Holistic View”, Appendix A.
Sea Traffic Management (STM) is a holistic approach to achieving a modern intermodal maritime industry. Its focus is on the **voyage berth-to-berth**, using it as a core element for safety and process optimisation, as well as for interaction between stakeholders. STM is also a response to the need to increase efficiency and safety in operations in port areas and en route. MONALISA 1.0 (2010-2013) showed that STM could lead to significant benefits in European waters through reduced bunker costs, enhanced safety, increased situational awareness, better traffic monitoring, updated regional information about potential hazards, and higher utilisation of port facilities and resources. This STM target concept shows how these benefits can be realised at all stages of a voyage through improved information sharing (see Figure 4).

Sharing real-time and other information with appropriate recipients and allowing them to access it for their needs is fundamental to improving the maritime transport industry. Currently, this industry consists of multiple autonomous organisations acting in competition but continually exchanging information on an *ad hoc* basis. Information sharing therefore needs to be built into the design of any new solutions for STM. Practically, because of the culture and established self-reliant practices of the shipping industry, centralised storage of data and a single communication channel should be avoided. Instead, a more flexible approach should be adopted so that information can be securely provided in a variety of different ways for a variety of different needs. Basic information services can then be offered using and integrating data from a number of diverse information sources.

The STM target concept builds upon continuous real-time information sharing about the intentions and actual actions of the various maritime actors. The proposed vision of STM conforms to existing practices and initiatives within e-navigation, e-maritime, and the

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collaborative port. It incorporates both private and public services across a berth-to-berth voyage. Some services should be mandatory but most could be adopted on a voluntary basis driven by competitive advantage gains. The STM concept focuses on enhancing existing operational services while also proposing and validating new innovative ones.

The proposed Sea System Wide Information Management (SeaSWIM) will act as a common framework for information sharing and service distribution for maritime activities. It will enable four STM concepts, each consisting of a specific set of operational services:

1. **Strategic Voyage Management** (SVM) to support improved route planning and route optimisation before a voyage.

2. **Dynamic Voyage Management** (DVM) to support improved route re-planning through continuous monitoring, route exchange and route optimisation during a voyage.

3. **Flow management** (FM) to support land organisations and ships in optimising overall sea traffic flow through areas of dense traffic or those with particular navigational challenges.

4. **Port Collaborative Decision Making** (PortCDM) to make arrival and departure processes more efficient through information sharing, common situational awareness, and process enhancement.

A performance assessment project identified the expected benefits from each service, linking Key Performance Objectives (KPO) with each operational service and stakeholder. Figure 5 shows the principal elements of this analysis. With enhanced collaboration and information sharing among actors in the maritime transport sector, it found that implementing the STM Target Concept will lead to improvements in:

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7 Such as: ACCSEAS; EfficienSea 2; SeaSHIFT; SESAME Strait; AVANTI; PRONTO; CORE; Vasco da Gama; HELCOM / Recommendation 34E/2; IALA e-Navigation; IMO e-navigation Strategic Implementation Plan; Global e-navigation test bed (South Korea, Denmark, Sweden); IHO / e-navigation, European Commission / e-Maritime; INTERMANAGER; and BIMCO.

8 To learn more about how STM could operate in the future, see "Envisioning STM in 2030", Appendix A.

9 See "Performance Assessment Case", Appendix A.
• **Navigational safety** through increased ship-to-ship, and ship-to-shore interactions. This will be achieved by better situational awareness and the ability to access the right information at the right time. Shore-based organisations will also be able to offer improved navigational information through enhanced traffic images, which can detect potential collisions, developing situations, groundings, and traffic congestion, alerting ships, and updating regional information to inform ships about potential real-time hazards.

• **Sea traffic efficiency** through enhanced information sharing among involved actors in which intentions and actual performance will be shared in real-time. Information related to a voyage would be shared by nominated recipients for the purpose of optimising a voyage (i.e., steaming between two ports), optimising ship traffic flow in congested areas, improving predictability of upcoming needs for port resources, and maximising utilisation of existing resources. Faster turn-around processes will also increase the efficient utilisation of ships.

• **Environmental sustainability** through enabling decision support to: minimise the use of energy (fuel/bunker) to steam between two ports, enable just-in-time approaches to ports, and minimise shipping traffic in sensitive areas. Just-in-time approaches, matched with a synchronised readiness in a port, would enable green approaches as well as green steaming by avoiding late departures to the next port.

In addition, STM will improve the effectiveness and efficiency of individual voyages berth-to-berth and create a higher level of predictability and interoperability across the entire maritime ecosystem. These improvements will enable the ecosystem to handle increased demand for sea transport, become more adaptive to changes in demand, and improve the security of maritime and port operations through shared information. Finally, STM will result in an increased innovation capability across the entire maritime transport ecosystem by providing a common platform to enable new, previously unanticipated services for maritime stakeholders.

The STM target concept supports the following existing principles of maritime transportation:

• The master is in command.

• United Nations Convention on the Law of the Sea (UNCLOS) and the Convention on the International Regulations for Preventing Collisions at Sea (COLREG) are complied with.

• The data owner controls access to its data and approves who has access to what, and when.

In addition, current systems, processes, and initiatives can be integrated into the STM framework.
The STM target concept introduces the following new principles:

- Each voyage is assigned a unique voyage identifier.
- Information related to a voyage is linked with the voyage identifier.
- Information for a particular voyage can be reported once and shared with all nominated parties.
- The operational intentions of all sea and land-based actors related to a particular voyage are provided to approved actors well in advance and kept up-to-date.
- Information sharing shifts from personal contacts to digital information sharing services.
- Information sharing enables collaboration and improved decision-making between all actors.
- Situational awareness is derived from multiple information sources.
- Information services are kept secure and provided only to authorised users as specified by the data owner.
- All information infrastructures, such as standards, are governed by a federation of stakeholders.

The proposed STM information framework will operate in four layers that different service providers can use to provide and consume maritime information services (see Figure 6). These will enable the development and distribution of new information services and allow inclusion of the same information into different applications. It will also support moving away from vendor-specific solutions to accessing and integrating diverse information services from multiple providers.

STM’s framework for information sharing proposes a common service and information sharing framework enabling trusted, non-proprietary, and federated collaboration. Such a framework would also enable third-party developers to provide new innovative

Figure 6: A Layered Service Delivery Model
services to the industry. Once an STM framework is in place, it will serve as a foundation for intermodal communication and to improve the performance of the total transportation value chain. This would bring maritime transport in line with other modes of transportation that already provide accurate information about departures and arrivals.

4.2 The Information-Sharing Framework (SeaSWIM)\(^\text{10}\)

The Sea System Wide Information Management (SeaSWIM) framework is STM’s information management solution (see box). It will support maritime activities both within and outside STM. The full potential of this framework will be realised when it is applied in many of the activities that rely on information sharing, service interaction, and actor collaboration.

The maritime industry has already seen the benefits of digitisation and information sharing with the introduction of AIS, which automatically broadcasts all ships’ current locations and headings, thereby improving situational awareness of surrounding ships. Public broadcasting however, restricts what information can be communicated because many data exchanges need to be restricted by content and receiver to preserve competitiveness. Therefore, at present, actors typically coordinate their actions directly with other actors. This process can become tedious when multiple actors are involved to achieve a specific goal. Because each communication is manual using a variety of means (e.g., radio, email, telephone), it effectively limits the supporting coordinating services that can be developed and provided and thus contributes to inefficiencies.

\[
\begin{align*}
\text{SeaSWIM is a framework for...} \\
\text{enabling a secure service ecosystem of providers and consumers of STM (and other) services} \\
\text{the use of standards to communicate information} \\
\text{federated governance of emergent standards, monitoring, quality assurance, and portfolio management} \\
\text{vendor-independent infrastructure for identity, service and access management.}
\end{align*}
\]

\[
\begin{align*}
\text{SeaSWIM is not...} \\
a product \\
a central database of information \\
a place where everyone has open access to all information \\
the services provided by STM.
\end{align*}
\]

\(^{10}\) See the “Target Information Systems and Information Technology Description”, Appendix A.
An information management framework such as SeaSWIM that is trusted to deliver necessary information to specific partners (nominated recipients) could facilitate:

- Information sharing across extended time horizons
- Continuous sharing of intentions and actual achievements both on land and at sea
- Improved situational awareness by combining several information sources
- Enhanced optimisation of voyage planning, execution, and evaluation
- Improved traffic coordination
- Optimised port calls and port resource utilisation.

It should be stressed that SeaSWIM is not a public data repository, but rather a mechanism for determining how to set up a secure data exchange under the control of the data owner.

Today’s maritime industry is composed of many separate actors working individually, which is why it is important to facilitate the emergence of trustworthy, non-proprietary, data sharing environments. Providers’ willingness to share data with others in the industry, which is characterised by a high degree of autonomy and competition, will be based on trust that their data will be used in accordance with their intentions and that sharing will not diminish their competitiveness. Therefore, the value of aggregated information from multiple sources must exceed the cost of data sharing. In other industries, federated and regulated approaches to service interaction involving all stakeholders have led to successful solutions for enabling exchanges between different actors (e.g., the SWIFT organisation for secure bank transactions).

SeaSWIM is based on a federated approach to governance, a framework of standards, and regulated service distribution. At present, the maritime sector lacks standards in its key interactions so the introduction and governance of open standards to be shared between maritime stakeholders is essential. A federated and regulated approach to information sharing and service distribution involving all stakeholders will enable different market-driven information and services to be provided from a variety of sources, as opposed to a single hierarchical approach which would not support such diversity and innovation. The SeaSWIM framework would be implemented using open standards and generic interfaces so it would allow for the provision and selection of diverse communication, information, and application services on an as-needed basis.

SeaSWIM will be designed to enable access to multiple maritime transport related data streams. It supports the standardisation of these data streams in order to lower overall system integration and transaction costs and enable information use by numerous services. Standardised data and the application program interfaces (APIs) to access it will be accomplished either by using established standards or by letting the first instance become the de facto standard.

The actor who generates a particular data stream will decide its access restrictions. Aided by an identity registry, a data owner can control who can access what, where, and
when. This means that supporting partners might only have access to a certain data point at a certain time and location. Data streams can be added and their properties defined according to specific access criteria. Discovery of new information sources will be promoted by publishing standardised APIs, which can be accessed according to the restrictions imposed by the data owner.

The federated governance structure proposed by SeaSWIM will contain processes for service approval, publication, and discovery (see Figure 7). Although SeaSWIM will certify that each data stream is supported by the appropriate level of security and governance, a common maritime infrastructure framework to support authorisation, validation, and secure information transfer, as well as the management, publication, and discovery of standardised information services, will benefit a large number of maritime stakeholders in many different areas. In order to support the governance and implementation of SeaSWIM as the enabler of information sharing, the following operational services have been defined:

- **Identity management** to manage an identity registry of maritime stakeholders providing access to, and consuming, STM services and information.
- **General service portfolio management** to support the development, publishing, maintenance, and use of STM services.
- **Access management** for as-needed services and information and to enable trusted information exchanges.
- **Governance and monitoring** to ensure quality and monitor performance of the service ecosystem in accordance with the rules and regulations set by and for the federation.

SeaSWIM provides a framework for the harmonisation of data formats and standards for information management and operational services. Some of the standards enabling it include:

- Route exchange format
- Port call message format
- Time stamp definitions
- Service specification language
• Processes for the approval, distribution, and discovery of services
• Processes for the federated governance of service portfolio
• Access management processes
• Geolocation standards

Major organisations responsible for information standards are:

• IALA – international standards for the implementation and operation of aids to navigation, including Vessel Traffic Services
• IHMA/ESPO/IPCSA/Port CDM Council – port reporting data
• IMO – International Conventions and guidelines for maritime matters, standards for ships' navigational and radio communications equipment, including e-navigation
• Transport associations/BIMCO – cargo goods information including relevant charter party clauses
• IHO – navigational data, definitions, geospatial information registry.

SeaSWIM will harmonise information sharing efforts to provide a common framework for a variety of different maritime transport uses and encourage information sharing and service distribution among maritime stakeholders. Defining such a framework will be the beginning of a journey towards a sustainable digital infrastructure for the maritime transport domain.

4.3 STM Services and Benefits

4.3.1 Strategic Voyage Management

Strategic Voyage Management (SVM) envisions the planning of a complete sea voyage, beginning with an idea that evolves and incorporates various actors connected together through a unique and agreed-on voyage plan. The overall objective of SVM is to:

Optimise the initial planning phase of a sea voyage by enabling a collective and up-to-date awareness of all influencing factors related to the undertaking and success of the planned voyage.

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11 Further information can be found in the "SVM Concept Description", see Appendix A.
In the beginning of the strategic planning phase a company identifies the actors who should participate in the different aspects of a specific sea voyage. These nominated actors then help to develop a voyage plan. This company also decides which parts of the voyage plan will be shared and with whom. The strategic voyage plan includes all the information required for planning and executing a sea voyage, such as a route with arrival times, towage requirements, pilot-pick up, port calls, reporting, traffic avoidance, permissions, weather information, and navigational warnings. Throughout a voyage’s lifecycle, and beginning with the strategic planning phase, a voyage plan is uniquely identifiable for all nominated actors (see Figure 8).

Each voyage plan connects all involved collaborators, keeping them informed of any changes of estimated arrival times, permissions, weather conditions and other relevant voyage information. As a result, all nominated actors have a common, up-to-date situational awareness that enables them to take appropriate action in a timely fashion.

The initial planning of a sea voyage will also be supported by information from previously executed voyages. A library of similar voyages will be made available through the SVM concept to help select and validate suitable routes in relation to current regulations, weather, and navigational warnings. In international shipping, crossing of boundaries and travel between continents is the norm and in each state and ocean different local regulations apply. SVM will provide governments with the tools needed to describe where and when certain maritime regulations apply to a voyage. Instead of the current manual reporting, standards for geo-located regulations will facilitate the automatic adherence to jurisdictional regulations through a navigational system, decreasing the administrative burden of ship reporting requirements. Early validation of relevant factors such as route-selection, legal requirements, and weather can then be moved from the bridge to the shore. With a strategic voyage plan covering the maritime component of the journey, it will then be possible to enable a complete transport solution for any shipment end-to-end, from the time it leaves its origin until it arrives at its final destination.
The principal characteristics of SVM are:

- All planned sea voyages are uniquely identified.
- All actors (both sea and shore) nominated to participate in a sea voyage are able to share and update their part in the plan.
- Early shore-based information regarding relevant factors affecting a sea voyage is made available to ensure a holistic view of transportation solutions end-to-end.
- Each planned sea voyage is supported by up-to-date and voyage-relevant information, improving its successful and on-time completion.

Key SVM services include:

- **Voyage Information**, which will provide other STM services with voyage-related information.
- **Unique Voyage ID – Voyage Plan Identifier**, which will uniquely identify each voyage plan and serve as a pointer to all voyage information.
- **Nomination of Collaborators**, which will identify all actors involved in a specific sea voyage. Each actor will have different information access rights, which will be assigned by the information's owner.
- **Geographical Legal Restrictions for Maritime Operations**. This will enable maritime authorities to describe where certain regulations are in place, so a voyage plan can take them into account in the earliest planning stages.
• **Route Catalogue Services.** This will provide maritime voyage planners with a catalogue of previous routes based on past AIS data, and serve as a tool to select routes undertaken by similar types of ships.

• **Post-voyage Analysis.** Since STM will facilitate the undertaking of all activities needed to successfully complete a voyage, it can also create a summary of route and other changes, updates, delays and deviations related to a voyage that can be analysed and used for continuous optimisation of best practices and company business rules.

Giving each actor access to real-time, high quality information will lead to higher success rates of each planned sea voyage. These, in turn, will increase the capacity and flexibility of the maritime transport ecosystem. Other benefits include:

• Enhanced common situational awareness and smoother coordination amongst sea voyage planners will improve safety and efficiency.

• Unique identification of voyage plans will facilitate interoperability amongst nominated actors while keeping information secure.

• Support from ship and cargo owners for Masters' tasks (e.g., updating, reporting and confirming different parts of a voyage plan) will reduce administrative burden on the Master.

• Early validation and improvement of a planned route's navigational safety.

• Development of a route library to support nautical expertise in developing and evaluating various routes.

• Consideration and validation of the geographical restrictions as well as maritime regulations along a planned route. This will improve environmental sustainability and safety of navigation, enhancing the security of the supply and logistics chain.

### 4.3.2 Dynamic Voyage Management

Navigation starts when a planned route is executed. The MONALISA project aims to add new technology that will speed up and secure this process with real-time access to appropriate data from relevant stakeholders and service providers on an as-needed basis. Today, this process is executed on board with manual updates via telephone, fax, email, pilot books, and charts. Dynamic Voyage Management (DVM) connects ships, adds intelligent processes, and new tools **DVM provides ship operators with an up-to-date and dynamic flow of information to improve ship efficiency and safety and reduce their environmental impact.**

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12 Further information can be found in the "DVM Concept Description", see Appendix A.
enabling all authorized stakeholders to be involved with a voyage. This provides a much faster, more secure, and transparent way of exchanging information that will optimise the execution of a voyage, reduce airborne emissions, and improve common situational awareness, leading to increased safety at sea. This will be implemented in conjunction with other e-navigation and e-maritime initiatives and services.\textsuperscript{13}

DVM starts once a voyage order is issued and a ship assigned, transitioning seamlessly from SVM. Its purpose is to monitor and optimise a voyage plan continuously during a passage and provide guidance for all future tactical actions when course or speed alterations occur. DVM uses the unique voyage ID issued in the SVM phase to connect all relevant data related to a specific voyage. The voyage ID and a standardised route exchange format make it possible for all authorized stakeholders, independent of equipment and manufacturer, to receive, read, elaborate, and transmit routes seamlessly.

DVM uses the strategic voyage plan as a base and assists the Master during a voyage when significant changes are necessary due to such things as: technical issues regarding the ship, weather and ice conditions, changes to the availability of berths, tugs, and pilots, traffic conditions, and cargo-related matters. DVM can then iteratively modify the original strategic voyage plan to ensure that a ship operates in the most effective way, using all possible data that affect its voyage plan.

DVM makes such information constantly available, affecting and affected by other processes involved in a ship’s overall voyage plan, such as the strategic voyage plan and Flow Management and PortCDM requirements. DVM also obtains information from PortCDM and Flow Management services regarding desirable arrival and departure times, managing updated Estimated Time of Arrival (ETA)/Estimated Time of Departure (ETD) by altering the time and speed dimensions of the route throughout the whole voyage. This, in turn, provides opportunities for just-in-time operations, reduced fuel consumption, and minimised airborne emissions. At the same time, changed sea conditions such as bad weather or ice, technical issues, or traffic, may affect an ETA and the just-in-time process at the port. DVM ensures that this information is updated with other STM services. DVM also exchanges information with Flow Management regarding traffic conditions when optimising specific routes, affecting and being affected by the shipping traffic patterns in a certain area. Five services are envisioned:

1. **Route Optimisation.** This service will provide continuous optimisation of routes according to cost, safety, and environmental parameters. Improved optimisation will lead to reduced fuel consumption and reduce emissions of GHG and pollutants. Efficiency and cost-effectiveness will also be improved. Better optimised routes will also have a greater predictability, improving the planning of port services and the overall predictability of the maritime transport system.

2. **Route Cross-Check.** This service will provide an additional check of the port-to-port route replacing verbal shore-side verification and improving existing on

\textsuperscript{13} For example see, http://www.imo.org/en/OurWork/Safety/Navigation/Pages/eNavigation.aspx
board verification practices. This will result in safer routes and reduced administrative burden both on board and ashore. Shore-based operators can also use route exchange to verify that ships’ routes are in accordance with local regulations, conditions, and knowledge. This will lead to clearer communication and safer navigation, thereby reducing the number of incidents and accidents.

3. **Route Exchange.** This service will enable particular route segments to be exchanged with nearby ships and with shore services to improve situational awareness and reduce accidents. The ability to exchange routes is one of the cornerstones of STM and an enabler for several other operational services.

4. **Shore-based Navigational Assistance.** This real time monitoring service will support on board navigation, add a new tool to existing navigational services, and serve as an alternative to deep sea piloting, thereby reducing the cost of a voyage. It will also increase voyage safety, especially in confined, sensitive or densely trafficked areas. Navigation in sensitive areas can also be decreased due to better support from operators with local knowledge.

5. **Single Reporting.** This service, utilising SeaSWIM, Voyage Information Service, and Route Exchange, will standardise and automate mandatory ship reporting requirements by facilitating route and voyage information exchange with all interested and authorized parties, such as port agents, vessel traffic services, and ship and cargo owners. Existing Single Window initiatives will gain added functionality through SeaSWIM, which gives all stakeholders the ability to access information related to a ship’s voyage. Improved interoperability will make reporting more efficient and cost effective, reducing the administrative burden both on board and shore side. A lower administrative burden will also help operators focus more on the safe navigation of the ship instead of on reporting, thereby increasing voyage safety.

### 4.3.3 Flow Management

Whereas Strategic Voyage Management and Dynamic Voyage Management consider individual voyages, the goal of Flow Management (FM) is to:

*Optimise throughput and increase the safety of the whole sea traffic flow during the planning, executing and evaluation phases of STM.*

The objective of Flow Management is to improve the overall flow of sea traffic through better information and coordination, not control. It leaves all ship decisions with the master and enhances decision-making with information and advice about traffic and safety. FM information will be provided to all ships during the strategic planning and dynamic stages of their voyage.

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14 Further information can be found in the FM Concept Description Report, see Appendix A.
FM will be the responsibility of administrative entities or possibly commercial service providers approved and appointed by the National Competent Authority (NCA)\textsuperscript{15}. If related to territorial waters, the NCA would decide which FM services should be implemented, to what degree, and in which geographical areas. These decisions will be based on risk analyses and only when a clear benefit for the safety of navigation is determined. Four major FM services are envisioned:

1. **Enhanced Shore-based Monitoring** will be undertaken in specific geographical areas where the risk of collision or grounding is high, enhancing the safety of navigation and environmental protection. A critical area can also be an environmentally sensitive area, for example where oil pollution could have major consequences. It will automatically compare live shipping traffic with ships’ intended routes. If a ship has made a major deviation from its planned route, has left its safety margin, or is heading for danger, the shore-based operator is alerted and can advise the ship immediately to inform it of the evolving situation and provide advice as needed.

2. **Flow Optimisation** is a service that operates both during the SVM and DVM phases of a voyage. It could be implemented by a *Vessel Traffic Service* (VTS) delivering a *Traffic Organisation Service* (TOS), or an advisory *Flow Optimisation Service* in geographical areas that have high traffic density and/or particular constraints to a passage. With flow optimisation, a shore-based operator monitors traffic using the *Enhanced Monitoring Service* described above, and can advise a ship to slow down or speed up based on its ETA at specific key waypoints, known as Flow Points (FP). This helps avoid potential traffic congestion and problems further down its route. The service can also re-direct traffic using a “recommended route” communicated to a ship. This will be helpful if a fairway is closed or obstacles are preventing safe passage. This service will ensure both safety and predictability for the maritime transport logistics chain.

3. **Area Management** and Maritime Safety Information (MSI) will constantly collect and update local and regional information regarding:
   - Legal and environmental requirements
   - Nautical information, which is today contained in pilot books
   - Environmental information, such as weather, ice, currents, tidal waters
   - Navigational safety warnings.

This service could be organised under today's system of NAVAREAS and Sub-NAVAREAS and implemented as a digital resource making commonly accepted and standardised navigational geo-references available, thereby improving safety, efficiency, and environmental sustainability.

\textsuperscript{15} This is the body appointed by a country's government to be the authority for a certain issue or function.
- **Traffic Pattern Analysis** will use statistical information from traffic images and all ships’ intended routes for an area (known as the game plan) in order to analyse traffic flows, including deviation from planned routes and schedules, and incorporate this information into future ship routing systems. This analysis could be performed by either STM or VTS services and will provide the necessary information to improve the overall cost-effectiveness and capacity of maritime transport.

4.3.4 Port Collaborative Decision-Making

Sea traffic both begins and ends at a port. To reach STM performance targets, integration with ports is therefore necessary. Inspired by a similar concept used for collaborative decision making within and between airports (known as AirportCDM)\(^\text{17}\), PortCDM is a way of establishing not only a common view of all available information, but also of using this information as a tool to create a common situational awareness and support the involved actors in making efficient collective decisions. This will result in better planning of arrival and departure times and improve how a port interacts with a ship to optimise its port call.

To enable just-in-time operations, the various actors engaged in sea transport-related actions need to contribute to the creation of common situational awareness. This is achieved by capturing and drawing on information from different sources in a standardised way. Common situational awareness will maximise utilisation of port facilities and resources and optimise the use of energy (fuel/bunker) in steaming between two ports. PortCDM relies on continuous interactions between the maritime actors involved in a port call -- the actors within a port, and between a port and the stakeholders who deal with it such as, ships, shipping companies, ship operators, ships’ agents, towage companies, pilot organisations, and terminals -- who all need to coordinate closely to execute it efficiently.

PortCDM helps visualise desired states to enable different operators to act in such a way that a port call (arrival, at berth, cargo operations, and departure) can be performed on a just-in-time basis. The overall principle is that involved actors should be able to trust the prediction of when a certain state will be reached and that their performance will thus be just-in-time (not too early, not too late) and at optimal capacity. Port CDM has three goals:

1. To synchronise ship arrival, departure, and port readiness, enabling green steaming in the latter stage of a voyage.
2. To optimise the use of port resources and ship turn-around time.
3. To provide the information necessary to facilitate just-in-time operations.

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\(^{16}\) Further information can be found in the "Port CDM Concept Description Report", see Appendix A.

\(^{17}\) [http://www.euro-cdm.org](http://www.euro-cdm.org)
To achieve these goals and benefits, all maritime and intermodal actors involved in a port call need to share information about various states and degrees of readiness for a particular ship’s arrival, such as estimated time of arrival (ETA), estimates of when certain states of readiness will be reached, commitments related to certain states, and changes to these states over time.

The final departure of a ship is the result of negotiation between port entities and the ship/cargo owner. For example, cargo handling could be planned to be completed the next day and all parties informed accordingly, but if there is an economic reason for a ship to sail as soon as possible, the owners must bear the cost for the stevedores’ overtime so that it can depart later the same evening. Many such negotiations take place today. PortCDM is a means for sharing information about state changes to enable such re-planning.

The ability to accurately predict when various operations should occur in a particular port call is difficult because of the numerous actors involved and the overall lack of situational awareness. PortCDM will address these deficiencies in several problem areas such as lack of information harmonisation, information redundancy, information reliability, poor predictability, administrative burden, and waiting times.

PortCDM incorporates several core concepts:

- A **port call process instance** is the backbone of the collaboration process, capturing information about the main activities/events of a specific port call.
- From a port call process instance, relevant states are identified and mapped into a **state chart** that captures their interrelations and states for interpretation and use (see Figure 9). This state chart uses a common measurement system of states and coordination points.
- The port call process instance and the state chart are then used as a **basis for collaboration** to identify who the collaborating actors are, when to collaborate, and what to collaborate about.
- In order to enable different actors to work together to reach a certain state (in time and place) there must be a common understanding of these different states. This requires **standardised information**.
- Finally, the **dependencies** between different states and coordination points during a port call related to different actors must be identified to enable planning and realisation of just-in-time operations.

PortCDM is predicated on the assumption that communication about an upcoming port approach is made as soon as it is known and that changes are communicated as early as possible. A port can only optimise its operations if it receives real time information about the status of the different activities and transports that affect them and gets updates if their states change. This means that the same measures function both as coordination mechanisms for optimising port operations (and creating readiness for
managing necessary activities) and as a means for enabling collaboration/optimisation between different activities.

![Figure 9: A State Chart](image)

Different planning horizons are associated with different levels of tolerance for deviation between the estimated and actual reached state (the outcome). This deviation should diminish with time and the closer to the time of an activity’s execution, the smaller should be the tolerance for deviation.

To decrease the administrative burden, PortCDM must be integrated with existing systems to ensure a single point for reporting intentions and completed activities. This could be enabled by implementing connectors into different existing systems, using standardised APIs, adopting common nomenclature for information and a common measurement system, and using standardised message formats. There are already standards for different time stamps, such as those set by BIMCO and FONASBA. PortCDM would build on these and develop a standardised time stamp definition that would constitute a port call message standard.

PortCDM will support four operational services:

- **Port Call Synchronisation** to support the coordination of a ship’s approach with port readiness and enable just-in-time approaches.

- **Port Call Optimisation** to support the coordination and adjustment of actions related to other actors’ intentions and performance, based on the set of states for a particular port call.
• **Port Call Monitoring** to serve as a basis for common situational awareness for upcoming and on-going port calls and enable involved actors to monitor and be informed by other actors and activities.

• **Port Call Improvement** to evaluate and propose improvements for optimising future port calls.

PortCDM will use data sharing and collaboration between key actors engaged in the port call process to improve efficiency. To encourage the development of these services, incentives for third-party developers need to be created. Two essential preconditions to stimulate new development are that beneficiaries acknowledge that the services are desirable, and that standards exist to enable wide-spread distribution and consumption of a service. A federated approach for governing service distribution would establish criteria for determining which services are STM and PortCDM compliant and ensure that information providers both retain information ownership and can regulate access to information they provide. Standards will ensure that the services developed can be utilised by existing applications and equipment and a wide variety of users. PortCDM will utilise STM standard route exchange information and will require the creation of a port call message standard, both of which in turn will be integrated with existing reporting formats, such as the single window.

4.4 **Target Concept Validation**

During MONALISA 2.0, extensive preliminary testing and validation took place to assess the core functions of STM, promote alternative perspectives, and prepare these services for the upcoming validation phase.

Voyage and traffic management were tested through a unique simulation network in which promising concepts for an information infrastructure were also evaluated. In addition, deep-sea shore-based assistance was developed beyond its conceptual definition and potential implementations were analysed. Port-related services were tested through demonstrations that assessed assumptions of the willingness and perceived value of sharing information. Affected actors were introduced to the intended services through joint discussions in a “living lab”. Furthermore, rudimentary demonstrations of some back and front-end features were also developed to promote discussion and ensure of the feasibility of a larger validation.

The upcoming STM Validation Project will carry on where MONALISA 2.0 left off. In this new phase, early prototypes will be scaled up and deployed on 300 active ships and in 13 ports. They will also move from isolated tests to more integrated initiatives linking voyage and port call processes, which is where the real promise and challenge of deploying STM lies.
5 The STM Value Proposition

5.1 Overview

The MONALISA 2.0 project undertook five studies\(^{18}\) to assess different aspects of the value of STM.

1. **The Target Business Description** explored the business benefits to shipping lines and agents that would result from implementing an 'ideal' STM.

2. **The Formal Safety Assessment** (FSA) studied the STM Target concept, based on IMO guidelines for such work.

3. **The Target Transversal Aspects Description** assessed the impact of the STM target concept on three Key Performance Areas (KPAs): safety, security, and the environment, and how standard shipping procedures within these KPAs would be affected by STM.

4. **The Target Concept Business Case.** This three-part study measured the potential savings from route optimisation, the impact of adjusted arrival times as part of Port CDM, and the possible gains for society by estimating the benefits and costs of STM.

5. **The Green Steaming Study.** This supplementary study used AIS data from the Swedish Maritime Administration for August 2014 to analyse arrivals at the port of Gothenburg and determine the impact of green-steaming on anchor-time at port, fuel savings, and emissions.

The results of these five studies have been integrated to derive a holistic value proposition incorporating both quantitative and qualitative analyses that describe STM's impact on its nine Key Performance Areas (KPAs).

5.2 The Impact of STM

5.2.1 STM's Impact on Safety

This KPA addresses the risks, prevention, occurrence and mitigation of maritime accidents and incidents at sea or in port. The primary quantitative KPI used in the FSA study was the relative reduction of ship conflicts when STM's Conflict Resolution Algorithm (CRA) was applied. Using CRA, conflict between ships was reduced by virtually 100% in simulations. However, real collision-avoidance occurrences would be fewer since some ships will not comply with STM conflict-resolution voyage plans. An expert workshop systematically assessed every navigational accident in Kattegat from

\(^{18}\) See Appendix A for the full references for these reports.
1993 to 2009 with respect to potential risk reduction by STM's CRA. They estimated the actual potential risk reduction of this STM service would be 30-50%.

STM's route exchange will increase situational awareness and therefore prevent collisions as well. To demonstrate its impact on safety, the FSA study evaluated 4000 potential conflicting routes over the course of a year. Assuming that 40% of ships followed STM's “collision and grounding safe” routes, route exchange reduced the expected frequency of collisions correspondingly. Analysis then showed that the combined effect of CRA and route exchange resulted in an even greater avoidance of collisions so that the combined risk reduction effect is estimated to be in the range of 50–70% for navigational accidents with collisions caused by human error. The FSA's assessment of accident case histories also concluded that using voyage plans optimised for speed and water levels could prevent up to 64% of groundings.

The Target Business Description study found that ship owners believe the transparency and predictability of STM optimised routes will also provide the ability to monitor ships more precisely and effectively, and ‘this is one of the best solutions in terms of accident prevention’ (Nørgaard, CMP). Finally, the Transversal Aspects study showed that STM's Flow Management service could assist with navigation in confined waters and high-density traffic areas and that increased common situational awareness and information exchange would improve navigation quality. In addition, these would facilitate proper communication and reporting from ships to ports and authorities and support existing codes of safe carriage, including those relating to safety and safe navigation when carrying passengers. To be effective however, STM would require training for bridge staff prior to implementation. This study also identified three key sets of legal and operational changes that must be addressed before the full impact of STM can be realized in this area (see Table 1).

Table 1: STM's Impact on Safety, Tools, Procedures and Codes of Conduct

<table>
<thead>
<tr>
<th>Safety Issue</th>
<th>STM's Potential</th>
<th>Changes Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>An Aid to Navigation</td>
<td>STM could fulfil requirements for aids to navigation and set a standard for future e-navigation equipment</td>
<td>Regulations must be adapted to apply to STM, including the IMO, IALA, and other organisations</td>
</tr>
<tr>
<td>Weather and Meterological Navigation</td>
<td>STM services could support this and improve nautical publication libraries</td>
<td>STM's formal mandate and legal liability for actors must be addressed</td>
</tr>
<tr>
<td>Carriers'/Shipowners' Liabilities and Responsibilities</td>
<td>STM could interact with laws governing contracts, including due diligence to man &amp; equip the ship and due dispatch under voyage</td>
<td>These must be addressed by STM's legal framework</td>
</tr>
</tbody>
</table>
5.2.2 STM's Impact on Efficiency

This KPA addresses the role of STM in improving the services that support the performance of maritime business. The Target Business Description found that in ports, every minute counts and even the slightest improvement in turnaround time will make a huge difference in monetary terms. Since a ship costs per time-unit both at sea and while lying in the port, a reduction of time spent at port also improves voyage efficiency, providing the owner/ship charterer with enhanced flexibility in arranging the next use of the ship. Optimised sea voyages with STM will therefore lead to reduced voyage turnaround time due to less time spent in the port. This saved time translates into savings on fixed assets, such as ship, crew, and provisions.

Independent players in the port ecosystem, such as the port authority, tugboat operators, pilots, and terminals also perceive large potential cost reductions from the implementation of STM believing it will result in more accurate and valid ETA/ETDs, making planning and execution more efficient. These different actors would then be able to adjust their capacities more appropriately, according to actual market demand. For example, the Transversal Study found that pilot ordering, reporting, planning and resource allocation processes would become more efficient and less time-consuming. The Target Business Description therefore found that optimising the port ecosystem as a whole will prevent the sub-optimisation of individual activities and all players would benefit from more efficient and effective collaboration and coordination.

Many activities are dependent on the ETA/ATA, and all port resources, such as loading and unloading could be optimised to improve turnaround time. Although the Target Business Description study could not get any concrete estimates from respondents, all saw clear efficiency gains from better turnaround time that would decrease port services costs. Overall, taking into account the many different ships and types of transportation, this study suggests a 10-15% increase in the effectiveness of port operations is achievable.

The Target Concept Business Case also found that there is significant room for improvement in the efficiency of arrivals planning in ports. Using port approach data from one month’s traffic, three different scenarios were hypothesised: a low impact scenario in which ships can reduce their speed by 10% for one hour and service times can be reduced by one hour; a high impact scenario in which ships reduce speed by 30% for four hours and service times by four hours; and a median scenario which estimates reductions at an average of the low and high scenarios, or a reduced speed of 20% for 2.5 hours and reduced lay time of 2.5 hours. The median scenario is supported by The Green-Steaming Study which found that by using STM's strategic and dynamic voyage planning and information exchange, combined with slow-steaming, to reach port in the planned arrival window, total anchoring time could be reduced by 18%.
5.2.3 STM's Impact on Environmental Sustainability

This KPA addresses the role of STM in the management and control of the environmental impact of maritime transport. The Transversal Aspects Report found that STM will have several types of environmental impact:

- **Fuel Savings** will result from three planned STM services: optimised speed, route validation, and optimised port services that reduce turnaround time.

- **Prevention of Maritime Pollution.** STM's voyage planning and route validation, and traffic oversight will prevent polluting accidents.

- **Safety of Protected and Special Areas.** STM's improved navigation and Flow Management will direct traffic safely through or away from these areas.

- **Social Health.** STM will reduce exhaust gases and particles related to maritime emissions.

The Green-Steaming Study looked at the potential of route optimisation and slow steaming to reduce emissions both at sea and in port. It found that there is a potential energy and emissions saving of 34% for ships approaching at their slowest safe speed in order to minimise anchoring time. Green steaming for 350 km would reduce CO2 emissions by 105 metric tons and reduce marine gas and oil usage by 33 metric tons for this sample. This study concluded that if ships continually indicate their ETA and port resource needs well in advance of arrival, as STM suggests, they can start green steaming earlier, leading to even greater emissions savings. STM's PortCDM can be used to discern which ships should be targeted for green steaming and to balance the needs of approaching and departing ships to coordinate the efficient use of port resources.

The Target Concept Business Case Study found that all society will benefit from reduced air pollution. Table 2 shows some estimated reductions in fuel and emissions for the Baltic Sea using several different scenarios. It suggests that a 25 per cent speed reduction and information four hours or twelve hours before original ETA is a realistic scenario. Thus, the benefits to society from reduced emissions and fuel savings *together* would be between €12.52 million and €37.48 million for this region alone.
Table 2: Fuel and Emission Cost savings in the Baltic Sea (€ million per year)

<table>
<thead>
<tr>
<th>Reduction in Speed</th>
<th>Time Prior to Original ETA that Information is Provided</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Four Hours</td>
</tr>
<tr>
<td></td>
<td>Fuel</td>
</tr>
<tr>
<td>10%</td>
<td>2.0</td>
</tr>
<tr>
<td>25%</td>
<td>4.6</td>
</tr>
<tr>
<td>50%</td>
<td>7.5</td>
</tr>
</tbody>
</table>

5.2.4 STM's Impact on Cost Effectiveness

This KPA addresses the role of STM in reducing the relative cost of a berth-to-berth voyage. There are three indicators for this area: the cost of port operations, the cost of ship operations in port, and the cost of ownership per voyage. The Target Business Description study found that even though bunker costs are at an all-time low and many shipping lines have already done a lot to reduce the use of bunker, it is still a significant part of operational costs, representing about 30% of the total cost of a voyage. Accordingly, there are still substantial benefits to be obtained from energy-efficiency improvements and smart shipping that would allow for green steaming and thus less bunker consumption. Furthermore, the longer a ship needs to stay in a port, the more significant port expenses become. A short turnaround time is therefore the best indicator for an effective and optimised sea voyage.

All the study's respondents agreed that more precise ETA/ETDs and improved voyage planning would contribute substantially to reduced bunker consumption, fewer CO$_2$ emissions, and more effective use of fixed assets. Many interviewees were very excited about the potential value of a fully-implemented STM and agreed on the potential savings they could achieve:

*I think, to cut 10-15% on bunker over the year is possible - more than possible. And also if you can have a system in ports, [it could] cut 1-2 hours, which is around 10-15%. Of course you can do it* (Möller, Tärntank).
Every ton we can save due to reliable information is worth something. [By slowing] down to 10 knots and then being there [just-in-time] for berthing, we can save 6-7 tons in 20 hours. That is fantastic. There is a value … for the environment as well (Gustafsson, Tämtank)

Just one knot is a lot of money already (Lewerentz, Stena Line)

Although the largest and most effective shipping companies have their own processes and control many parts of the value chain themselves, all companies interviewed believed that there would be positive impacts for them from STM, such as foreseeing congestion with Flow Management and reacting to it as early as possible in order to save bunker through adjusting speed, instead of waiting outside the port for a berth.

The improved information provided by SeaSWIM will not only lead to a significant reduction of workload for some actors in ports, e.g., agents, linesmen, or pilots, but also for the captain and his/her crew. Almost all interviewees stated that STM would reduce phone and email communication significantly and provide more possibilities for both customers and organisations to work more electronically. Some of our respondents reported a huge waste of time with the current system:

… It is very stupid. Sometimes 50% of our time is about having phone calls [and chasing or giving information]. We could use our employees in a better way. Instead of all these phone calls, they could start to be involved in different projects and help developing other affairs (Kärnebro, Port of Gothenburg).

Finally, the Transversal Aspects Report found that STM would increase competitiveness by reducing voyage costs and increasing port efficiencies, resulting in improved turnaround times for ships.

5.2.5 STM's Impact on Predictability

This KPA addresses STM's ability to ensure a reliable and consistent level of sea voyage performance. The differences between ETA and ATA and ETD and ATD for ships and the difference between the estimated and actual start of port operations are the key metrics for this area. The Target Business Description found that improved predictability and transparency in port operations, especially the crucial ETA/ATA, would contribute to a reduction of costs, since planning and operations will be easier to optimise. The earlier one gets the information, the better.
Predictability derives from the publication and continuous updating of ETAs to all interested parties through SeaSWIM. The Transversal Aspects Report found that these, in combination with route optimisation and green steaming, as discussed above, can be used by ships' masters and all port services to coordinate arrival, service, and departure times thereby making transportation and logistics chains more predictable.

5.2.6 STM's Impact on Capacity

This KPA addresses STM's ability to cope with increased sea traffic throughput per unit of time for a given safety level. Two key indicators of STM's ability to improve capacity are: reduced delays in port operations, and delays on a voyage, both due to congestion.

This is a second order benefit that will result from improved predictability, improved information flow to all stakeholders, route optimisation and green steaming, improved traffic flow management, and fewer accidents. The Target Business Description Study found that with such real-time and bundled information, it would be possible to decrease the need for buffers in the voyage planning, which will improve capacity.

5.2.7 STM's Impact on Interoperability

This KPA addresses STM's ability to cope with increased sea traffic demand at a given safety level. It has three objectives: increasing technical and operational integration; improving infrastructure interoperability for information sharing; and improved information sharing. As this report has stated above, information sharing is foundational to STM and is the focus of SeaSWIM.

The Target Business Description Study found that with the introduction of improved information sharing, the agent's work will look very different. Many tasks, like the gathering of ETA/ETD, booking of pilots and tugboats, or arranging other port services, can be made much more effective through the provision of more reliable, formalised, transparent and externalised information, as proposed by SeaSWIM. Informal communication would be replaced by network-based communication with an up-to-date information flow between all actors involved. Agents will then be able to focus on their core value proposition -- quality of service -- rather than fire fighting. An agent's focus will therefore change from being coordination-centric to being service-oriented and customer-centric through his/her local expertise, network of key partners, and on-site support for a shipping company.

At present, a big challenge for interoperability is the lack of common standards in current business processes. Better and more standard information flow between the different actors would enable a reduction in the notice time for ordering a pilot or tug so actors could react more quickly and flexibly to unexpected events. Closer collaboration will also
facilitate learning and the spill over effects will complement and nourish STM's coordination effectiveness.

SeaSWIM's proposed layered implementation framework will reduce the need for technical integration while enabling operational integration. However, the Target Transversal Aspects Description found that three current business practices could inhibit STM's ability to facilitate interoperability:

- **Contracts of Carriage of Goods by Sea.** STM will affect contracts, rights and responsibilities, and contracts of hire, as well as operational procedures.
- **Parties Involved.** STM will affect carrier obligations and operational tools (e.g., notice of readiness, lay time calculations, demurrage and dispatch) applied in shipping.
- **Documents.** STM will affect Bills of Lading and tradable attributes of cargo.

### 5.2.8 STM's Impact on Flexibility

This KPA addresses STM's ability to respond to sudden changes in demand, capacity, traffic patterns, and last minute changes in voyage plans. This is largely a second order KPA in that increases in flexibility can only be achieved once the basic STM target concept is implemented. However, the Target Business Description Study concluded that with optimised sea voyages and efficient port operations, shipping companies expect that they can offer greater reliability and improved flexibility to their customers. It also found that STM's Flow Management services would help ships avoid accidents and congestion. Combined with dynamic voyage planning, ships would therefore be better able to adjust their routes to avoid problem areas. Similarly, last minute changes in voyage plans could be better managed by all port services with the improved information sharing provided by SeaSWIM.

### 5.2.9 STM's Impact on Security

This KPA addresses the risk, occurrence and mitigation of unlawful interference with maritime and port operations. At present, STM only proposes to enhance information exchange security (see Technical Considerations Section below.) However, future services utilising STM information could possibly assist with maritime and port security procedures.
6 Holistic Cost-Benefit Analysis

The current costs of the maritime transport ecosystem can be categorised into ship costs, port costs, business costs, and environmental costs, excluding overhead and administrative costs\(^\text{19}\). Table 3 provides a summary of what these include.

The Target Concept Business Case study found that the total of all these costs (including emissions) for the northern part of the EU\(^\text{20}\) (North Sea and Baltic Sea) are €3.674 billion. As might be expected, particular costs will vary by type of ship, port, geography, and shipping line. Therefore, an analysis of STM's overall cost savings must be limited by these caveats. This section explores the potential benefits of STM in these areas by examining the conclusions of five studies using different methods of analysis.

<table>
<thead>
<tr>
<th>Ship Costs</th>
<th>Port Costs</th>
<th>Procedural Costs</th>
<th>Environmental Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Fuel</td>
<td>- Berthing</td>
<td>- Contracting &amp;</td>
<td>- Emissions</td>
</tr>
<tr>
<td>- Overhead</td>
<td>- Pilotage</td>
<td>- Enforcement</td>
<td>- Accident clean-up</td>
</tr>
<tr>
<td>- Insurance</td>
<td>- Towing</td>
<td>- Information sharing</td>
<td></td>
</tr>
<tr>
<td>- Repairs &amp; maintenance</td>
<td>- Harbour dues</td>
<td>- Coordination costs</td>
<td></td>
</tr>
<tr>
<td>- Crew</td>
<td>- Stevedores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Capital expenditure</td>
<td>- Utilities &amp;</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>services</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Equipment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6.1 STM Savings

STM will make many of these types of shipping costs more efficient and effective in several ways, including:

- **Reducing Fuel Used.** Depending on the price of fuel, bunker represents between 30-60% of the cost of operating a ship. Therefore, even at the lowest price, there are substantial savings to be gained by energy efficiency initiatives.

- The Target Business Description concluded that implementing STM likely will save 10-15% of current bunker consumption through optimised voyage planning and execution alone. When ETA coordination with a port and route optimisation are used together, the Green-Steaming study found slow-steaming and reduced

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\(^{19}\) Bjorn-Andersen and Schellhorn, "Sea Voyage Costs", Copenhagen Business School, 2015

\(^{20}\) All costs and savings in the studies done refer to this region.
anchor time resulted in a potential energy saving of 34% for ships approaching port at their slowest safe speed in order to minimise anchoring time.

The exact savings from the route optimisation/port coordination scenario depend on assumptions about time and speed. Overall, the Target Business Case found that a 25 per cent speed reduction for between four hours and twelve hours with port coordination to meet an ETA is a reasonable scenario. Fuel savings are therefore estimated to be 4.0-4.3%.

- **Improved Turnaround Time and Reduced Port Costs.** Reducing the amount of time spent in port or at anchor can make operating a ship more efficient because it can be more fully utilised and therefore more productive. A smooth turnaround requires that port services for incoming ships are ready on time, and that terminal operators are able to provide berthing capacity on time. Port operations that are collaboratively planned by these actors therefore strive to increase transparency regarding their intentions, capacity and readiness to enable efficient turnarounds and reduced port costs.

- In assessing the cost of unproductive lay time, it is necessary to consider not just the cost of running a ship, but the time cost for the cargo owner, since during the time that cargo is in transit (including the time it spends in port) there is an opportunity cost of capital for the cargo owner. Therefore, the anticipated benefits of Port CDM stem from four types of savings: time; fuel, capital cost, and manning costs. If ships can reduce their annual time in port by nine minutes per trip, the Target Business Case study found this would result in overall port cost savings of 2.3%.

- The Target Business Description supports this conclusion using a different method of analysis. It found that a 10-15% increase in the effectiveness of port operations is achievable and this would further reduce turnaround and port costs. It would also lead to an increase in the return on assets (ships, crew, provisions, etc.) of about 10%. It also concluded that more efficient use of a port’s resources would in the long term reduce the demand for fixed capital as well as labour and hired resources in ports leading to even greater cost reductions.

- **Digitising Procedures.** Standardised information can reduce contract enforcement, information sharing and coordination costs. The Port CDM component of the Target Business Case and the Target Transversal Aspects Report note that many potential port efficiencies hinge on contracts being formulated in such a way that there is no incentive for actors to contribute to efficient behaviour. For example, shipping contracts that require chartered ships to arrive in their destination port as soon as possible, or at “utmost despatch”, is standard practice today. A related instance of contractual inefficiency that may limit the potential for STM is demurrage, i.e., compensation paid to a ship operator for days in port spent waiting, for instance because of congestion. If demurrage is high relative to fuel costs, there is an obvious tendency for a ship operator to arrive as early as possible, even if not contractually obliged to do so, diminishing the fuel
and emissions reducing incentive. It is important to note that under such contracts, many potential benefits of STM can be inhibited.

- **Reducing Emissions.** Emissions can be reduced by optimising routes, reducing time at anchor, and reducing time in port. When ETA coordination with a port and route optimisation are used together, the Green-Steaming study found slow-steaming and reduced anchor time resulted in a potential 34% saving in emissions for ships approaching at their slowest safe speed in order to minimise anchoring time. The Target Concept Business Case found that the total savings to society from reduced emissions due to route optimisation and green-steaming would be 4.3%.

- **Reducing Accidents.** Optimising routes, sharing route information, and monitoring traffic more effectively can prevent accidents and eliminate collisions and groundings. As noted above, the FSA found that the combined impact of STM’s CRA and route exchange services is likely to result in an reduction of 50–70% for the navigational accidents with collisions caused by human errors and that groundings could be reduced by 64% with Flow Management.

### 6.2 STM Costs

Estimating the cost of implementing STM was not a significant focus in this phase. However, the Target Concept Business Case did some preliminary estimates for how much STM would cost per year. It concluded that STM would cost about €16.5 million per year to implement and maintain in the Northern EU (see Table 4).

<table>
<thead>
<tr>
<th>Type of Cost</th>
<th>€ Million per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investments for ships</td>
<td>3.75</td>
</tr>
<tr>
<td>Investment for training</td>
<td>2.0</td>
</tr>
<tr>
<td>Communication costs</td>
<td>2.5</td>
</tr>
<tr>
<td>Governance costs</td>
<td>2.5</td>
</tr>
<tr>
<td>Flow Management</td>
<td>5.1</td>
</tr>
<tr>
<td>Port CDM</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16.35</strong></td>
</tr>
</tbody>
</table>

In addition, the Target Transversal Aspects Report assessed the impact of STM on a variety of international laws, conventions, and regulations and concluded that there would be little impact on these (see Table 5).
<table>
<thead>
<tr>
<th>Law</th>
<th>Relationship With STM</th>
<th>STM's Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>International Convention for the Safety of Life at Sea (SOLAS)</em></td>
<td>Interacts with STM in a number of areas but no direct conflicts identified</td>
<td>ZERO</td>
</tr>
<tr>
<td><em>International Regulations for Preventing Collisions at Sea (COLREG)</em></td>
<td>STM would support COLREG but must make sure there are no doubts about their overriding role</td>
<td>LOW</td>
</tr>
<tr>
<td>Standards of Training, Certification and Watchkeeping (STCW)</td>
<td>Instruction in STM components could be added to deck officer training before implementation.</td>
<td>LOW</td>
</tr>
<tr>
<td><em>International Convention for the Prevention of Pollution from Ships (MARPOL)</em></td>
<td>STM would not be constrained by MARPOL or impact it</td>
<td>ZERO</td>
</tr>
<tr>
<td>Load Line</td>
<td>No interaction was found but attention should be paid to the provisions regarding zones, areas, and seasonal periods by SVM and DVM</td>
<td>ZERO</td>
</tr>
<tr>
<td>Search and Rescue (SAR)</td>
<td>No interaction was found</td>
<td>ZERO</td>
</tr>
<tr>
<td><em>International Convention on Oil Pollution Preparedness (OPRC)</em></td>
<td>STM would interact with OPRC provisions relating to reporting pollution</td>
<td>LOW</td>
</tr>
<tr>
<td>International Safety Management/ Safety Management System (ISM/SMS)</td>
<td>STM is fully aligned with these objectives.</td>
<td>ZERO</td>
</tr>
<tr>
<td><em>International Ship and Port Facility Code</em></td>
<td>STM's communication and information sharing and reporting would interact with this. Could be used to communicate security issues</td>
<td>ZERO</td>
</tr>
<tr>
<td>Cargo Type-Specific Codes</td>
<td>STM could interact with this for improved operational and emergency communication and could facilitate additional services</td>
<td>LOW</td>
</tr>
</tbody>
</table>
6.3 Cost-Benefit Summary

Each of these studies looked at different aspects of the value of STM and have couched their findings in different formats and units of analysis. However, each has concluded there is a significant benefit to introducing STM in Northern Europe, and by extension in the rest of the EU. Figure 10 summarises these benefits.

![Figure 10: Range of Expected Cost Savings from STM implementation](image-url)

Relative to Analyses of Current Costs (from lowest to highest)
The FSA concludes:

"Preliminary cost-benefit considerations indicate that the relationship between costs for introduction of STM and its expected risk reduction in terms of averted fatalities caused by collisions and groundings justifies its introduction."

The Target Business Description agrees:

"Implementing STM will likely save 10-15% of current bunker consumption through optimised voyage planning and execution. Furthermore, it will also lead to an increase in the return on assets (ships, crew, provisions, etc.) of about 10%. Overall, taking into account the many different ships and types of transportation, this study suggests a 10-15% increase in the effectiveness of port operations is achievable."

The Green Steaming Study states:

"Green steaming is a sensible and practical solution for ship operators and the world’s citizens. It reduces costs and emissions for an industry that will likely need to use fossil fuels for the foreseeable future. To benefit from it, it is essential to implement coordinating mechanisms [and]… an information service that advises captains how to minimise anchoring (i.e., STM). These are not technically difficult to develop, and the challenge will more likely be in convincing key stakeholders to change habits."

The Target Concept Business Case found that route optimisation alone has positive net benefit. For Sea Traffic Management as a whole, including all three concepts analysed in this study, the net benefits are very positive with savings of between €60-124 million in the Baltic Sea alone. With the estimated costs of implementing STM at €16.35, this results in an overwhelmingly positive net benefit.

However, the most significant long-term impact on maritime shipping will probably be much more than monetary. As the Target Business Description concludes:

"The introduction of an ‘ideal’ STM is likely to make a significant re-engineering process of the overall maritime ecosystem very beneficial. Accordingly, one could say that the biggest advantage of STM is exactly this – a reinvention of the maritime shipping industry."
7 Other Considerations

7.1 Legal Considerations

The implementation of STM will not cause a revolutionary change in the maritime transport industry's existing processes and systems. It will instead lead to evolutionary changes as different actors create and adapt to a federated information exchange and a service-provisioning ecosystem. Hence, the focus of this legal analysis is SeaSWIM, which will enable this improved information exchange between the various stakeholders in the maritime transport industry.

The primary goal of SeaSWIM is to provide an identity management service for both shore-based and ship-borne actors. Identity management is essential for the delivery of any e-service because it provides assurance to an actor that no unauthorised use is made of its identity and personal data. It also enables the service providers associated with SeaSWIM to make sure that an actor is the entity it claims to be and has the right to receive the requested service(s). Currently, there are several possible technological solutions to identity management but the main challenge in the implementation of SeaSWIM is the multitude of unresolved legal issues involved.

In order to develop the trust necessary to make the SeaSWIM ecosystem work and understand and assess the risk of participation, all stakeholders in the ecosystem need to understand the legal and technical rules/obligations involved, believe that these rules/obligations are effective, fair, and appropriate, be assured that others will follow those rules, and be able to enforce those rules/obligations if needed. In theory it is possible to implement SeaSWIM using the existing laws of most jurisdictions but many lawyers will not know what that legal framework is, and the impact of these laws on SeaSWIM is uncertain. This is because most of the relevant laws were written at a time before the Internet came into being and therefore may not address current needs exactly. At present, these laws also vary by a number of factors, such as, jurisdiction involved and nature of the participants.

The existing laws that may provide a legal framework to SeaSWIM can be categorised as:

1. **Statutes, regulations, and common law** involving maritime and transportation issues because SeaSWIM is directed towards shipping, ports and logistics industries.

2. **Statutes and regulations specific to identity management** including public key infrastructure laws, certain European Union (EU) regulations, identity laws, and authentication laws.

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21 Further information may be found in the "Target Institutional Description Report", see Appendix A.
The broad legal environment relevant to SeaSWIM includes legislation in relation to: contracts; warranties; torts (negligent performance, negligent misrepresentation, fraudulent misrepresentation and defamation); third party beneficiaries; e-transactions; consumer protection; data security; privacy/data protection; identity theft; antitrust; unfair competition; false endorsement; false advertising; intellectual property (copyright, trade secrets, trademarks and patents); governance of the identity management process and compliance obligations; liability for the conduct of others; and governmental immunity. Factors which may affect the application of these laws to SeaSWIM range from the nature of person involved (consumer, business, government entity), expertise of the person involved (unsophisticated or professional in the business), nature of the information involved, nature of the use involved, and nature of any resulting harm (economic loses, property damage, personal injury).

Developing an appropriate legal framework must therefore incorporate the following principles:

- Enforceable rules that are binding on all participants.
- Adequate protection for the rights of the parties.
- Fair allocation of risk and responsibilities among the parties.
- Legal certainty and predictability for all participants.
- Compliance with/works in conjunction with existing law; and acceptability across jurisdictions.

The successful implementation of SeaSWIM will require overcoming three types of challenges:

1. **Organisational risks** associated with technology, process, and procedure.
2. **Economic costs** related to the deployment, coordination, and use of SeaSWIM by the various maritime and transport stakeholders.
3. **Legal considerations** involving potential liability to the participants, the privacy and security of identity information, and the mutual concerns of all participants in the ecosystem that everyone performs their obligations properly.

A second goal of SeaSWIM is to provide reliable identity assertions so that all relevant maritime stakeholders are willing to participate and rely on the results. Achieving this goal requires building a trust framework for the SeaSWIM ecosystem. A pre-negotiated trust framework allows a trust relationship to be established among a group of parties that have established a set of rules by which each of the parties agrees to abide. Such rules provide a basis that allows the parties to trust each other. The agreement to abide by the rules occurs before participation in the trust framework by the parties and provides a baseline for security that those parties who agree to abide by the framework can implement.
A trust framework for SeaSWIM, (i.e., the “SeaSWIM Rulebook”), would consist of a set of documents specifically drafted for SeaSWIM and designed to cover the operational requirements and governing legal rules of the identity system. Provisions that must be addressed by the Rulebook are: identity life cycle management; user credential life cycle management; attribute life cycle management; federation services; identity attribute repositories; authentication of federation participants; claim and token profiles; session lifecycle requirements; facility, management and operational controls; technical security controls; accreditation and certification rules; general provisions of the common operating rules; and warranty, indemnification, and liability. The major benefit of creating a Rulebook is that it removes the requirement for the maritime stakeholders participating in SeaSWIM to negotiate bilateral legal agreements with each other. The Rulebook is a multilateral contract binding each participant to every other participant in relation to their use of SeaSWIM services and ensuring that every user agrees to be governed by a common set of rules.

The operational components of this trust framework would address a variety of key operational and policy issues, such as identity proofing, authentication, credential management, privacy, security and assessment/ audit. Each component would establish the technical specifications, processes, standards, policies, rules and performance requirements necessary to address the issues important to the operation of SeaSWIM. Taken together, they ensure that SeaSWIM will operate properly and in a manner that all parties trust to be appropriate for the task.

The legal rules that will govern SeaSWIM and make the operational requirements legally binding and enforceable, will regulate the content of the operational requirements, and define and govern the legal rights, responsibilities, and liabilities of the participants of SeaSWIM. They will consist of both existing statutes and regulations and new agreements between or among the participants. They will affect the Rulebook in three ways. First, legal rules make the specifications, standards, and rules comprising the various operational components legally binding on and enforceable against each of the participants. Second, they define the legal rights and responsibilities of the parties, clarify the legal risks parties assume, and provide remedies in the event of disputes. And third, in some cases, they will also regulate the content of the operational components.

Legal rules may be set out in numerous contracts at different management and execution layers, depending on the governance structure used. In many cases they will serve as gap-fillers with respect to issues not addressed by existing laws. Where existing laws address issues in a permissive rather than mandatory manner, the legal rules may also express the choices of the parties among legally permissible alternatives. In these ways they provide the legal certainty and predictability necessary to encourage participation.

Creation of a Rulebook can therefore facilitate the launch and use of SeaSWIM. However, the exact terms in the Rulebook will depend on the composition of the STM services that use SeaSWIM. The relationship between the operational requirements and legal rules of the Rulebook is similar to the relationship between a contract and several sets of technical specifications attached to the contract as exhibits. Execution of the
contract is what creates a legally binding relationship between the parties. The specifications in the exhibits detail the parties' expectations of how the contract will be performed. Adopting such an approach will enable SeaSWIM to accept any internationally agreed standard by simply incorporating it under the operational requirements of the Rulebook. For example, the International Hydrographic Organisation’s S-100 standard can be adopted as the baseline data structure for SeaSWIM through such incorporation. Thus, creating a Rulebook to implement STM in general and SeaSWIM in particular will cause the least disruption to the established framework of maritime and commercial laws that govern the navigational and commercial aspects of shipping.

Although a Rulebook may solve some of the major legal hurdles, the implementation of SVM, DVM, FM and PCDM may require some fine-tuning of trade practices and legislative dictates to embrace modernisation. For example, enhanced information sharing between various stakeholders in STM may allow ports to use such information to organise the incoming traffic in accordance with availability of berths, stevedores, pilots, etc. However, in certain shipping trades the provisions of existing legislation may not allow ports to assign time slots to ships before they arrive within the geographical boundaries of the port. A revision of such port-related laws across jurisdictions and relevant standard form contracts will therefore be needed to allow ports to assign time slots to ships situated outside a port’s geographical limits. However, it is envisaged that such revisions will not be difficult to pursue as trade practices evolve with adoption of new technology, and legislators generally respond to market forces. Thus, we expect that when various STM services are made operational, legal impediments will be able to be addressed through spontaneous legislative and contractual fine-tuning of relevant instruments.

A third goal of SeaSWIM is to establish itself as a trust framework provider for the maritime transport industry. Such a scenario will be possible if a considerable portion of the maritime transport industry adopts the SeaSWIM Rulebook as a legally binding trust framework. In that case, SeaSWIM will provide the Rulebook and also the governance infrastructure needed to support it.

This study also reviewed legislation that would affect SeaSWIM. Identity management law is still in a state of infancy given that legislative efforts have commenced only recently in Europe and in the US. The current state of legislative activity indicates that identity management technology has come of age and businesses are now keen to harness the benefits. Several national and regional initiatives in the field of identity management and/or trust services are already actively underway and if enacted, will change the legal rules under which SeaSWIM operates. Relevant legislation that has recently been adopted or proposed, includes the EU Regulation on electronic identification and trust services for electronic transactions in the internal market (eIDAS Regulation), the Belgian law on the eID card and the draft Belgian law on trust services, the French legislation on electronic signatures, as well as on electronic registered mail, the Italian regulations on the posta elettronica Certificata, and the Electronic Identity Management Act of Virginia from the United States of America. Also, there are several
public and private sector national and international initiatives that are currently being undertaken in various parts of the world.

The legislative initiatives in the EU and the US take divergent approaches. Yet there is a general recognition that identity management is a global issue, and that interoperability across national boundaries is critical. Accordingly, in the spring of 2015, the American Bar Association Identity Management Legal Task Force, and the countries of Austria, Belgium, France, Italy, and Poland with support from the EU Commission, all submitted proposals to UNCITRAL recommending that it undertake a project to develop “a basic legal framework to cover identity management transactions, including appropriate provisions designed to facilitate international cross-border interoperability.” At its July 2015 meeting UNCITRAL agreed to move forward with such a project.

SeaSWIM is thus a timely concept which has the potential to push the conservative maritime industry to embrace modern information and communication technology. SeaSWIM may also play a pioneering role in shaping the identity management legal framework for the maritime transport sector. Proponents of SeaSWIM should therefore monitor current legislative efforts on an on-going basis.

7.2 Human Considerations

At all levels, shipping depends on the performance of humans. It involves numerous complex processes and multiple skills and job roles. International and national regulations, labour unions, and other policies all affect these processes and skills, making the maritime industry a multidisciplinary ecosystem composed of many different stakeholders and roles. The Human Considerations Study therefore addressed the human interactions involved in STM, ranging from working with devices, to system and process design, team work, and work and organisational design, including social factors affecting performance at multiple levels – from small teams through to corporate culture. This section discusses how humans will interact with the STM concept and the services it provides. It focuses on the bridge crew on board STM-compatible ships and the operators providing shore services.

Human factors have played a role in several major maritime accidents in the recent past. Key human considerations that have been related to these incidents include:

- An overreliance on automation and technology
- Poor understanding of technology
- Suboptimal human-machine interface
- Poor situational awareness
- Heavy administrative workload

Further information can be found in the "Target Human Aspects Description", see Appendix A.
- Lack of standardised technology
- Information overload
- Lack of information integrity
- Inadequate operating procedures
- Inadequate training

Improved information sharing as a result of STM will deliver four significant human benefits that will address some of these issues. These include:

- Improved interoperability of technology
- Decreased administrative workload
- Increased situational awareness
- Receiving the right information at the right time, reducing information overload

However, when introducing new or upgraded bridge and shore-based technology or services in order to display information or implement new ways of ship-to-shore interaction, there are risks that will need to be monitored, such as:

1. Information overload. Adding new information to the bridge crew might lead to information overload in some situations and this could negatively affect operators’ decision-making.

2. Poor information integrity. Although new relevant information can increase situational awareness and provide a better basis for decision-making, this information could be inadequate, misleading, or contradictory, resulting in poor decisions.

3. New services and equipment. New or updated services may need new or upgraded technologies and equipment, which could introduce new risks arising from expecting the bridge crew to know and understand these new functions and procedures.

4. Need for Training. New or updated services or equipment could necessitate improved training in order to operate them effectively.

Risk mitigation measures should therefore be designed with the following principles in mind:

- They should be user driven.
- Process and service development should follow user-centred design practices.
- Common functions and human-machine interface standards should be adopted in order to harmonise bridge equipment.
• Vendor-specific solutions should be avoided.
• Operating procedures should be adapted to incorporate new functions and services.
• Training should be adapted to include new processes and services.

Innovation is often technology-driven, so it is crucial that the research and development process involves the users early and throughout the process. Human Centred Design (HCD) is a methodology consisting of different methods and techniques to ensure that new products and services are developed to address user needs. HCD calls for developers to interact with users early before starting to design prototypes of products or services. Early prototypes should then be tested and evaluated with the users and redesigned in an iterative spiral until the product or service is found useful enough for launching. Some STM functionalities and services have already been tested in this way. For example, "STM Operations and HMI" and “Deep Sea Shore Based Assistance” have been evaluated by active mariners and the results of these tests led to the re-design of these functions, while still confirming some of the expected benefits.

In the STM concept definition phase, IMO guidelines have been followed in STM testing, evaluation, and usability analyses. In parallel with the usability assessment, changes in current processes, procedures and training needs have been identified and high level operating procedures proposed for the prototyped services. To date, these have been used in the following way:

**Low-fidelity prototypes.** Some STM operational services have been implemented as prototypes or demonstrators in real or simulated environments, including:

• *PortCDM* to demonstrate port synchronisation, port optimisation, and monitoring in a real port environment.

• *Dynamic Voyage Management* to demonstrate route exchange, tactical routes, and route optimisation simulating both ship and shore users.

• *Flow Management* to demonstrate flow optimisation and enhanced monitoring by simulating ship and shore uses.

**Context analysis.** Feedback from users and reference groups, such as the Operational Advisory Group (OAG) and Policy Advisory Group (PAG), has been used in the overall definition of services.

This project also conducted an evaluation of future training needs for STM. A ship’s crew’s competencies, certificates and requirements are set by the IMO’s International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW). STCW includes detailed learning objectives broken down for each subject and for each certificate. The IMO has also issued a number of guidelines – IMO model courses – giving detailed curriculum for each course leading to a particular certificate. Officers are trained at maritime academies and universities that include both theoretical
studies and practical training in ship simulators. To hold a valid officer license extensive seagoing experience is also required. VTS operators are trained according to IALA recommended Standards of Training and Certification of VTS personnel. These model courses provide national members and other relevant authorities with specific guidance on the training of VTS staff. However, these are not yet mandatory requirements.

A training needs analysis of STM was performed at conceptual level. It was divided between on board and shore-side processes. Required training for bridge crews needs to distinguish between mission-critical functions and strategic, administrative functions. This study found that mission-critical functions should be part of ECDIS training and included in the IMO ECDIS model course and in the generic and type-specific courses. Hence, the training should be included in the normal STCW education at maritime academies and universities and a dedicated course for active mariners. Training for specific strategic or administrative services should be arranged by service providers as part of their service agreement.

The exchange of route information is deemed to be in line with the current navigation process and only minor updates of operating procedures will be necessary. However, with the introduction of a deep sea shore-based assistance service, there will need to be a clearer distinction between the two types of pilotage (shore vs. on-board).

### 7.3 Technology Considerations

This section addresses the technical infrastructure needed for STM. The specific services identified by the STM target concept mostly do not exist today. To develop and realise these services, it is important to understand the possibilities and limits of the current technical infrastructure.

To implement the STM target concept, the maritime world must deal with three types of technical infrastructure: technology ashore, technology on board, and available communication channels. In this era of highly connected systems and massive information exchange through various different channels and systems, it is very important to define clear requirements not only for existing but also for new technical systems. Bringing the right information to the right actor at the right time in an environment where broadband is quite expensive and many of the devices needed for information exchange are not connected efficiently or even used, is a challenge and in some instances, a new technological framework may be needed. STM’s four requirements for its technical infrastructure are:

1. **Reliable communications channels.** Although STM services will lead to some changes in the maritime technical infrastructure, the critical first step toward STM and its advantages involves changes in the technical infrastructure to improve connection quality and availability. This may lead to an increase in data rates,

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23 For more information see the "Target Systems Technical and Technology Description", Appendix A.
depending on the STM requirements. Today's voice communication with ships and between ships via HF or VHF is unreliable and dependent on weather conditions. In a first stage, this communication needs to be supported by the introduction of digital communications that operates on other, possibly additional, frequency bands. In a second stage, voice can be moved to digital systems that increase reliability and spectrum efficiency. The new communication systems need to provide high reliability with date protection and error correction capabilities as well as increased spectral efficiency and adaptation to the channel conditions. Satellite communication systems are required for oceanic navigation as well as in all locations where terrestrial links are not available. Both terrestrial and satellite communication links shall be interoperable and the communication shall seamlessly switch between them. The switching could depend on the links quality and operators contracts with the two or more vendors.

2. Depending on the specific application, different types of communication traffic are generated. Applications like updates of weather conditions are much different from tracking and monitoring of vessels, in terms of frequency and type of data that needs to be exchanged. In this way, the design of proper rules for the share of the common bandwidth among different vessel links, or the selection of already existing solution is of upmost importance.

3. **Information security.** Communication security has often been neglected and this must be taken into account in any future infrastructure. It should be seen not only as a technical consideration but also as an operational one. Each new port and interface to a ship’s systems creates a new platform for hackers and attackers to search for vulnerabilities and attack. Therefore it is important for STM's technical infrastructure to provide appropriate physical and logical security. STM's technical infrastructure could be attacked at many different levels, through:
   - Satellite communications
   - AIS
   - Marine radar systems
   - Electronic Chart Display Information System (ECDIS).

4. Services using these systems can be attacked as well. However, information security in STM is not a greater problem than with other land-based systems. The shipping industry must therefore incorporate proper defensive strategies to handle cyber-threats, just as must any other industry.

5. **Open interface standards.** STM services will be implemented by several different service providers. Therefore, open interfaces and open interface standards must be introduced in order to enable more effective communication as well as to facilitate innovative competition between service providers.

6. **Integration of new and older technologies.** Since shipping changes slowly, over the foreseeable future STM services must be able to be distributed over a
8 Conclusion

Sea Traffic Management is an idea whose time has come. Shipping has fallen well behind other modes of transport and the lack of digital integration of the processes and information involved in maritime transport has created inefficiencies, increased costs, and resulted in unnecessary risks to safety and the marine environment. STM is an opportunity for the EU to offer world-class leadership in this field and build a solid platform which will not only deliver significant benefits to all stakeholders, but also act as a foundation for innovation within the maritime transport industry and between it and other modes of transport. The recommendations contained in the STM master plan describe the steps that will be needed to make STM a reality.
Appendix A  Activity 2 Deliverables

This Appendix lists the MONALISA 2.0 deliverables on which this report is based and where further details can be found.

- Collaboration in the Maritime Transport Ecosystem, MONALISA 2.0 – D2.3.1-12-3.
- DVM Concept Description, MONALISA 2.0 – D2.3.1-4.2, 2015.
- Envisioning Sea Traffic Management 2030, MONALISA 2.0 – D2.3.1-12-4.
- FM Concept Description, MONALISA 2.0 – D2.3.1-4.3, 2015.
- Formal Safety Assessment Case, MONALISA 2.0 – D2.3.1-11, 2015.
- Performance Assessment Case, MONALISA 2.0 – D2.3.1-9.
- Port CDM Concept Description, MONALISA 2.0 – D2.3.1-4.4, 2015.
- Sea Traffic Management: A Holistic View, MONALISA 2.0 – D2.3.1-4.0, 2015.
- SVM Concept Description, MONALISA 2.0 – D2.3.1-4.1, 2015.
- Target Business Description, MONALISA 2.0 – D2.3.1-3, 2015.
- Target Human Aspects Description, MONALISA 2.0 – D2.3.1-7, 2015.
- Target Information-Systems and Information-Technology Description, MONALISA 2.0 – D2.3.1-6, 2015.
- Target Institutional Description, MONALISA 2.0 – D2.3.1-1, 2015.
- Target Systems Technical and Technology Description, MONALISA 2.0 – D2.3.1-5, 2015.
- Target Concept Business Case, MONALISA 2.0 – D2.3.1-2, 2015.
- Target Transversal Aspects Description, MONALISA 2.0 – D2.3.1-8, 2015.
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