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1 General information

- **Name of testbed**
  *Sea Traffic Management (STM) Validation project, voyage management testbed*

- **Location of testbed**
  The STM voyage management testbed is focused on two geographical areas. One in the Baltic and North Sea and the other in the Mediterranean Sea. As ships operating in worldwide trade are included in the testbed, tests are also performed outside of these two areas.

- **Time and duration of testbed**
  2015-2019

- **Status (planned, completed or ongoing)**
  Completed

- **Contact person(s)**
  Björn Andreasson, Swedish Maritime Administration, bjorn.andreasson@sjofartsverket.se

- **Testbed website**
  www.stmvalidation.eu

- **Organization(s) involved in the overall project**
  Beneficiary partners:
  - Swedish Maritime Administration (lead partner), Airbus, Carnival Corporation, Chalmers, CIMNE, Costa Crociere, Cyprus University of Technology, Danish Maritime Authority, Finnish Transport Agency, Flensburg University of applied sciences, Fraunhofer, Frequentis, Furuno, GS1, HiQ, Magellan, Maritiem Instituut Willem Barentsz, Ministry of Infrastructure and Transport in Italy, Navicon AS, Norwegian Coastal Administration, Novia University of Applied Sciences, OFFIS, Polytechnical University of Catalonia, Port Authority of Valencia, Port of Barcelona, RISE Viktoria, Rørvik Maritime Safety Center, SAAB, Sasemar, Southampton Solent University, SSPA, Svitzer, SMHI, Transas, University of Oldenburg, University of Southampton, Valenciaport Foundation and Wärtsilä SAM-Electronics.

  Associate Partners in the overall project:
Campus North (NORD University), Novikontas, Marine Institute of Memorial University of Newfoundland, DFDS, Rolls-Royce, Utkilen, Wallenius Marine, Dalex Shipping, NAPA, Estonian Maritime Academy, VTT Technical Research Centre of Finland, ÅF Digital Solutions, Sperry Marine, ChartWorld, Offshore Navigation, Indra and MeriTaito.

- Funding programme and budget
  The STM Validation project is 50% co-financed by the European Union via Connecting Europe Facilities (CEF). Remaining 50% is funded by each beneficiary partner with a budget in the project. The total budget is approximately 42 MEUR.

- This report includes activity 2 milestones and deliverables:
  o MS6: Final system prototypes tested and reported
  o MS10: Report from Mediterranean testbed
  o MS12: Report from Nordic testbed
2 Executive summary

The goal of the voyage management testbed was to operationalize and validate the concept of voyage management services based on digital information exchange. The information exchanged in the testbed includes voyage plans, navigational warnings, port call messages and text messages. A total of 312,800 messages has been exchanged. In addition to these, route messages, a segment of ship’s monitored route, have been sent on AIS as Binary Broadcast Messages (BBM) to other ships within AIS range.

Interoperability between systems from different suppliers in an eco-system is a complex task. In STM, this interoperability has been enabled by a distributed service eco-system approach, the Maritime Digital Infrastructure. The testbed has proven this approach to be a suitable solution and the number of partners and systems that are now interoperable is a major result of the project. Accordingly, and as an outcome of the project results, a generic service interface, communication protection measures and service lookup functions have been proposed to IEC (International Electrotechnical Commission) for standardization.

Leading market actors have integrated STM functionality in existing operational systems such as onboard navigation systems, shore-side services, Vessel Traffic Services (VTS) and in ports. As of 2019-06-01, 311 ships have been upgraded with STM capability. These systems have been provided by Wärtsilä Voyage (former Transas), Furuno, Adveto and via Carnival Corporation Fleet Operation Centre. On shore-side Kongsberg, SAAB. Wärtsilä Voyage and Navicon have developed the STM capable systems for monitoring and VTS. They have been installed in the VTS centres in Gothenburg, Tarifa, Kvitsøy, Horten, Tallinn and in the Danish Joint Operations Centre. SSPA and GAC/SMHI has provided route optimization services via STM while the Swedish Maritime Administration has provided Search and Rescue (SAR) services, pilot routes and navigational warnings as integrated services. In addition, the Baltic management system for icebreaking, IBNET, has been made STM capable.

In conclusion, end-user feedback, from navigation officers onboard testbed ships, validates the hypothesis set up for the project. The results indicate that digital information sharing between shore-ship, ship-shore and ship-ship can improve situational awareness, increase operational safety and improve operations. For example, an average of 75% perceived operational safety to be increased and 74% thought STM supported tools and services assisted their ordinary bridge duties. The responses to whether STM has reduced workload are more diversified. This was expected since not all services aimed to reduce workload. In addition, training and usability refinements are expected to reduce the effort to use the various services. Taking into account the overall maturity the digital infrastructure and some services, for example SAR and the pilot route service, are considered mature for industrialization and to be taken into large-scale operation.
3 Methodology

3.1 Methodology and objectives of the voyage management testbed

The mission of analysis and evaluation in the testbed is to facilitate the validation of the STM concepts through the quantification of the effects associated with STM implementation.

The Key Performance Areas (KPAs), Objectives (KPOs) and Indicators (KPIs) developed in the MONALISA 2.0 project, available at https://www.stmvalidation.eu/documents/ allows for evaluation of the impacts of the STM concept. The testbed provides data for a detailed analysis and lessons learned with regard to long-term feasibility of the STM concept and its wider implementation.

The overall metrics used sets the focus for the testbed activities and forms the basis from which the tasks are carried out in the voyage management testbed.

To be able to analyze and evaluate the results of the testbed a methodology built on the three main key performance areas: safety, efficiency and sustainability was broken down to sub-hypothesis, see Figure 1. These hypotheses are validated by different operational STM services. The operational services are defined as an operational act that provides an observable effect that fulfils a need, optionally by providing a tangible product. The voyage management testbed sets out to validate the hypotheses set up for this part of the STM concept. Further information on hypothesis, validity, reliability and respondents are included in Annex A.

Figure 1 The STM concept is implemented by different operational services aimed at validating the set up hypothesis.
The objectives of STM, further described in the STM Final report, are summarized below.

From a safety perspective, STM sets out to decrease the workload on the bridge and adds situational awareness through timely and tailor-made information. With knowledge of the intentions of ships in the vicinity, planning ahead can be improved. Shared knowledge between ship and shore also enhances awareness.

For improved efficiency of shipping, STM and its digital infrastructure enables a variety of digitalized services to be detected and consumed, for example allowing navigators onboard to get informed by different means of optimizing the route. From a shipping companies perspective port call optimization services aims at saving fuel and emissions via more just-in-time arrivals by collaboration between ship and port.

Environment sustainability links to both efficiency and safety. Decreasing the bunker consumption is an obvious sustainability measurement and so is improved environmental protection through safer routes.
4 Results

4.1 Background

4.1.1 The Sea Traffic Management concept

STM ambition is to connect and update the maritime world in real time, with efficient information exchange. Through data exchange among selected parties such as ships, service providers and shipping companies, STM is creating a new paradigm for maritime information sharing offering tomorrow’s digital infrastructure for shipping. This will not only strengthen shipping efficiency and competitiveness but also substantially contribute to more sustainable and safe maritime transport.

The STM Validation project takes its offset in the MONALISA (2010-2013) and MONALISA 2.0 (2013-2015) projects where the STM concept was defined. These projects also demonstrated how supplying ships with the capability of seeing each other’s planned routes, give the navigator a more complete picture of how ships in the immediate vicinity are planning their onward voyage. At the same time, shore-side services are able to retrieve valuable information, as well as supply ships with relevant services related to their routes. The STM Masterplan describes the need to validate the effects and consequences before further deployment and a validation phase was agreed as the next step in STM development.

In the definition phase of STM within the MONALISA 2.0 project, the current situation of traffic management at sea was described, KPIs were elaborated and a target concept was developed and analyzed from different perspectives (business, institutional, legal, operational and technical).

Central parts of STM are Voyage Management with route planning and optimization, information sharing and traffic optimization. Port Collaborative Decision Making (PortCDM) concept includes the process of port calls and departures being made more efficient through information sharing, common situational awareness and enhanced processes.

The development of STM is the result of a joint effort bringing together industry, academy and a proactive public sector, as well as international intergovernmental organizations and key stakeholders outside of Europe.

Sea Traffic Management is fully in line with the vision and strategic directions of IMO and in line with a majority of national, regional and global policies protecting life at sea, property and the protection of the marine environment.

4.1.2 Previous tests and outcome

The effects and consequences of the exchange of voyage plans have previously been studied in several e-navigation projects like the ACCSEAS, EfficienSea and the MONALISA projects. Lessons learned from these projects, e.g. end user feedback and human centred design, have been taken in to consideration when planning the STM Validation testbed.
4.1.3 STM and inter-linkage to IMO and UN activities

IMO’s e-navigation Strategy Implementation Plan (SIP) – Update 1

IMO’s Maritime Safety Committee, at its ninety-ninth session, recognizing the need to regularly update the e-navigation SIP to allow prioritized tasks to be included in the work programme of the NCSR Sub-Committee, approved the *E-navigation Strategy Implementation Plan – Update 1*, prepared by NCSR 5 (MSC.1/Circ.1595).

A comparison between STM and the e-navigation definition is made in the table below:

<table>
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<tr>
<th>E-navigation</th>
<th>STM</th>
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<td>“the harmonized collection, integration, exchange, presentation and analysis of marine information on board and ashore by electronic means”</td>
<td>STM is a concept for sharing secure, relevant and timely maritime information with authorized service providers, by proposing a framework and standards for information management and interoperable services</td>
</tr>
<tr>
<td>“enhance berth to berth navigation”</td>
<td>A holistic approach to distributed service related to the berth-to-berth voyage enabling the efficient, safe, and environmentally sustainable sea transport</td>
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<tr>
<td>“related services for safety and security at sea and protection of the marine environment”</td>
<td>The potentials of enhanced information sharing are increased safety, efficiency and less likelihood of an environmental impact</td>
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*Table 1 Comparison between STM and the e-navigation definition*

The Sea Traffic Management (STM) concept mainly addresses aspects of four of the e-navigation solutions, namely S2, S3, S4 and S5:

- **S2** Means for standardized and automated reporting; Single reporting using the maritime digital infrastructure and SeaSWIM for the exchange of information
- **S3** Improved reliability, resilience and integrity of bridge equipment and navigation information; integrity of navigational information is achieved by cyber security measures in the maritime digital infrastructure
- **S4** Integration and presentation of available information in graphical displays received via communication equipment; In STM, services have been directly integrated to ECDIS to allow presentation of e.g. text messages, route proposals and MSI
S5 Improved communication of VTS Service Portfolio (not limited to VTS stations); several of the STM operational services would enhance VTS operations

Risk Control Options

A total of seven Risk Control Options (RCOs) were identified in order to aid the assessment of the e-navigation solutions and some of the sub-solutions. The STM validation concept directly addresses four of the seven RCOs, namely:

RCO1 – Integration of navigation information and equipment including software quality assurance
RCO 4 - Automated and standardized ship-shore reporting
RCO 6 - Improved shore-based services and
RCO 7 – Bridge and workstation layout standardization

Maritime Services

As part of the improved provision of services to ships through e-navigation, maritime services have been identified as the means of providing electronic information in a harmonized way, which is part of solution S5.

Maritime Services relevant to STM are VTS Information Service (INS), VTS Navigational Assistance Service (NAS), Traffic Organization Service (TOS), Local Port Service (LPS), Maritime Safety Information Service (MSI), Pilotage Service, Tug Service, Vessel Shore Reporting, Ice Navigation Service, Meteorological Information Service and Search and Rescue Service (SAR).

Tasks, deliverables and schedule for IMO’s SIP – Update 1

In IMO’s E-navigation Strategy Implementation Plan (SIP) – Update 1, the identified tasks with a short definition including deliverables and transition arrangements, if considered necessary, including an indication of the prioritized implementation schedule have been outlined. The Sea Traffic Management concept, as developed in the MONALISA 2.0 project, addresses aspects of 12 of the 18 identified Tasks** (including Task 1, 2 and 18 to which the MONALISA 2.0 project had provided information based on project results).

** Note: These tasks are reflected in Table 7 of the Annex to MSC.1/Circ.1595.
Task Nos. T1, T2, T7, T11, T12, T13, T14 (b) and T18 have already been completed.

United Nations Sustainable Development Goals (2030 Agenda)

The STM Validation Concept activities have linkages to SDG 2 – Zero Hunger, SDG 4 – Quality Education, SDG 7 – Affordable and clean energy, SDG 9 – Industry, Innovation and Infrastructure, SDG 13 – Climate action and SDG 14 - Life below water of the United Nations Sustainable Development Goals (2030 Agenda).

STM and its relationship with key IMO UN Conventions
STM compliance and relationship with key conventions like SOLAS, COLREGS and UNCLOS have been investigated in separate reports available at www.stmvalidation.eu

4.1.4 STM Master Plan deployment strategy
The ambition is that once the STM concept has been validated via the established testbeds, governments and industry will take a more active role in the implementation aspect of the concept.

It is envisaged that as a start the STM concept would be introduced on a voluntary basis in a smaller area like the Baltic Sea where the revised HELCOM Recommendation 34E/2 proposes "Further testing and developing the concept of pro-active route planning as well as other e-navigation solutions to enhance safety of navigation and protection of the marine environment in the Baltic Sea Region". As more experience is gained, implementation could be mandated and replicated in other regions of the world via a systematic approach. Once sufficient experience has been gained, there would be the opportunity to look at the international regulatory aspect of STM.

4.2 Testbed setup and STM ship systems
The scope and objective of the voyage management testbed was to validate and operationalize STM services, and to boost efforts by system manufacturers to develop STM functionality in prototype systems, such as onboard navigation systems and shore side services as VTS centres. Another objective was to provide data for evaluating the effects on the maritime transportation system as a whole as well as benefits and costs for shipping companies when utilizing STM services. This evaluation was done with data from both the voyage management testbed and from the simulated environment whereas this report only covers the voyage management testbed.

Figure 2 Different aspects of STM was collected from both voyage management testbeds and from simulations
The goal was to make 300 ships, 6 shore centres and a number of operational services STM capable. See figure 3 for testbed areas and nodes. To fulfill these goals the testbed started by analyzing the strategic concepts, operational services and enablers defined in the MONALISA 2.0 project. The concepts and operational services were broken down to operational needs expressed as use-cases. With these use-cases as a basis set of information needs, functional and technical requirements were designed. A Service Oriented Architecture (SOA) approach was proposed already in MONALISA 2.0 and the requirements indicated needs on the architecture itself with authentication and access management, but also on new information services to be developed and new/updated data formats. Information service is defined as an implementation independent representation of the use of information by an actor.

**STM Validation Project**

The STM Validation Project will demonstrate the STM concept in large scale test beds in both the Nordic and Mediterranean Seas, encompassing around 300 vessels, 13 ports and 6 shore based service centres as well as using the European Maritime Simulator Network.

![STM Validation Project Map](image)

**Figure 3 Testbed areas, ports and centres**

Partners in the project developed the architecture, SeaSWIM, and information services, e.g. Voyage Information Service, while the parts that would affect ships’ systems were discussed and analyzed together with an industry group consisting mainly of ECDIS and VTS manufacturers. The jointly agreed technical and functional requirements were then used as a basis for development of STM capable maritime services ashore e.g. VTS systems and in the equipment of STM capable ship systems.

The goal of development was that major providers of maritime navigation systems should develop interoperable systems that support route exchange and other information exchange as defined by the STM concept. The onboard installations would include either a software upgrade of an existing ECDIS or planning station to support the specified STM functionality and/or installation of a dedicated planning station for STM functions, which is connected to the onboard ECDIS. Furthermore, the goal was to reach as many manufacturers as possible in order to
get as wide a market spread as possible to facilitate international acceptance for the proposed standards and formats. Consequently, the procurement of ship systems was open to all type-approved ECDIS manufacturers’ and eventually resulted in contracts with Transas, Wärtsilä SAM Electronics, Furuno and Adveto.

The actual realization of the functional specifications with regards to technical solutions, user interfaces etc. was up to each system manufacturer to decide upon, even though it was recognized that some standardization in this area would be beneficial for both users and system providers.

After initial product development, Transas, Furuno and Adveto have upgraded existing systems with STM capability during the latter part of the project. Wärtsilä SAM Electronics did not manage to install any approved STM capable systems due to technical issues. Even though the specifications allowed the functionality to be implemented in any system or in an additional unit provided by the manufacturers all choose to integrate STM functionality into the ECDIS. Although the STM functionality is available in the ECDIS this is not the same thing as having SeaSWIM or the Voyage Information Service integrated into ECDIS. On the contrary, all ECDIS manufacturers have this functionality as part of a shore-based service and then uses a private secure connection including own message exchange patterns between their shore-based service and their ships. Further all their STM ship systems have been tested and approved according to the revised performance standards for ECDIS as reflected in IMO’s Resolution MSC.232(82) adopted on 05 December 2006.

The positive experience with STM functionality directly in the ECDIS is that the officers onboard does not end up with an additional system which could have increased the work load and made information consistency more complicated. The main negative experience is that there have disturbances on ordinary ECDIS functions and that there have been a reluctance from shipping companies “to connect their ECDIS to internet” despite the implemented cyber security measures. This standpoint seems to be based more on general principles rather than on not agreeing to the cyber security solutions. The information security in the voyage management testbed is further described in chapter 4.3.6.

In addition to these ship systems, the cruise ship company Costa Crociere, part of Carnival Corporation, has developed interfaces to integrate STM features with the existing Neptune Platform, part of Costa Group software suite since 2012. This new functionality in Neptune allows the FOC operator to interact with STM services and shore centre operators, and to evaluate the voyage optimization suggestions received by the shore centres through the maritime digital infrastructure. Currently all Costa and Aida ships shares their voyage plan automatically. Costa EU fleet counts 11 ships, while Costa Asia has four additional ships. AIDA fleet counts 14 ships. Potentially all the ships of Carnival Group that have Neptune live system active, would be connected to STM. Carnival fleet is around 106 ships and Neptune platform is planned to be available also onboard of Carnival ships through an on premise infrastructure that will allow the activation of Neptune modules and dashboards.

The plan was to have all 300 ships in operation from the second half of 2018 but the
installations has been delayed and installations has continued during the extension of the project and until 2019-05-30. See Figure 9 for increase of the number of ships in the testbed. The delay has mostly been caused by complex developments including lengthy type approval processes by the manufacturers’ classification societies, to make sure the STM capable ECDIS systems, for use by testbed ships, comply with the Revised Performance Standards for ECDIS as reflected in IMO Resolution MSC.232(82).

Further, time-consuming installations have caused the installation phase to take longer time than expected. The delays in installations caused results from the testbed ships to be used for analysis and validation to be equally delayed. This was one of the factors that the overall project applied for and received an extension of the project with six months. As a result, sufficient data and results from the testbed ships was possible to collect.

**Guidance documents**

To support ships’ crews in understanding and using the new STM functions several guidance documents have been produced e.g. introduction to STM, user guide, description of services and instruction videos. In addition, the four ECDIS manufacturers have their product specific user manual. All of these documents are available at a user forum tab created at the STM website, http://stmvalidation.eu/user-forum/

In addition to these, there are specific operating procedures for each shore centre. These are unique for each area due to different operating conditions and responsibilities.

### 4.3 Maritime Digital Infrastructure in the testbed

#### 4.3.1 General architecture description

The STM voyage management testbed includes ships, fleet operation centres, ports, shore centres and service providers. Information is exchanged via secure network on the Internet, and the existing AIS network is used for ship-to-ship exchange of AIS route messages.

All actors have been digitally connected through Internet and a dedicated security domain called SeaSWIM, System Wide Information Management, where secure exchange of information is executed. In the STM testbed, the Maritime Connectivity Platform (MCP), available at https://maritimeconnectivity.net/, realizes the infrastructure part of SeaSWIM with its common registries for identities and service information lookups.
Figure 4 Overview of SeaSWIM and MCP

Figure 5 gives an example where an operator onboard uses the STM capable ECDIS application to search for enhanced monitoring services along the route.

Figure 5 Example of ECDIS with STM Tools
The technical architecture is a service oriented architecture with REST services and secure HTTP (HTTPS, TLS and X.509 certificates) for exchange of information through services. Identities and services are registered in the MCP through a web portal or exposed API’s to the MCP Service Registry and certificates are issued through the MCP web portal.

Interoperability between actors is established through use of a limited set of common message formats and a common set of service interfaces (Service API).

The set of common message formats used are: Route Exchange Format (RTZ), Navigational Warnings (S-124), Port Call Message Format (PCMF) and STM text message format (TXT). The set of common service interfaces used are Voyage Information Service (VIS) for RTZ, S-124 and TXT, Assisted Message Submission Service (AMSS) and Message Broker (MB) for PCMF.

Figure 6 shows the common infrastructure in the STM voyage management testbed and the additional components added specifically for STM. The common MCP enables service and identity lookup but the actual exchange of information is done actor-to-actor directly in the STM testbed, no information is stored centrally other than identities and metadata regarding services.

![Figure 6 Overview of STM voyage management testbed](image)

**4.3.2 Information exchange in the testbed**

**Ship to Ship**

The main information exchanged between ships are the AIS route message and TXT messages, but ships can also exchange route templates and voyages in RTZ format.

**Ship to Shore**

Information from ship to shore is mainly the voyage plan in RTZ, TXT and port call messages in PCMF. Most services in STM voyage management testbed is initiated...
by the ship sending its voyage plan to the service, such as for enhanced monitoring, for optimization or for port call synchronization. The ships can also send their routes back to their Fleet Operation Centres.

**Shore to Ship**

Information to the ship from shore are voyage proposals in RTZ, pilot routes in RTZ, ice routes in RTZ, optimized route in RTZ, recommended update of schedule, such as new time for arrival to port in RTZ format and PCMF format, navigational warnings in S-124 format, search areas in S-124 and search patterns in RTZ and text messages in STM TXT.

Until 2019-06-01 a total of 311 ships, see Figure 7, have been upgraded with STM capability.

![Figure 7 Number of STM capable ships in the testbed](image)

![Figure 8 Number of exchanged messages between ships and between ship and shore in the voyage management testbed](image)
Figure 8 gives the total number of exchanged messages for each payload type. The statistics is obtained by collecting log files from all actors with active STM services that has been involved in the voyage management testbed. As more ships joined the testbed, the level of activity increased.

The figures are relatively high, given the number of ships, with more than 215 000 RTZ messages. One of the contributing factors to this is that the figures comprise the total data exchanged e.g., a ship that shares its voyage plan with seven subscribers will generate seven exchanged messages. Normally there are also several updates of the route and change of status on the route during a voyage.

In the same manner, a ship that receives several navigational warnings associated to one voyage generates several navigational warning messages. When it comes to text messages, not all of these are operator/navigator manually created messages but most of them are automated service responses e.g. textual information about service result etc.

The number of exchanged port call messages between ships and ports is substantially lower compared to the other data formats. The reason for this is a limited number of port calls to the ports that has been a part of the project, a low level of activity within the ports to use PortCDM demonstrator to communicate with approaching ships, few arrival times included in ships shared information and several PortCDM focus months completed before the majority of ships were equipped.

In addition to logs of exchanged messages, data is also logged for internal evaluation and continuous improvement when it comes to system stability, number of faulty messages, correct data information etc.
4.3.3 Data formats

Four defined formats have been used for information exchange in the STM testbed; Route Plan Exchange (RTZ v1.1STM), Navigational Warnings (S-124 v0.0.7), Port Call Message Format (PCMF v.0.016) and STM Text message format (TXT v1.3).

Voyage Plan in RTZ format

The main information exchange in the STM voyage management testbed is initiated by a ship sending its voyage plan (RTZ format) to another actor (ship-shore). For example to a shore centre performing enhanced monitoring, a service provider performing route optimization or a port to synchronize the port call.

The RTZ format was developed as part of the MONALISA 2.0 project and standardized by IEC, included in the IEC 61174 ed.4. In the testbed several findings and conclusions have been made related to the use of RTZ in machine-machine communication and the importance of interoperability tests to ensure that all actors have interpreted and implemented RTZ in the same way e.g. manual and calculated schedules correctly handled. This level of detailed findings is difficult to capture without implementation and common usage. All these lessons learnt are brought forward to IEC WG 17, which is now developing the predecessor to RTZ; the S-421 Route Plan based on S-100.

The core components of the exchanged voyage plan are ship identification, route geometry and calculated schedule. Depending on receiver, the route plan also contains additional information such as displacement, draught, fixed times, fixed speeds etc. A service can also send a proposal for changed route geography or proposed change of schedule back to the ship using the same format (RTZ). SAR services also uses the route exchange format to send search patterns to ships.

Route message

Part of the route plan (Binary Broadcast Message, BBM next seven waypoints) onboard the ship can also be broadcasted as AIS Route message. In addition, a VDES protocol (BBM 13 waypoints) has been finalized but not tested.

Navigational Warning in S-124 format

The project also serves as testbed for S-124 Navigational Warnings, which is under development in an IHO Correspondence Group.

Navigational Warnings in the Baltic Sea area are sent to the ship using the IHO S-124 format for the areas concerned with the route, in geography and time. SAR services also uses the S-124 to send search areas to ships.

STM Text message in TXT format

In addition, text messages are also exchanged via the STM Text message format. Text messages are used as both free text by humans and automated response texts from services in addition to the defined formats. The text message is equivalent to an email message with geographical attributes for positioning etc.
Port call message in PCM format

A Port Call Message Format (PCMF) to be used for optimization within a port and as one of the available formats for synchronization of arrival times with approaching ships has been developed within the project. The ship can report its planned and estimated time for arrival, and the port can recommend a new time of arrival (RTA) to the ship. The format has been brought forward to IALA for standardization and is assigned S-211 as identifier.

4.3.4 Detailed architecture description

The technical design of the Service Oriented Architecture in the STM Voyage management Testbed is based on REST services and HTTPS with X.509 certificates. The common principles to gain technical interoperability are encapsulated in the SeaSWIM Connector, which is expected to be used for all STM services. The specific implementation varies depending on internal design, but is equal when seen as black boxes in front of the services.

Figure 10 shows an example of connectivity between two services and the relation to the MCP for lookup of information about services and identities. The picture also shows the connectivity to the ships where the service is commonly located on a shore based server with a private communication to the ship, hence the ship may not always be connected but the shore-based service can always be consumed for request of the latest route plan (access controlled).

Figure 10 Overview of service interaction

Figure 11 contains an example of a typical sequence where the Service Registry is used for lookup of service to consume (1), and then the service is consumed directly (2), and if identity is authenticated (3) and authorized the service returns the result (4).
Figure 11 Example of interaction with MCP and services

4.3.5 Voyage Information Service (VIS)

The main purpose with VIS is to handle the communication around voyage information and the main artefact Voyage Plan (VP) in RTZ format. VIS implements methods for exposing new and updated VP’s and to consume external VP’s. VIS also supports subscription of voyage plans, see Figure 12.

In addition to voyage plans (RTZ), VIS also supports exchange of STM Text Message and area message (S-124). The Voyage Information Service interface is used by all actors in voyage management testbed for exchange of voyage plans; both ships, ports, shore centres and service providers.

The VIS interface is intended for international standardization and has been proposed by the Swedish Maritime Administration to the Swedish section of TC 80 in IEC who proposed a new work item to the IEC Secretariat.

Figure 12 Overview of VIS interface
4.3.6 Information Security in the voyage management testbed

The information security, further described at [http://stmvalidation.eu/developers-forum/cyber-security/](http://stmvalidation.eu/developers-forum/cyber-security/), in the testbed is mainly facilitated through the principles and capabilities of the Maritime Connectivity Platform and the SeaSWIM Connector. Confidentiality is facilitated in SeaSWIM by use of an encrypted communication between authenticated parties in MCP by use of host certificates. Integrity measures are not implemented in SeaSWIM since this would add a level of complexity and incur delays in the STM Validation project implementation (integrity means that a hash is calculated from the message content and the identity of the message producer. This will give the recipient a way to be sure that the message has not been manipulated in any way during transportation.).

Authentication is based on instance certificates issued to each exposed service provider’s service instance registered in MCP (i.e. ship, VTS). Identification is realized by registering an organization and related users in MCP. Authorization to information is handled by each service provider (onboard/ onshore operator), the owner of the information grants authenticated actors access to each information object (i.e. a route etc.). The adjacent information service (VIS, SPIS etc.) facilitates this, providing an Access Control List table in storing which stakeholders have access to specified information.

4.3.7 Findings, Consequences and Recommendations

The following findings have been captured related to the Maritime Digital Infrastructure:

**XML Schemas**

All payload (information products) have been described in XML Schemas. XML Schema is a standardised description language that can be understood by both humans and machines. A clear identified need is a strict verification of the XML Schemas that are supported under the STM information model, possibly through a common schema pool. The usage would be two-fold; firstly as a support to developers when designing systems with standardized STM interfaces. Secondly, to allow operational systems to verify that they are using supported schemas. The use of common XML Schema is essential to achieve technical (and partly semantic) interoperability.

The XML Schemas used today in the voyage management testbed fulfills the main goal to achieve common understanding of the information exchanged, but still Guidelines have been developed to achieve operational and semantic interoperability. The detailed use of the information exchange format in an operational dynamic context is achieved with the combination of XML Schema and Guidelines. In future, the XML Schemas and Guidelines will eventually become a victim of evolution and change. This requires a solid version handling, which is an implicit objective in creating a payload/ schema repository.
Identities
In the STM voyage management testbed the operational nodes are not fully registered in the identity registry. For instance, a VTS as a main stakeholder is not always clearly represented in the identity registry; instead, it is often the technical supplier of the equipment that are registered as identity. In some cases, the operational provider, such as Norwegian Coastal Administration (NCA), has registered the service, but still it is not possible by identity to separate the different operational nodes (different VTS’s in this case) within NCA.
The recommendation is to introduce more operational entities in the Maritime Digital Infrastructure to cover all relevant STM stakeholders.
There is also limited technical support for hierarchical levels in Maritime Digital Infrastructure with no possibilities to register for instance subsidiaries or departments of registered organizations in the Maritime Digital Infrastructure.
The recommendation is to introduce more levels of hierarchies to facilitate the above requirement.

Voyage identities
The use attribute vesselVoyage in the RTZ format has not been consistent. The setting of voyage identifier has mainly been implemented as a manual operation by the officer onboard. Hence, the decision to create new voyage identifier or use the previous one is up to the officer onboard. The consequence is that a voyage from berth-to-berth can have both same voyage identifier as previous and different voyage identifiers along the route. The consequence is that the attribute cannot be used in today’s implementation to collect route plan updates for a voyage. Until there really is an operational benefit to reference the voyage, the voyage identifier will be a theoretical abstract identifier that is less useful. The recommendation is to elaborate use cases and rules for the voyage in relation to the route.

Service design
In the current version of the maritime digital infrastructure a clear view on how to register composite services in the service registry misses. This affects the way the operational service is registered versus the technical information exchange service.
It is recommended to include a chapter in the Service Description Guideline on how to register composite services.
Further service orchestration is not included in above description and it is recommended to include a chapter in the Service Description Guideline on how to describe service orchestration.

Operational dynamic of service interface
The approach in the STM Validation project to achieve interoperability for exchange of information is to create a common information exchange service with focus on the payload rather than on a specific operational purpose. In practice, this means that the STM Validation project has released one Service Specification and one Service Technical Design for exchange of e.g. RTZ. The operational context is then
introduced on Service Instance level and the operational service provider registers the operational instance.

The use of one Service Technical Design have the benefit that e.g. a ship can implement one service interface that can be used in many operational contexts. The consequence however with the use of only one Service Technical Design is also that the different need to support different interfaces need to be handled at runtime rather on technical design level. A shore centre for example may not want to accept subscriptions while a ship will.

The recommendation is to add support to ask service instance at runtime for implemented service interface. This information can then be used e.g. onboard a ship to present only possible actions for the service.

### SeaSWIM Connector

In the beginning of the STM Validation Project, the decision was to create a SeaSWIM Connector as a proxy service. The design was also implemented by CIMNE in the JAVA version, and the design with a proxy may be useful when only one service are exposed, such as the case of service provider or shore centre, but less practical for a ship operator that need to expose hundreds of services. The design with a built-in SeaSWIM Connector in the parent service is then preferred. The SeaSWIM Connector however fulfills the main purpose of encapsulating the requirements and principals regarding communication and authentication procedures between services.

### RTZ

Overall, the RTZ fulfills its purpose to exchange route plans. In some cases, the attributes should have more precise patterns, such as vesselVoyage.

One of the areas that need to be more elaborated is the term “complete schedule”. Several services, such as Port Call Synchronization, is depending on the schedule in the route plan. If there is no schedule, it should not be sent nor accepted for port call synchronization. This finding raised a set of other discussions, such as how the port call synchronization service can tell the ship that a schedule is required.

The routeStatusEnum in the STM extension has defined 8 different statuses, which can be summarized as 1-6 during planning, 7 as the active route under monitoring and 8 as inactive. The use of status inactive is however used in different ways by different ships and implementations. Some ships sets and shares the route as inactive (8) every time it’s unloaded from ECDIS to be updated, and then shared as monitored (7) again. Some ships only share the route as inactive (8) when route (voyage) is finalized. Hence, the definition of inactive route needs to be clarified, possibly also discussed in the context of route and voyage status. The need and usage from service providers such as shore centres need also to be considered, not only the need from the ship.

### S-124 Navigational Warning

In the STM voyage management testbed an early version (0.7.0) have been used. The complexity of the XML Schema, fixed limited enumerations and only one value...
for e.g. area for the navigational warning generates issues, which has been fed back to the workgroup.

The use of S-124 for sending SAR search areas also need to be discussed, especially in relation to the setting of identifiers in the S-124 message.

**TXT**

The text message has been widely used as complement to the other formats. The need for human communication is still present in a digital world. The text message can also provide more explanations than often possible in other formats in a much easier way.

**Service interface**

If a ship has not nominated e.g. a shore centre along the route, the shore centre needs a way to ask for ship’s route. The ship can then accept or reject the information request. This procedure is handled in two ways in the current testbed:

- **Trial-and-error.** The shore centre can issue a get or subscription request towards the ship. The response is either retrieval of requested information or that access is denied. In the case of access denial, depending on private interface implementation by respective ECDIS supplier, a notification is sent and presented in the ECDIS for the operator to handle manually.

- **Operator in shore centre sends a TXT message to the ship requesting/asking for the monitored route**

**4.4 Operational services available in the STM testbed**

STM consists of services that shares a common infrastructure based on standards. Information services, as the VIS, are part of the architecture to support operational services that delivers value to its users. The operational services in STM are developed and delivered by different service providers and will be presented in this chapter.

All services in STM need to be registered in the Maritime Service Registry, part of Maritime Connectivity Platform.

The basic principle for using a service is that a ship shares their voyage plan with a service provider in the planning stage or during the voyage and get requested service result in response, see Figure 13.
4.4.1 Nordic Pilot Route Service

Background and prevailing situation
Planning a route passing through previous unvisited areas could be tedious and difficult. Officer of the watch on board might need to consider unknown obstacles such as shallow waters, speed and size of the ship, local regulations etc. and in most cases a pilot is needed. When the pilot boards the ship, a pilot route candidate could be included into the route that is loaded into the ship’s ECDIS system and if the pilot agrees, it can be used for navigation into or out from the port.

Service description
The Nordic Pilot Route Service (NPRS) is an onshore service that exposes a route catalogue consisting of pilot routes in RTZ format. NPRS service is intended for real time usage during the route-planning phase. End users (ships and shore centres) uses the service either by sending their planned route or by sending a STM Text Message with an area included. For the sent in route NPRS will perform a geographical search for pilot routes based on the waypoint coordinates in the route solely i.e. NPRS is not dependent on UN/LOCODE or any naming objects. For a sent in area, NPRS will return all pilot routes intersecting that area. NPRS is including pilot routes from Sweden, Finland and Norway (restricted to Bay of Oslo). NPRS architecture enables connection to many databases and each request will merge the search for routes among all of these.

Figure 13 Services on ship´s voyage
Operational usage description

While planning the next upcoming route, the navigator can use NPRS for detailed route planning closer to shore by sending the ship’s route. When the ship route is planned from/to berth, NPRS will return the closest pilot route(s) from/to that route segment. On the other hand, when the ship route is planned from/to a pilot boarding point, NPRS will return all pilot routes from/to that point. The navigator has now the option to choose among the returning pilot routes and possible use the best candidate by merging it to the ship route. NPRS has also an option to receive an area. In an early phase of the route planning, the crew might not have a complete ship route yet and can send in an area through a STM Text Message payload format and receive pilot routes intersecting that area. Each request will get zero to many routes in RTZ and one Text Message with further information.

If the ship route is passing close to a Swedish open sea piloting route, one or more of such routes will be returned to the ship.

When a ship has done a search in the NPRS, a text message stating what route has been found will be sent to the ship. (See Figure 15)
The data exchange between NPRS and ships is possible by utilizing the standardized components of the STM architecture.

Figure 15 Reply from NPRS

Figure 16 and Figure 17 is an example of the result after a request to NPRS. The returning pilot routes are displayed in the ECDIS and after navigator action merged with the existing ship route. This enables:

- Efficient planning
- Shared mental model
- Safe navigation berth-to-berth
Figure 17 Pilot routes merged with existing voyage plan

Service usage statistics

![Service usage statistics chart]

Figure 18 User statistics for Pilot Route Service
End user feedback
Feedback from navigators on testbed ships:

- Smooth! Our ship is in a time charter and has a fixed roundtrip and a well-proven route berth to berth. As we tried NPRS we saw the opportunities if you are going to a port you have not called before. The second Officer on the product tanker in European trade says that he might not have merged the pilot route to their own route as they always plan berth to berth but have used the pilot routes for comparison and that have been of great value. The ship does not have the route from the ECDIS as a layer in the radar so their own route is not considered when they have pilot onboard. The second Officer sees the value of getting the route information earlier because when the pilot is boarding it is already a lot of information that is to be exchanged in a short time. Knowing the route on beforehand would give more time to other information.

- Good. When going to a new port and we don´t know the way of the route it saves time and is easy to access. When going to a known port for example Gothenburg we used it to compare our own route. It was almost the same. Good check for own route.

- We will not use your routes between Pilot-Pilot, but Pilot to berth would be interesting. I have informed navigation officer to start to include “Nordic Pilot Routes”, so when he has time he will use NPRS. We are always planning berth to berth, which should be done before leaving berth.

- I appreciate the service; I imagine that it is very good for ships sailing less often to same ports, also for us the times we call new ports. I already use about kind of the same type of service, by downloading pilot routes from the Swedish Maritime Administration website when we are bound for e.g. Gothenburg - Karlstad or in the Stockholm archipelago. This Pilot Route Service is smoother as it goes directly into our ECDIS If you make it work satisfactorily in all ports throughout the Nordic countries it would be even better. Alternatively, there could be an online list available, that states in with which ports the Pilot Route Service is working in.

Results and recommendations

- The service has proven valuable and it is recommended to continue the work on including pre-planned routes from more areas and countries.

- Continuous update of service algorithm based on user experience and requirements will further refine the service usability.

- It´s important that the users know how the service is working, and the service instance description is not a good way of conveying that information to the
ECDIS, the ECDIS users should be able to read about the service in the “Service Search”, similar to how it’s done in “App Store”

- NPRS connection and access to routes in different national databases need to be further elaborated and tested
- NPRS is one type of route catalogue service, there could be others, e.g. to provide standard routes between different ports/positions. The service for these standard routes could also include ships’ size and draft as parameters so that the response route is adapted for the specific ship.

4.4.2 Baltic Navigational Warning Service

Background and prevailing situation
IMO has divided world’s oceans into Navareas where appointed area coordinators are responsible for providing Maritime Safety Information (MSI) as part of the Global Maritime Distress and Safety System (GMDSS). In addition, every ship, while at sea, has to comply with these regulations and notices are typically received from the coordinators by voice (radio) communication at specified time intervals and by the receipt of textual information, typically received at a NAVTEX printer. The ship enters different area codes into the receiver to receive those notices applicable for its area of operation. Some ECDISs’ can show notices as text at correct geographic positions but no functionality or standards on showing actual affected areas exist.

Service description
The purpose of the Baltic Navigational Warning service is to provide the service consumer, i.e. ship, with only those warnings that are relevant for that specific route that they intend to sail/are currently at and at the time specified in the route schedule. Moreover, the warnings will be displayed directly in the ECDIS, see Figure 20, and automatically be deleted when they are expired and no longer valid.

The hypothesis is that benefits are to be achieved in the following areas:

- Reduced workload – no need to manually plot positions/areas received by NAVTEX/voice communication at ENC/paper chart. This allows the navigator to concentrate on safely navigating the ship
- Increased safety of navigation – according to London P&I Club, insurance inspections regularly find deficiencies in managing navigational warnings and notices to mariners as officers fail to implement navigational safety notices. By providing the notices directly to ship’s ECDIS manual work and risk of missing important information is reduced
- T&P notices can be received digitally already before sent out as ENC updates. In addition, some NAV AREAS do not send out Temporary and Provisional (T&P) Notice to Mariners, which means that full ECDIS ships, sailing paperless, do not get all notices.
- Reduced human errors – as warnings are provided digitally and seamlessly shown directly on ECDIS possible human errors, errors in misunderstandings
and manual plotting can be avoided.

- Increased Navigational Warning focus - since only notices relevant for the planned and/ or actual route will be sent to the ECDIS, the Officer On Watch can concentrate on these and need not bother with warnings issued outside the adjacent areas.

The service provides safety notices to ships in S-124 format. The S-124, navigational warnings, product specification is being developed by an IHO Correspondence Group with the purpose to submit it for endorsement. Before being mature for endorsement the STM Validation Project will serve as one of the testbeds to validate a draft version of the specification.

An important statement is that the service is not intended to relieve its users from ordinary receipt of Maritime Safety Information (MSI) as part of the Global Maritime Distress and Safety System (GMDSS), which with every ship, while at sea, has to comply.

**Operational usage description**

When a voyage plan is received by the service, the consumer/ship is added in a subscription list for Navigational Warnings in the Baltic Sea area. The ship will initially receive all active warnings within 15 nautical miles from each side of the route centerline, see Figure 19, and then continuously receive updates, new and cancelled messages until the route leaves the area and subscription is removed by the service. More operational details and elaborated service description are available in Service instance description for the Baltic Navigational Warning Service version 1.0, available at [http://stmvalidation.eu/developers-forum/service-catalogue/](http://stmvalidation.eu/developers-forum/service-catalogue/).

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**Figure 19** Service coverage area and example of relevant notices based on ship’s voyage plan and sub-area division

**Figure 20** Example of a navigational warning displayed in the Wärtsilä SAM Platinum ECDIS where the ship used the geographically received area to re-plan their initial route
How received notices are handled in each STM capable ship system is described in respective user manual but the common requirements are that the ECDIS/bridge system should be capable of:

- Displaying received areas
- Handling updated notice area
- Deleting notices when expired/obsolete

Service usage statistics

![Service usage statistics chart]

*Figure 21 Number of navigational warning requests and warnings sent back to ships*

End user feedback

“Navigational warnings are useful but delay in receiving service response is a problem” stated by a master on a Ro-Ro ship in Baltic and North Sea trade. Seeing navigational warnings directly in ECDIS has shown to be among the most popular functions. In this case, the response time depends on system settings to save bandwidth and the ship’s connectivity. Even though the transferred data is of relatively small size connectivity is still an issue for some ships.

“It is a great advantage to be able to see the navigational warning as an area. It is very easy to discover an area where there is an alert. However the NW markings clutter up the picture which is annoying.” Stated by a master on a product tanker.

“Clear marking of Navigational warning.”
“Easy to access information - click and read the grey box.”
“Nice to have nav.warnings in ECDIS when normal Navtex is not connected ECDIS.”
All three stated by a second officer on a Ro-Ro ship.

Results and recommendations
Results from questionnaires and interviews shows that the service is appreciated and considered useful by navigators. Some ECDIS manufacturers already show navigational warnings on ECDIS and for those the benefits are not as prominent as for those where notices are only received on NAVTEX.

The negative feedback has been related to HMI and that notice markings on ECDIS need to be changed. This is application functionality and how specific systems display the information and not directly to the service functionality itself.

As the first implementation of the draft S-124 Navigational Warnings format several findings and improvements in the format has been found and brought forward to the S-124 working group and taken into consideration in the work to improve and finalize the format.

As the service has proven positive effects, it is recommended to bring forward the results to relevant bodies to consider the results in the work to modernize navigations warnings distribution. It is also recommended to investigate the possibility of including data from more area coordinators to expand service coverage area. As an example and proof of expandability, Finnish Local Warnings were not included in the first release but has been added during the testbed.

4.4.3 SSPA Route optimization
Background and prevailing situation
During the STM Validation Project, SSPA, a Swedish route optimization provider, has implemented its route optimization tool based on VIS and SeaSWIM-compatible application as well as continued development to further focus on usability aspects related to direct usage from ships.

The core of the route optimization tool was developed during the MONALISA projects where its features and some benchmark figures concerning potential savings are described in more detail. This description focuses on the route optimization as a service within the STM ecosystem.

The route optimization service coverage area is given in Figure 22.
Figure 22 The SSPA route optimization service coverage area is European waters

Service description
The SSPA Route Optimization Service is an onshore service that provides optimized routes to ships when planning their voyages. The service requires a crude manually planned route as input and returns an optimized route and a text message with information about potential savings and a liability waiver.

The service performs optimization based on bunker consumption/total ship resistance, i.e. the returned route aims to be the most efficient route from A to B. The service accounts for the following physical effects:

- water depth (resistance increase from shallow waters)
- wind
- current
- waves
- ice (in terms of added resistance due to ice breaking)

Bathymetry data is sourced from the EMODnet EU-project (http://www.emodnet.eu/) and weather forecasts/hindcasts are sourced from DMI (Danmarks Meteorologiske Institut). Note that weather is only accounted for during a period consisting of 5 days ahead and 7 days prior to the current date, i.e. a rolling 12 day-period is covered. Submitted routes with scheduled legs outside this period will be optimized without influence of weather condition.

The route optimizer is working in both spatial and temporal dimensions and the optimized route may therefore differ from the inputted route in terms of:
- Number of waypoints
- Waypoint spatial position
- Waypoint ETA/ETD

For an example, see Figure 23.

![Initial and optimized route](image)

**Figure 23 Initial and optimized route**

The optimization algorithm does not account for any navigational aspects such as Traffic Separation Schemes (TSS) and therefore the returned route has to be checked from a nautical perspective onboard once received. This is a conscious design choice in order to promote the service as a support tool during voyage planning stage rather than a “black box”-routing software. The added benefit of this is keeping the active involvement of the Officer of the Watch in the planning stage.

**Operational usage description**

When a voyage plan is received by the service, the following simplified processes are carried out:

- Validation of incoming route (xml schema validation as well as specific validation for the purpose of this service)
- Optional: Ship library lookup based on MMSI for some ship particulars
- Send acknowledgement (if required)
- Send text message with information about estimated waiting time for reply
- Load and pre-process correct weather data based on schedule in route
- Perform optimization
- Simplify optimized route to reduce number of waypoints
- Send optimized route
- Send text message with information about:
  - Used ship particulars
  - Estimated energy savings
  - Liability waiver

A typical workflow for using the service as part of planning a route onboard a ship could be as follows:

1. Create a rough initial route complying with the following:
   a. Sailable (in terms of Under Keel Clearance (UKC))
   b. Include a schedule where ETD of first waypoint and ETA of last waypoint is included
   c. Optional: Include ETAs for any intermediate waypoints for “locking” this waypoint, both in space and time
2. Send route for optimization
3. Receive optimized route
4. Check optimized route for violations against nautical/navigational aspects (such as TSS) and update as required
   a. In this stage, it is possible to “lock” more waypoints and resend the updated route for optimization, thereby adding constraints for the optimization algorithm

More operational details and elaborated service description are available in Service instance description for the SSPA Route Optimization Service version 0.6, available at [http://stмvalidation.eu/developers-forum/service-catalogue/](http://stмvalidation.eu/developers-forum/service-catalogue/).

For the purpose of focused live testing in the voyage management testbed, held during September-December 2018, requests for route optimization and returning an optimized route were in great part supported by the Gothenburg shore centre. Only a few cases of vessel requests were submitted directly from the ships.

The common procedure was that an operator of the shore centre would search for suitable ships that could potentially benefit from the route optimization service. The voyage plan often lacked a schedule, draught and displacement, so these attributes were added manually. After that, SSPA optimized and sent back the voyage plan to the shore centre where it would be checked manually in terms of whether it seemed useful for the ship, i.e. if it offered any bunker savings. If so, the ship would be asked via e-mail if they wanted to receive the optimized route on their ECDIS. The reason for asking before sending was to avoid having routes that popped up on the screen without a notice to the Officer of the Watch.

In cases where the estimated bunker savings were deemed insignificant, Gothenburg Shore Center would not contact the ship.

The route optimization service made possible a quick return of a voyage plan that, in many cases — depending on the conditions such as weather, length of the route, etc., could help the ship to save fuel compared to their original routes. Under conditions...
where the original routes could not be optimized for fuel any further, the service would still send a message with a summary.

Service usage statistics
Figure 24 shows the number of requests for route optimization and the number of optimised routes returned.

The requests that could not be returned with an optimized route were those that lacked crucial parameters for the algorithm to work, such as schedule and draught, among other issues.

The numbers include only requests from installed and approved STM ships in the testbed. In this statistic, the route is considered as “optimized” if it is sent back to the ship, regardless of how improved it really is against the original route.

![Figure 24 Number of route optimization requests](image)

End user feedback
Feedback provided by the test ships’ crews and by Gothenburg shore centre was collected during the focus period September-December 2018.

Characteristics of the route optimization tool, such as the aforementioned function of not accounting for navigational aspects such as Traffic Separation Schemes (TSS) or Maritime Safety Information (MSI) warnings/notices was an aspect where SSPA received important user input. Namely, the users emphasized the importance of considering TSSs in the returned route as value added to the usefulness of the service, since TSSs are a typical concern for mariners. There were indeed a number of cases where the optimized route was drawn over a TSS inaccurately. It was not expected to pose a problem provided the disclaimers from SSPA and Gothenburg shore centre were read and well understood. It is possible that this issue can be
overcome with appropriate training for the ships' officers in how to use the service, or this function will have to be reconsidered. One option could be to combine the service result with a route cross-check service that considers these aspects. This feedback suggested that it might be important to provide clearer instructions on how this service is intended to be used. Another indication of this was the fact that initial routes were being sent without all the necessary parameters for the optimization algorithms to function. Regarding the schedule, it also seemed difficult for mariners to provide one at this point of voyage planning. If the service is to prevail, this problem must also be addressed.

Yet another indication of the need for improved instructions is the fact that the ships that requested route optimization sent an average of 199 requests each between September and December 2018. This is indicative that they may have chosen the wrong command on the interface that not only sends the original route once but also actually keeps sharing the route continuously for every route change that occurs.

The user feedback obtained will require careful further consideration and testing as to how to best incorporate it in the design while avoiding risks of complacency and overreliance.

Results and recommendations

Results indicate that the route optimization service could be useful in terms of suggesting a route that could help the mariners to save fuel compared to manual route planning. Estimated reductions of fuel consumption with more than 12% for specific voyages have been calculated. However, the above-mentioned limitations that there might be other restrictions that prevent the actual reduction of fuel consumption to be equal to the calculations are still applicable to these examples.

User input received during the STM tests needs to be carefully considered, assimilated into the existing design and tested to measure the benefit and/or the cost. Further testing directly with ships needs to be performed.

In terms of the integration of the service within existing ECDISs, it is recommended that machine-to-machine information exchange, as well as interface and visualization of information are further refined for usability and user experience, for better information provision for the users and not to make more intricate and cluttered an already complex navigation system. Supplementary ECDIS and STM training including standardization among manufacturers are matters to be continuously discussed as well.

4.4.4 SMHI Route ETA Forecast

Background and prevailing situation

Within the scope of STM Validation, Swedish Meteorological and Hydrological Institute (SMHI) has integrated a route optimization service in form of an automated ETA calculating service in the STM ecosystem. The actual ETA calculation part was made during the MONALISA 2.0 project. The ETA calculator service was not possible before STM since it builds on real-time route sharing. Weather routing is currently
optimizing with the timeframe of days and weeks but with the new ecosystem provided in STM the optimization can be done more frequently giving the opportunity to decrease the energy consumption also on short voyages.

Service description
SMHI Route ETA Forecasts main purpose is to combine the information about the voyage with information about weather, sea current and ship characteristics. This information is used to calculate a more probable time of arrival for each waypoint on the route as well as a calculated time-window for the estimated arrival time. This window gives an indication of the uncertainty of the estimated arrival time. The service uses SMHI’s vast knowledge about the weather and ship performance in different kinds of weather to enhance the voyage with more accurate estimates. The service is to be seen as help for the navigators on the ongoing voyage, being able to run multiple optimizations during long voyages to maintain a realistic ETA.

The gains from a more correct calculation of the estimated time of arrival in efficiency terms are big. Being able to calculate the arrival time with higher accuracy gives the ability to adjust engine settings for fuel efficiency, saving fuel at lower speeds knowing you will reach your destination at a given time. This is what the SMHI Route ETA Forecast provides. Adding to that the service also gives a window of arrival based on the uncertainty in the weather to give the navigator a better understanding of the estimated arrival time based on the weather. Having an accurate arrival time also unlocks the possibility for ports to work more effectively handling incoming ships. When it comes to saving fuel it is not only a monetary gain, the environment also has clear gains when the ship operates at lower engine settings, which in turns lower Green House Gas (GHG) emissions.

Operational usage description
The service is only available to customers of SMHI since there is a need for more ship data for calculation of ETA. To use the service one will have to search for the SMHI Route ETA Forecast service on an STM enabled ECDIS. Once located the voyage should be uploaded/sent to the service. When the ETA Forecast is done with calculation after 1-2 minutes, it will be returned together with a text message. If something is missing in the RTZ, a text message will be returned with info /reason.

Required components on the RTZ are:

- Ship IMO
- Speed on all the waypoints except the first (manual or calculated schedule)
- At least 2 waypoints in schedule
- ETD on the first waypoint (calculated or manual schedule) and ETA on the rest of the waypoints (calculated or manual schedule)
Service usage statistics

![Service usage statistics chart](image)

*Figure 25 Number of requests to SMHI ETA Forecast service*

### 4.4.5 Winter Navigation Service

#### Background and prevailing situation

During each winter, large areas of the Baltic Sea are covered with sea ice, which severely affects maritime traffic and requires ice-breaking services to several ports in the area.

When navigating in ice-infested waters in the Baltic Sea, ships are assisted by icebreakers. The coordinating icebreaker also provides waypoints, which indicate the recommended route through the ice. The waypoints are set in order to help ships navigate more easily and safely in ice conditions and in order to enable ships to navigate unassisted for as long as possible. Today the communication between icebreakers and directed ships in the Baltic Sea is a challenge, relying on a series of administrative tasks and use of rudimentary communications channels such as voice over VHF, AIS messages and email. This means that the workload on icebreakers, merchant ships and on shore centres is sometimes high and the directions are limited to a small number of rough waypoints through the ice. Waypoints and other information are transferred by hand in several steps – often using pen and paper – between different systems, both on icebreakers and on the directed ships, which leads to risk of errors or misunderstandings in the communications.

#### Service description

STM Winter Navigation Service provides ships information related to icebreaker assistance in the Northern Baltic. The service enables ships, icebreakers and shore centres to share routes and other operative information directly using machine-to-machine interfaces. The information is available to users directly on their operational
systems, without a need for manual operations, see Figure 26. This enables information to become more precise and up to date, the amount of manual tasks for information management can be reduced which consequently will lead to reduced risk of errors and misunderstandings. The service consists of two operational parts, namely information to assist route planning and up-to-date information to assist navigation during the voyage.

Figure 26 Example of route exchange between M/S Steel and the Winter Navigation Service. The routes are displayed in the icebreaker coordination system IBNET

Figure 27 A route proposal from Winter Navigation Service is received in a ship’s ECDIS and can be loaded to route planning for review.
Operational usage description

Ships that are bound for ports in ice-covered areas of Northern Baltic are recommended to share their voyage plans with the service. Information will be used for monitoring of ships’ voyages in the ice-covered areas and for planning of the icebreaker assistance.

When the navigators are making voyage plans they can get recommended icebreaker waypoints in force from the service. These short route segments can be used when creating new route or when modifying existing route to follow the recommendations in current ice conditions.

During the ships’ voyage, icebreakers and shore centres will monitor ships proceeding.

When ships are entering the ice-covered waters, shore centres will send the up-to-date waypoints directly to the ship.

The voyage plans received from the ships can be displayed in the icebreaker coordination system, together with detailed ice maps and satellite images. When needed, icebreakers will send detailed recommended ice routes to ships.

By using the service, route recommendations will be automatically imported to the planning station or ECDIS on-board and there is no limitation on the number of
waypoints and turns. The ice-route can consist of a number of continuous turns, which truly reflect the channel that the icebreaker has opened through the ice, instead of being an approximation.

In addition, icebreakers and coordination centres can send further information using text messages. This can include information such as; the position, name and VHF working channel of the icebreaker, recommended time of arrival to icebreaker meeting point, assistance order or other navigational instructions.

Service usage statistics

![Figure 29 Number of routes received (blue) and sent (red) from WNS during winter season 2018-2019](image)

End user feedback

“When the ship receives a dir-way (ice route), they will be more alerted and aware of that their normal route is not an option anymore.” Second mate, Icebreaker.

“So far the STM Winter Navigation Service works perfect, especially with the routes and ice waypoints. “

“Using the STM for Winter Navigation makes our Route Planning faster for the voyage, because whenever we ask for some ICE waypoints or routes from the VTS, they send it to us via STM. Upon receiving the route or ICE waypoints, all we have to do is to double check and finalize the route.”

“The only small problem we had is sometimes there is some delay of receiving the route or ICE waypoints, maybe it is because of the Internet connection?”

Results and recommendations

The operational tests of Winter Navigation Service were held during the winter 2018 - 2019. During this winter only the Bay of Bothnia had heavy ice conditions, which
meant that it was not feasible to have tests in other areas, such as Gulf of Finland. Due to the limited area and limited number of participating ships, the collected results of the use service usage are not enough to draw any final conclusions but some operational benefits have been noticed together with some recommendations for further refinements.

During the tests most of the route exchanges were done between the shore center to which all ships are required to report to, Bothnia VTS, and the STM capable ships operating in the area. As the operational tests were done during real ice navigation it was noted that ships who regularly operate in the ice-covered area were still using the traditional ways to get ice information and waypoints during route planning. That meant that in many cases ships already had a voyage plan that followed the optimal ice channel.

However, based on received feedback it was obvious that receiving the ice route directly to ECDIS would make the use of the information more user friendly and reduce the time needed for route planning and modifications.

It was also noted that as the navigation officers were not used to the use of STM functionalities in ECDIS's they could not get the full potential of route exchange. It is envisaged that after navigators get more familiar with using STM capable ECDIS's it will also further reduce the time needed for route modifications.

As the ships were not fully familiar with the use of STM ECDIS's most of the routes received by WNS was lacking ETA information, which meant that the icebreakers were not able to use the information for preplanning of icebreaking operations. Further, the status of the route plan was in many cases incorrect.

The test bed has proven that the concept of sending ice routes directly to ships EDCIS’s can reduce the risk of misunderstandings and reduce the administrative tasks needed to deliver the information. Therefore, it is recommended to continue the development of the service and to maintain it in operation.

During the testbed period a number of user requirements for the development of user interfaces, both on the ships and shore systems were collected. These include the further development of the use of text messages, more automated messages from the service to ships and several minor user interface enhancements. It was also noted that the information exchange reliability needs to be ensured. Currently there can be some delay for the ships to receive the information from the service due to restrictions of internet connections. In some cases, where more up-to-date information exchange is needed also other means of communication, such as AIS ASM messages could be used as alternative method.
4.4.6 Port call optimization

Background and prevailing situation

The project started with the aim to have 13 ports involved and the voyage management testbed included the following connected ports: Port of Gothenburg, Kvarken Ports (Umeå & Vaasa), Port of Stavanger, Port of Barcelona, Port of Valencia, Port of Sagunto, Port of Limassol, Port of Venice and Port of Rotterdam. The purpose with the port call optimization description within this report is to describe the interaction with the voyage management testbed ships. Further information are available in the report STM_Validation_D1.3 Improving port operations using Port Collaborative Decision Making.

Service description

Figure 30 illustrates the different services that have been explored during the STM testbed. Focus in this report is the Port Call Synchronization where ships and ports communicate digitally about; 1) The ships arrival expressed as Estimated Time of Arrival (ETA) or Planned Time of Arrival (PTA) and 2) the port’s Requested Time of Arrival (RTA).

![Port call optimization diagram](image)

**Figure 30 Port call processes**

Definition of port call processes:

- **Port Call Synchronization** - The continuous process of coordinating a ship’s approach, its previous and next ports’ operations, hinterland transport operators plans, and the progress of a port call.
- **Port Call Coordination** - Port call actors share their estimated and actual times regarding certain states in the port call process. This to increase the situational awareness among the port call actors and to raise the predictability of ships port calls to be able to communicate the readiness of the port.
- **Port Call Optimization** - Port Call Coordination and Port Call Synchronization are the basis for Port Call Optimization. Best described as the process of making the port call process as efficient as possible according to the needs of...
the involved actors in the sea transport berth-to-berth, including hinterland and the communication port to port.

Operational usage description
In this operational usage description the attempts to optimize arrival times for ships bound for Skarvikshamnen, Port of Gothenburg, January to March 2019 will be described. During this period the PortCDM demonstrator was not in operation due to technical problems. This means the port internal contacts were done manually while the communication with approaching STM testbed ships were done via the STM module tool part of the operations in the Gothenburg shore centre.

The process will be described, the results presented and possible improvements pointed out. However, the methods and definitions may vary a little between the test ports so in the following a short list of abbreviations and definitions will be given.

Gothenburg PortControl. Fully operational service operated 24/7 by Port of Gothenburg, but only a few of its operators have been involved in the Port Synchronization test.

Gothenburg shore centre. This position is manned office hours by one operator from the Swedish Maritime Administration dedicated to support and encourage the test vessels to use as many of the STM Services as possible. Gothenburg shore centre is located together with Gothenburg PortControl, working together and together they are abbreviated PC/SC.

ETA – Estimated Time of Arrival. In this context this is the time that vessel submits to state when they expect to arrive to the anchorage, pilot, berth or other locations referred to.

RTA – Requested time of Arrival. After having shared and reviewed the ETA given by the vessel with actors important for this particular port call it will be reviewed if the ETA given is the optimal time for the vessel to arrive. For example, a ship communicates their ETA to be 06:00 but the cargo is not ready for loading until 09:00. The RTA will in this case be set to 09:00.

Introduction to the trials
From January 30 to March 11, it has been tested to optimize product tankers ETA and provide a RTA at 16 occasions. Eleven unique ships have been involved. The process of calculating a RTA can be compared to a chain where shackle must be attached to shackle from the beginning when the vessels voyage is planned leading up to an as well optimized arrival time for next port as possible.

The ideal outcome of an attempt to optimize a ship’s ETA for the port is to find an ETA that is harmonized with the time that the ship can be first served, i.e. loading or discharge can begin. What is desired to avoid is that the ship arrives too early to the port thus consuming unnecessary fuel by maintain a higher speed than necessary. The gain for the ship owner is the saving of bunker and for the society in general lower emissions.

Description of the process leading to an optimized ETA
The above-mentioned chain could be described as having the following parts:
1. The vessel submits their Voyage Plan (route and valid schedule) with Gothenburg Port Control and with Gothenburg Shore Center. (PC/SC).

2. The ETA for Gothenburg that the Vessel submits along with its´ Voyage Plan is forwarded from PC/SC to three key actors in the Port of Gothenburg which have been chosen since their information regarding the particular port call must be known to the ones (PC/SC) trying to calculate a RTA for the vessel.

The three key actors in Gothenburg, and the information asked of them, are:
- The terminal who needs to provide information regarding if the cargo is ready or not.
- The production coordinator responsible for planning of the use of the different berths.
- The agent which is the actor that has the best overall information regarding all details of the port call.

3. If it is found that the ETA initially submitted by the ship is earlier than then the earliest possible time that the ship can be served in the port this may imply a possibility for the ship to arrive later, thus saving fuel and emissions. For example, the ship has submitted their ETA to be at 06:00 but no berth will be available until 1000. The RTA will then be set to 10:00 by PC/SC and this will be forwarded to the ship and to the ship owner/operator.

4. The decision and the responsibility now fully lies with the ship owner/operator. If they decide to slow down the ship in order to reduce the fuel consumption, the economic win of these saving benefits the ship owner/operator alone. Should such a decision cause the ship owner/operator any loss e.g. losing their turn in a queue, the ship owner/operator will stand the full loss.

5. Outcome. Basically four outcomes of the process are possible:
- For some reason no RTA could be calculated then no change of plans was made.
- A RTA was calculated but the vessel did not adopt it.
- A RTA was calculated and the vessel adopted it and a win was made.
- A RTA was calculated, the vessel adopted it but it led to a loss.

Results of the arrival time synchronization trials
As mentioned 16 attempts to find RTAs have been done during the beginning of 2019. In the following, the attempts will be reviewed. The idea is to put up a “race” between the 16 contenders to see where in the chain they fail and how many of them that reaches the ultimate goal, i.e. receives a RTA, follows it and makes a win. Of course, it must be understood that in most cases it was a combination of factors leading to that the RTA could not be produced.
Not all obstacles, and combinations of obstacles, can be accounted for but the ones that can be generalized are accounted for under each section below. The obstacles can be regarded as hurdles that can stop any ship on its way to the goal. The ships’ representatives, i.e. the captains, clearly indicate that they do not want to participate in tests on this particular voyage.

It is very rare that the testing of any STM Services are initiated by the test vessels. It is more likely that the initiative comes from the Shore Side of the STM Project, and this is usually done by e-mailing the ship. This may be due to several factors, for example:

- The STM functionality in onboard systems may not yet be enough matured and user friendly or intuitive.
- The new work methods are not yet described in operational procedures and that may cause hesitance or low awareness of the possibilities.
- Real benefits and cost savings are not yet proven; STM is still a novel concept in the field.

In two cases, the captains immediately responded that it was not possible to make any changes, of any sort, in the planning of the active voyage. A couple of others expressed their doubts about STM and STM technology and planning but they still went on with trying to submit their voyage plans to Gothenburg shore centre and Gothenburg Port Control.

**Technical and operational issues**

Out of the 11 unique ships that tried to get their ETA optimized by using the port call synchronization, all of them, at least to some extent, struggled with technical issues. The majority of these issues were regarding the schedule part of the voyage plan (the voyage plan consists of the route and the schedule).

There are several different problems regarding the schedules. Occasionally ships will submit voyage plans without any schedule at all. Such voyage plans cannot be used for port call synchronization purposes since they do not include any ETD or ETA. When the ships are asked to supplement their voyage plan with a schedule they usually give a positive reply to this request, but it often takes both quite a lot of time and support before they manage to do this in their navigation systems onboard. This issue with the schedule-handling problem has so far been the main obstacle in the attempts to optimize ETAs. In some 6-7 cases, it is likely that the decisive reason for the failure of producing the RTA was of technical/operational handling reasons.

The STM functionality is still in a test phase and is not yet implemented in daily routines, Standard Operational Procedures etc. In addition, the testbed support functionality is only manned during office hours. This means that valuable time may be lost if the ship plans their departure and starts the voyage in nighttime or during weekends.

**The cases where ETA was provided**

In five cases, the process reached the point where the ship provided PC/SC with an ETA that could be forwarded to the key actors. In two cases, the key operators
agreed upon that it was not possible to make any changes that would improve the port call. On the contrary, the original planned ETA submitted by the ship was the only possible time of arrival that would fit in to a complex planning.

In one case, an ETA was sent to SC/PC and the key actors were contacted. However, no RTA could be calculated since it was off office hours, (late Friday afternoon). The failure this time was not only depending on 24/7 issues but also of a technical nature. Quite a lot of efforts were put in both on the ship’s side and on the shore side before the voyage plan was shared.

In two cases, a RTA could be calculated and forwarded to the approaching ships. In one of these, the proposed RTA was not adopted. This was due to contractual constraints and first-come-first served principles.

In the second case, the approaching ship adopted the RTA and reduced their speed on the last approximately 100 nautical miles before reaching port. This lead to an estimated saving of some 1.5 tonnes of fuel equaling to approximately 1 000 US dollars.

Results and recommendations

Even though it is, only a few port calls included in the trials to optimize arrival times some patterns can be seen. In the following, these patterns will be presented, discussed and some possible actions that might improve the process of calculating a RTA will be proposed. This section are divided in to three parts, in the first one the positive effects of port synchronization will be pointed out. In the second part, the process of calculating the RTA and actions that could be taken to improve this process will be accounted for. Finally, the use of the RTA will be discussed. The source material used is the data that has been documented during the attempts to optimize the ETAs received from the ships.

The positive results of port synchronization are quite simple to spot and account for. The bearing beam, the Just-In-Time concept, allows ships to steam slower, thus saving both the costs for bunker and reducing the emissions. The successful attempt, the one where the chain held, clearly proves that it is possible to improve efficiency as well as saving the environment by sharing and coordinating information. It is not possible to do this on every voyage, but it can be done in some cases. Another positive effect with the STM process of sharing information is that the information is often shared earlier via STM i.e. a ship communicates their voyage plan with the STM shore centre before the same information is received at Port of Gothenburg.

The process of producing a RTA has been successful in about one third of the 15 attempts. This result can most likely be improved with quite simple means. As pointed out previously one of the main obstacles is that it is hard for the on board officers to send their voyage plan including a valid schedule. However, the problems are more related to handling the software rather than malfunction. It simply takes a little bit of practice. The 24/7 issue meaning that valuable time is lost because the process not is ongoing 24 hours a day can be solved by including sharing of voyage plans when applicable in the ships’ Standard Operational Procedures. If this is done on a regularly basis when planning the next voyage no time will be lost and the operations with the system will gradually run smoother. On the shore side it is likely that the work with port synchronization will have to be incorporated in some already
existing 24/7 operations. In the case of Port of Gothenburg it would most likely to be PortControl who would be responsible for this.

The process of calculating and producing the RTA is one step; to make this RTA useful in real life is much more complex. The idea of receiving a RTA giving the ships the opportunity to reduce speed, saving both money and environment, is easy enough to grasp. However, putting this idea in to real use could mean substantial losses of money and time for the ship owners. Should a ship slow down in order to appear just in time it may very well risk that a ship from a competing company tenders their notice of readiness earlier and are served earlier according to “first come, first served”. In Gothenburg, the situation is complex since there are three terminals sharing berths and loading/discharging facilities. To overcome these obstacles are not easy but it is not impossible. The STM BIMCO clause, presented in the next paragraph, has already been drafted. There may also be other solutions that can be agreed upon during these initial tests of STM port synchronization. However, discussions must be held with the most important actors in the process not least with the shipping companies.

Port Call optimization and charterparties
In the effort to facilitate the use of arrival time information and to enable its usage within the STM concept, one identifiable problem is that charter parties, as well as other contracts, allocate risks in a way that creates a conflict between economic and environmental efficiency. In collaboration with BIMCO efforts have been made to resolve such conflict by developing contractual clauses, which enable and encourage the exchange of information under the STM concept while, at the same time, permitting the parties to agree on a contractual arrangement, facilitating an improvement in the overall efficiency of ship and port operations. The voyage charter party was identified as most affected by and representative for the STM environment and consequently, a new appropriate clause has been drafted.

BIMCO Sea Traffic Management (STM) Clause for Voyage Charter Parties, with appropriate Explanatory Notes, has been adopted by the Documentary Committee during its session on 13th of November. The Clause is available from BIMCO website https://www.bimco.org/contracts-and-clauses/bimco-clauses after login.

Service usage statistics
Figure 31 displays the amount of shared voyage plans from STM capable ships to ports in the voyage management testbed. Only requests with ETA are included in the figure. The diagram in Figure 32 displays the amount of STM equipped ships, which shared their routes with ports.
Figure 31 Number of Port Synchronization requests with complete ETA

![Graph showing number of Port Synchronization requests with complete ETA]

Figure 32 Number of unique ships requesting Port Call Synchronization for each port in the voyage management testbed

SEGOT – Port of Gothenburg
SEUME – Port of Umeå
FIJAA – Port of Vaasa
NLRTM – Port of Rotterdam
ESBCN – Port of Barcelona
ESVLC – Port of Valencia
ESSAG – Port of Sagunto
CYLIM – Port of Limassol
ITVCE – Port of Venice
4.4.7 Ship-to-Ship route exchange

**Background and prevailing situation**

Each ECDIS equipped ship has a monitored route, the route the ship is sailing. In STM this route is defined according to the RTZ format and exchanged using IP communication.

To assist in safe navigation also monitored route exchange formats for use over AIS and VDES as Binary Broadcast Messages (BBM) have been developed within the project. These are denoted as AIS/VDES route messages and allows ships to exchange a fixed part of the monitored route with other ships in the same geographical area in a standardized format. Only AIS broadcasts have been used in the voyage management testbed.

In addition, VTS can get access to the route messages over AIS/VDES. In the testbed, the route message is identified using Swedish binary application identifiers. The full description of these new formats can be found in “Route Message system requirements” available at http://stmvalidation.eu/developers-forum/schemas/.

The route message broadcast is used as a means to indicate intended navigation and route information to nearby ships, allowing them to avoid ending up in a close quarter situation. The route message information should be used as an aid to navigation and not interfere with existing watch keeping practices of keeping a proper look-out or compliance with the COLREGs.

**Monitored route information content and transmission**

The AIS route message is developed for transmission using the AIS VHF data link, containing a minimum of needed information. The VDES route message type, with higher fidelity and capacity, is developed for transmission over the VDES ASM VHF data link.

The VDES route message format has the capacity for carrying information about the current and the next 12 legs with Cross Track Distance (XTD), leg geometry (Rhumb Line or Great Circle leg representation), planned leg speed, turn radius, and steering mode (manual, heading, and track control are defined so far. Another steering mode is proposed to be reserved for unmanned ships.)

The AIS Monitored Route Message format has less information due to the limited capacity of the AIS VHF datalink to carry this type of data. A maximum of seven legs and no XTD information are the most notable differences from the VDES ASM message.

The use of this message requires that both the receiving and transmitting ship have the appropriate communication equipment as well as presentation and navigation systems. For the AIS route message, a standard AIS transponder is used as communication equipment and the STM capable ships have the presentation capability as part of their navigation system.

The route message is broadcasted so that ships in receiving range have accurate information within a reasonable time period, avoiding creation of unnecessary load on the limited AIS/VDES VHF datalinks. A set of rules have been defined to ensure...
that the most up to date information about a ships’ monitored route is made available at proper intervals, and are currently being evaluated in the testbed. The system also allows for polling of a ship’s route message if special circumstances would require it.

Route CPA prediction
Closest Point of Approach (CPA) is a well-known estimated geographical point in which the distance between two ships, with no assumed change in course and speed, will reach a minimum distance. The CPA can be used to evaluate the risk of collision.

One major drawback with CPA is that it uses constant course and speed in the calculation and therefore can underestimate the collision risk – if one or both of the ships are maneuvering.

This drawback can be overcome if route CPA estimation is used instead of ordinary CPA. Route CPA means that speed and course of both ships routes are mathematically projected and then the CPA algorithm is applied.

An example of a monitored route received over VDES in the shore centre, or received onboard a ship, is depicted below in Figure 33.

![Example of received route message](image)

**Figure 33 Example of received route message**

End user feedback
From the testbed ships the feedback on ship-to-ship route exchange usefulness, effect on situational awareness and safety has been positive. However, there are refinements necessary when it comes to Human Machine Interface and how/when routes are to be presented to the Officer On Watch not to clutter the screen.

Feedback from testbed ships:
"I can really see route exchange ship to ship being useful" stated by a navigator on a product tanker outside the Swedish west coast when seeing a sister ships route displayed.

“Displaying too many ship’s Routes on the ECDIS could get confusing by over-cluttering the display." Although being positive to the functions several officers on testbed ships have had some concerns on display issues. It shows the importance of
proper HMI but also familiarization with the new tools and getting used to working with them, as there are settings available to filter, which ships routes you want to display based on route CPA and TCPA. As with all electronic aids to navigation, the meaning is not to interfere with proper lookout.

Results and recommendations
Ship-to-ship exchange of route messages has been a test within the test, as it does not use the digital infrastructure for exchange but the on-board AIS equipment. Feedback from these trials will be used to fine tune the rule set for broadcast of monitored route updates, the message content and the portrayal of received monitored route data.

Currently more than 2000 route messages are being broadcast daily along the Swedish coast. This only represents a fraction of ships in the STM testbed.

As proven in the testbed, future ECDIS could be upgraded to support the concept of route message exchange with limited changes, but in order to enable a truly global method of exchanging route segments with nearby ships an important piece is missing; worldwide-recognised route message formats. An update to SN.1/Circ.289 could be appropriate, including both the new formats for route messages as well as deprecating some older formats for AIS binary messages no longer are appropriate.

It is also important to take into consideration that due to the widespread adoption of AIS, there now are significant challenges to sending many of the data messages as defined by SN.1/Circ.289 in AIS user dense areas. It is therefore recommended that such data exchanges in the future is moved to the VDES ASM channels, as defined by ITU-R M.2092, that have been designed specifically for such applications, offloading AIS from existing and future data exchange applications. Should further developments give that additional parameters need to be included in the route message exchange protocols, or even complete RTZ routes; these could be transferred using the VDES VDE channels, also defined by ITU-R M.2092, which have even higher data capacity.

4.4.8 STM SAR
Background and prevailing situation
Introduction of STM supported digital tools in Search and Rescue (SAR) operations sets out to improve the Maritime Rescue and Coordination Centre’s (MRCC) and the On Scene Coordinator’s (OSC) overview and possibility to control SAR-units in search operations. As per today the communication between these actors rely on voice communication, which can lead to misunderstandings and longer response time as there is manual work to plot e.g. positions and search areas. Supported by the digital infrastructure of STM MRCCs’ will be able to send areas, search patterns and search routes to a SAR unit, a Vessel of Opportunity (VoO) and to other assets participating in the SAR operation, and this information will be visualized directly in the onboard units navigation system e.g. ECDIS or portable tablet.
Service description
As part of the voyage management testbed, the SAR management system at the Swedish Joint Rescue and Coordination Centre (JRCC) has been upgraded with STM capability. Moreover, 26 SAR units have been made STM capable. The information exchanged between JRCC and SAR units includes:

- Text messages with the essential information, e.g. number of persons in distress and data identifying of missing object etc.
- Search area/distress position where the units should be heading.
- Search patterns or routes that the SAR mission coordinator wants the units to follow during the search to enable optimal coverage of the area that should be searched, Figure 34.

Figure 34 JRCC SAR management system displaying two SAR units conducting a search according to search pattern sent by SAR management

Operational usage description
STM SAR tools have been tested in live operations at three exercises. During the tests, the methodology and various STM SAR functions have been evaluated. The first exercise focused on familiarization with the new functionality to gain knowledge and experience in order to develop procedures for the use of STM in SAR operations. During the second and third exercise, the crew and SAR mission coordinator had become more familiar with the STM functions and the results indicated reduced voice communication via VHF and reduced manual work to create search patterns etc.

End user feedback
In connection to the tests, a questionnaire has been sent out to the participants. Exercise number three included STM tools and three SAR units participated. Five crewmembers responded to the questionnaire and Figure 35 gives the average figures from the five received answers.
Figure 35 The bold figures on each question indicate the average rating of SAR units' crews after STM SAR exercise 3.

In addition to specific questions on the STM SAR functions used during the test, the participants also had the possibility to comment on the service as a whole. Some of the feedback from the participants:

"Overall good experience. There are things to improve such text sent out to long names and routes that didn't work onboard (rate of turns) /Master"

"The value of a system like this, that can transfer important graphical and text information without the use of voice communication and its limitation, goes without saying. Effects and values that comes to mind are faster, clear for all, less mistakes and misunderstandings and less work in difficult conditions."

"The SAR units' time can be used for constructive work and thinking rather than simple, but yet under conditions time consuming, tasks/work. /Coxswain and SAR-operator."

"The STM tools made it possible to transfer many times more data to the units from the JRCC. Fact/text, areas, track lines and receiving confirmation via text was used. It would not have been possible to do this without the STM function. This was a success test! /MRCC SAR coordinator"

"That search area and / or text related to the mission is presently presented in the system when crew arrives onboard, is a clear advantage and simplifies significantly"
as well as eliminates misunderstandings. However, exchanging text messages between JRCC / SRU as a chat function is in most cases not possible given the environment on board, (small unit, high see, dark, inexperienced crew, etc.) here preferable voice communication. /Operator navigation”

Results and recommendations
Results from the tests indicate that STM SAR tools will lead to reduced misunderstandings and reduced administrative burden onboard the SAR units. In addition, the response time to start operations will be shortened, an effect that in the end may save lives. Due to reduced voice communication, as some information will be exchanged digitally, there will be better possibilities for exchange of other relevant information with voice communication.

At the JRCC, the administrative burden also was significantly reduced due to usage of the STM tools and the SAR mission coordinator felt after a short period relatively safe with the new STM tools. During the test the SAR mission coordinator were following the original Standard Operational Procedures (SOP) but due to STM, some of the moments were change from voice communication to digital communication, which can have effect on the SOP.

New standard operational procedures have not been established during the project and there is a need of more usage of the STM tools before any change in SOP will be done. Information, education and live exercises using the new tools are very important.

From the JRCC prospective the digital communication is quicker to produce and distribute, especially when the information includes many figures, like positions in latitude-longitude. Text message was easy to produce, allocate and broadcast to one or several units at a time. Contrary to work without STM tools, only short voice message had to be supplied to SRU, usually only for confirmation purpose, instead of giving the entire message over voice communication.

Further, due to reduced workload and saved time for the SAR mission coordinators, there were more time to reflect over the overall mission. This opens up possibilities to create and distribute information regarding the current status in order to increase the situational awareness. This information was distributed both digitally as a text message and by voice communication.

4.5 Shore Centres
4.5.1 Background and general description of the shore centre
The shore centre in the STM Testbed has its origin in traditional VTS. A VTS is a land-based station with the aim to enhance efficiency, safety and environmental protection through surveillance of ships’ movements with the means of radar, AIS, CCTV etc. When deemed necessary the VTS operator can provide the Officer of the Watch on board with information regarding the traffic situation, port operations, adverse weather conditions etc. Should the VTS Operator detect a potentially dangerous situation e.g. a collision or grounding the VTS Operator can issue a warning to the involved ships or give an advice or an instruction.

The shore centre is similar to the VTS in that respect that it is a land based station
with one operator communicating with ships at sea, but there are also significant differences between a traditional VTS and a shore centre equipped with STM functionality.

### 4.5.2 Similarity and differences compared to VTS

From an outside perspective, the similarity between VTS and shore centre is obvious. An observer will see a person surrounded by screens displaying nautical charts and targets i.e. ships. The software used is, if not identical, at least very similar between VTS and the STM Shore Centre. The differences between a VTS and a STM shore centre are hard to detect by an uninitiated person, but they can be summarized as follows:

- VTS has been in use since the 1950s and is clearly defined and regulated by international organizations such as such as IMO and IALA. The institution of VTS is well known and what can be expected on the ships´ side from the VTS is well recognized by the OOWs.
- A flag state can only provide VTS Service in their territorial waters. Should it be necessary to monitor international waters this must be a joined venture by different states and it is no longer VTS but SRS (Ship Reporting System).
- A VTS area is clearly defined and usually geographically rather small. Often it covers the entrance to a port, a narrow sound or a passage that is hard to navigate.
- The use of VTS may be made mandatory in sea areas within the territorial seas of a coastal State. Ships navigating in a VTS area must follow the reporting rules of this area.
- The level of automation in a VTS is fairly low. The VTS Operator´s experience, skill and ability to assess and analyze traffic situations are the main sources for risk assessment and decision of if the VTS should intervene or not.

The institution of a STM shore centre is new. It has therefore few clear defined tasks or duties to fulfill. The situation described below applies to the STM Validation testbed and in general the following features can be recognized:

- The shore centre covers much larger areas than VTS. Instead of covering the entrance to a specific port it may cover for example the Baltic Sea or the North Sea.
- The Services offered by the shore centre, or a Service Provider in general, are optional. I.e. it is up to the ship owner or ship operator to decide if he, or she, wants the companies´ ships monitored by a shore centre at all times when navigating in e.g. the Baltic Sea.
- The level of automation in the shore centre is high and it relies on the basis that participating ships share information i.e. their route and schedule with the shore centre.
- Thanks to the fact that the shore centre receives the Voyage Plan well in advance it can review the ships intentions and act proactively whether it be regards port synchronization, navigation or other issues.
Figure 36 The figure shows the VTS area of Stockholm, all vessels longer than 50 meters or above 300 GT are obliged to report to VTS Stockholm when entering the area or leaving a berth or anchorage within the area. In return, they will receive traffic information and the VTS will monitor the vessels at all times.
Figure 37 The area displayed is approximately where Gothenburg Shore Centre has assisted STM Test ships to try different kind of STM Services. The green colored area between Denmark, Norway and Sweden are AIS targets and the rectangle over Stockholm is the VTS area in the previous picture.

Shore centres in the voyage management testbed
There are six shore centres in the voyage management testbed. They have slightly different aims and scopes.

4.5.3 Horten VTS and Kvitsøy VTS
The two Norwegian VTSs’ participating in the STM Testbed are mainly aiming to try the new STM functionality in a VTS context. The idea is to test and see how, and if, the STM Tools such as route exchange, text messaging, possibility of route cross checking in advance can improve traditional VTS Services. The areas covered by the two Norwegian VTSs’ are the same as they survey in daily VTS Operations. The VTS operator on watch is responsible for the VTS Service as well as testing the new STM Tools. Regarding ship contacts, both Kvitsøy VTS and Horten VTS have had relatively few route exchanges between shore and ships.

Figure 38 Voyage plans shared with Kvitsøy VTS

In Figure 38 the number of voyage plans that Kvitsøy VTS has received are presented. The statistics for Horten VTS indicates some more activity but the pattern is about the same. The conclusions drawn from the Norwegian VTSs are that the use of STM functionality in VTS operations improves the VTS Service in that way that the surveillance of ships is more effective. The response that Kvitsøy VTS has received from participating ships has also been positive.

Equipment
Aim to test the STM functionalities in a VTS context, Horten and Kvitsøy are equipped with regular VTS equipment and sensors such as radar, AIS, VHF, Digital Selcall,
CCTV etc. as well as with STM shore center system. They have been provided with STM shore centre software from Kongsberg.

4.5.4 Gothenburg shore centre and Tarifa shore centre

The shore centres of Gothenburg (Sweden) and Tarifa (Spain) are separated entities from the VTSs’ of Gothenburg and Tarifa. Dedicated operators manned the two shore centres during office hours. The aim of these shore centres are to encourage the testbed ships to share their voyage plans with suitable stakeholders and to offer support and guidance to new STM test ships. The operating area of Gothenburg SC is confined to Swedish Waters and all of the Baltic Sea area while Tarifa shore centre monitors the Western parts of the Mediterranean Sea. Figure 39 and Figure 40 presents the number of voyage plans shared with Gothenburg SC and information exchange between Tarifa SC and testbed ships.

Equipment

Gothenburg SC has been provided with STM software from Kongsberg, Wärtsilä/Transas and SAAB and also it has been equipped with three different ECDISs’ (Wärtsilä/Transas, Furuno and Wärtsilä SAM for test and support purposes and Tarifa SC has been provided with STM software from Kongsberg.

Figure 39 Voyage plans shared with Gothenburg SC
4.5.5 Royal Danish Navy shore centre

During the project STM functionality has been integrated into an operational system at the Royal Danish Navy Command, Control, and Information System (RDNCCIS), in particular into the Maritime Domain Awareness (MDA) system. The voyage plans exchanged in STM has been utilized to monitor the behaviour of ships from a safety perspective. The MDA system integrates with STM by requesting voyage plans for all ships known to be part of STM when they enter the Danish area of responsibility. When voyage plans are received, the MDA STM application will continuously check that the ship follow the route given, and warn operators if not so. The MDA system does not interact automatically with the ships. Operators have the ability to send text message directly, but otherwise the MDA STM integration is passive in the sense that no data is sent from MDA to STM.

The data gathered by the STM monitoring application is also used to calculate a risk assessment of each ship (whether a STM participant or not). This is done by comparing 10-12 different data sets for each voyage against averages for the same ship and for ships of the same ship group. The data sets being compared gets a higher quality when the ship has shared a voyage plan because it is possible to compare the behavior of the ship with their own plan. For example, how often it leaves the route, how far it is from the centerline and how many course corrections are done.

In conclusion the large number of ships in transit inside Danish area of responsibility at any given time, it is very beneficial to have ways of "trivializing" voyages by knowing the route a ship intends to follow; as long as the vessel is on route, the voyage can be assumed "trivial". A risk assessment of the ship further improves the "trivializing" task, especially if this risk is calculated based on actual routing data. In a Coastguard context, the MDA system would undoubtedly benefit from STM functionality and the main obstacle during the testbed has been that not enough ships actually shares their
voyage plan. Number of received voyage plans is given in Figure 41. It is therefore recommended that further refinements of STM includes the possibility to automate and/or mandate accept of voyage plan subscription requests made by services registered by governmental organizations, for example VTS services.

**Equipment:**
The Royal Danish Navy has been provided with STM equipment from Navicon.

![Figure 41 Number of shared voyage plans with the Royal Danish Navy shore centre](image)

4.5.6 Tallinn VTS
The VTS in Tallinn (Estonia) had their STM Software of make Wärtsilä/Transas installed in October 2018. This VTS was not part of the initial project plan but joined the testbed as associate partner. The aim of Tallinn VTS participation in the STM testbed is the same as that of Kvitsøy VTS and Horten VTS; they will test the STM Tools, looking to improve VTS-Services. Although the test period has been short and the STM ships in Estonian waters are few positive results have been noted. The feature that Tallinn VTS is likely to have most use of is the prediction of close quarter situations, based on intended route and speed of the ships by means of sharing STM routes and schedules. To reach its full potential all ships sailing in the VTS area has to be STM equipped but even at this point with a relative small proportion of STM ships, some improvements in situational awareness can be noted. Number of shared voyage plans with Tallinn VTS is given in Figure 42.

**Equipment**
Tallinn is equipped with regular VTS equipment and sensors such as radar, AIS, VHF, Digital Selcall, CCTV as well as with a STM shore centre system. It has been provided with STM shore centre software from Wärtsilä/Transas.
General descriptions of the shore centre systems
The shore centre system, be it Kongsberg, SAAB or Wärtsilä/Transas, is based on the latest version of each manufacturer's VTS software. The innovation that makes STM possible is the option of sharing voyage plans between different stakeholders in the STM community, e.g., ship and VTS or ship to ship. The voyage plans can be shared in two ways. They can be shared via Internet in RTZ format. The intention is that this will be the common way of sharing voyage plans. In addition, text messages can be shared in the same manner as voyage plans.

The other way is to share routes via AIS, this can only be done for a limited part of the voyage plan since the bandwidth and time allocation of AIS is limited. This function is mainly to be used between ships to be able to predict developing close quarter situations.

The software used in the shore centre will not be further described or compared here. Manuals and technical descriptions of respective system is available at http://stmvalidation.eu/user-forum/stm-shore-centres/.

Coverage area of STM enabled services
The STM ambition is to build a worldwide net of information sharing where the different stakeholders choose with whom they will share their information. As an example, a container ship leaving the port of New York bound for Rotterdam is likely to share their route with a Route Optimization service and the port of Rotterdam. This can be done by the means of IP based communication.

Other services e.g. Enhanced Monitoring Service, described below, requires that the shore centre that is to provide the service can track the ship with some sensors such as radar and/or AIS. In the case of Gothenburg shore centre the input to the shore centre system comes only from AIS and the coverage is Swedish waters, parts of Danish waters and most of the Baltic Sea.
Services and purpose of the shore centre

First, a distinction must be drawn between the shore centre of the testbed and the shore centre of the (hopefully) coming real STM world. In this report mainly the procedures and purpose of the testbed centres are described.

Figure 43 The inbound Stena Danica displayed in a VTS System without STM functionality. The information in the image clearly indicates that the Stena Danica for the moment is heading for the entrance of Gothenburg. However, it does not give any information about whether Stena Danica intends to proceed to the Port of Gothenburg or perhaps aim for an anchorage. Nor does it reveal if Stena Danica has made a reasonable Passage Plan.
Figure 44 This figure shows Stena Danica in a STM equipped shore centre system. The red line on which Stena Danica is sailing is the route that she has submitted to Gothenburg Shore Centre. The route, which of course can be zoomed in and reviewed, clearly indicates that the intentions of Stena Danica is to proceed to the port of Gothenburg. It is also clear that Stena Danica has made up her voyage plan as can be expected of a ship of her type and size.

Purpose of the operations conducted in the shore centre
Gothenburg shore centre and Tarifa shore centre, both manned by people fully dedicated to the work of STM and with no other duties such as providing VTS etc., are the two centres that best fit in to the definition of a STM Shore centre.

So far, their major task and contribution to the STM Validation testbed has been to contact the testbed ships and “push” them to take active part in the testbed. The first steps are to establish a connection with the ships, ask them to share their Voyage Plans with suitable stakeholders like STM Validation Centre, Gothenburg shore centre, Tarifa shore centre et al and to send text messages.

As the crews of the testbed ships gets a bigger understanding and knowledge of the STM Project and they are encouraged to try more complex services of STM like route optimization, port synchronization, receiving navigational warnings directly to their ECDIS etc. During the latter part of the autumn 2018, a lot of the work in Gothenburg shore centre has been dedicated to encouraging test bed ships to try STM Services.

It may sound strange that this kind of “pushing” is necessary but it must be realized that the officers on board receives only a short introduction of the STM functionality when the service technician from either Adveto, Furuno, Wärtsilä/Transas or Wärtsilä
SAM does the on board installation, upgrading’s and put the settings in the ECDIS right. Should the crew of the particular ship not be interested or should their relievers not receive a proper handover it is possible that there are OOWs of the STM testbed ships that are not even aware of that they are a part of STM. With 300 testbed ships with at least three persons with watch-keeping duties plus a master, all in a 1:1 relief system it is likely about 2400 navigators who needs to be introduced, trained and supported in the use of STM. Quite a large part of this burden will rest on the shore centres.

**Enhanced Monitoring Service**

Enhanced Monitoring Service is basically what the VTS has been doing since the 1950s. A ship is monitored and surveilled by an operator from shore and if the ship should seem to be running in to a potentially dangerous situation e.g. head for shallow waters, the operator will alert the ship.

What differ the basic VTS service from Enhanced Monitoring Service (the term is used in conjunction with STM and shore centres, not in VTS) is that the STM shore centre receives the route from the ship, which is to be monitored in advance. It is also important to note that this route, sent from the ship, states the ship’s intentions. This gives the shore centre operator the possibility to review the ship’s planning of their approach to shore. Should the ship deviate from its intended route the shore centre operator will be alerted that the ship, for some reason, no longer is complying with its plan, see Figure 45.

*Figure 45 Enhanced Monitoring Service. In this figure the Stena Danica has, for some reason, deviated from her intended route. This is indicated by that the ship is colored red on the screen. By means of the STM technology, the VTS Operator will be alerted. In this case, with open water all around, it is not a very alarming situation but still, for some reason the ship has left its plan.*
Figure 46 Enhanced Monitoring Service, Stena Danica back on track. In this figure, Stena Danica is back on track, between the cross track limits. The ship is now complying with their plan, which we have seen assessed earlier to be a safe planning. The situation is, as far as can be understood, under control.

Enhanced Monitoring Service can also be used to foresee dense traffic situations. Supposing that all, or nearly all, ships in e.g. Dover Strait or Gibraltar Strait are STM equipped a prediction can be made well in advance of the time and position of complex traffic situations. Furthermore, shore centers can transmit information regarding temporarily restricted areas for example military exercises, SAR operations etc. Figure 47 and Figure 48 gives examples of enhanced monitoring service in the Strait of Gibraltar.
Figure 47 Enhanced monitoring service. The figure is a screenshot of a voyage plan shared with Tarifa SC. The route is passing through a firing exercise area in force. The dotted line is the ship route and the solid lines indicate the boundaries of the firing exercise area.

Figure 48 Enhanced monitoring service. Tarifa SC sends several area messages to the ship regarding firing exercises in force. In this figure, it is showed how the ship has changed her route according to information received from Tarifa SC.
STM functionalities working together with AIS allows shore centers to enhance monitoring beyond traditional VTS areas. Figure 50 contains examples of enhanced monitoring berth to berth.

Figure 49 Enhanced monitoring service berth to berth. A ship has shared its voyage plan from Castellón to Huelva. The red line is the route and the blue line is the ships AIS track. Tarifa shore center could monitor the ship also outside of the VTS area. In this example the ship followed the route and the schedule sent by her STM compatible navigation system

**Operational procedures in the shore centres**
The four shore centres that are operational i.e. Kvitsøy, Horten, Tallinn and the Royal Danish Navy Centre are using the same Standard Operational Procedures (SOPs) as usual in their daily work. The STM tools e.g. Enhanced Monitoring Service are tested in parallel with ordinary VTS operations. For the two STM shore centres, Tarifa SC and Gothenburg SC no SOPs have been written yet.

**Ship contact log and live tests with ships**
All contacts between testbed ships and shore centres are logged manually in an Excel Sheet, the “Ship Contact Log”. The purpose of this is to map the communication between the testbed ships and the shore centres. The idea is to spot which of the testbed ships are active in sharing information and which are passive. The active ones are contacted by the shore centre and are encouraged to try more complex STM services, for example port call synchronization. The passive ones are encouraged to start sharing their voyage plans with STM Validation centre and with applicable shore centre and to try text messaging. This work has continued throughout the whole test period.

**Evaluation and achieved goals**
The main goal that has been achieved are that the STM technology has been installed in the six shore based centres. The sharing of information, voyage plans and text messages, is possible and it is being used by the STM equipped testbed ships and the shore centres. At this stage the technology, the infrastructure is operable and the quality is high but not 100% yet. The human part of the STM Voyage management testbed is also in place. Every day
routes are sent from the test ships to the different shore centre, sharing of information is taking place. This work has continued throughout the whole test period and the data collection was done by saving log files of data transmission.

**End user feedback**

As previously mentioned the shore centre part of the STM voyage management testbed can be divided in to different parts, classic operational VTS (Kvitsøy, Horten, Tallinn), monitoring territorial waters (Royal Danish Navy) and STM SC with the purpose to act as catalyst for the test ships to try STM Services.

Looking at the VTS part of the Shore Centres, no absolute conclusions can be drawn from the voyage management testbed. Since there are relatively few test ships not many enough of them have appeared in the same VTS area at the same time. Given this, it is simply not possible to evaluate the STM services based on the test bed results.

However, the STM services that could be useful for VTS operations have been tested in a simulated environment. The results from the simulations, included in the project report STM_ID3.3.6. EXTENSION_EMSN Test Report_Evaluation of STM services_Human Factors_Including_VTS_SC, clearly indicated a change in the work of the VTS. Given the possibility to review the intentions of the ships well in advance before entering the surveillance area of the VTS made it possible for the VTS to work more proactively. In general, the test VTS Operators opened the voyage plan that was submitted to them as soon as they could find the time. Then they did a fast first review of the plan. Should the planned ship route entail a part that was deemed unsuitable the VTS Operator would edit the route and send it back to the ship. This route suggestion was usually supplemented with a TXT message.

When the ships as in the VTS area the VTS Operators would usually monitor the ships manually by following them on the screens. The communication was to quite a large extent done by texting and sending route proposals and changes with the STM tools.

The simulations gave a fairly clear image of what STM could bring to VTS but testing is one thing, reality another. The voyage management testbed forms a too thin base for conclusions of VTS operations. However, interviews with VTS operators and VTS managers of Tarifa SC, Kvitsøy VTS and Tallinn VTS indicates that it is generally believed that most, if not all of what was found during the simulations is believed to be the case in real life as well.

**Results and recommendations**

Regarding VTS, the simulator tests indicate that the STM Tools will prove much useable in a VTS context. Further testing must be done and the STM Tools should be fitted in to Standard Operational Procedures. It will probably also be necessary to make preparations e.g. building up a library of routes suitable for different ships in different fairways. Testing, training and reconsidering must be done, but the potential is very big.
Regarding the shore centre role of catalyst, it must be considered as vital for the STM voyage management testbed. In very few cases the test ships have tried STM services on their own. On the majority of occasions when the ships interacted with any STM service they did that after being contacted and encouraged from shore side. The shore centres have also, along with the ECDIS manufacturers, been able to provide the test ships support in getting started with STM. It is likely that future newly equipped STM capable ships will need the same help. Even ships that have been equipped quite a while ago and who has tested the STM Services with good results occasionally requires assistance because they have a new crew on board or they simply have forgotten how to use the STM features. If the idea and use of STM is to last after the test period, the tests and support from Shore Centres are of great importance to keep STM operational.
5 Conclusions and recommendations

5.1 Conclusions and results in summary

One of the main tasks of the STM Validation project has been to develop, implement and validate an infrastructure that create interoperability between maritime systems. Given that a ship, VTS centre or a port system supports the same standardized artefacts, Application Programming Interfaces (APIs), data formats and common authentication mechanism they can exchange information seamlessly. A distributed service eco-system approach was selected and has proven a suitable solution. The eco-system, in the project denoted Maritime Digital Infrastructure, includes cyber security measures and enables episodic tight-coupling between maritime actors. For example ship-shore communication between systems from different manufacturers.

As per 2019-06-01, 311 ships representing different market segments and a dozen shore-based services have been upgraded with STM capability. Figure 9 indicates the delivered number of systems per ECDIS manufacturer, SAR units, Icebreakers and ships from Carnival Corporation connected via their Fleet Operation System Neptune. The ship installations were delayed compared to the initial plan. The delay has mostly been caused by complex developments including lengthy type approval processes by the manufacturers’ classification societies, to make sure the STM capable ECDIS systems, for use by testbed ships, comply with the Revised Performance Standards for ECDIS as reflected in IMO Resolution MSC.232(82). Further, time-consuming installations have caused the installation phase to take longer time than expected. The increase in the number of equipped ships are given in Figure 9. These delays in installations caused results from the testbed ships, to be used for analysis and validation, to be equally late. This was one of the reasons that the overall project applied for and received an extension of the project with six months. As a result, sufficient data and results from the testbed ships have was possible to collect.

The level of activity in the testbed has been high and the total number of exchanged messages per data format is given in Figure 8. The information exchanged includes voyage plans, navigational warnings, port call messages and text messages. In addition, route messages (a segment of ship’s monitored route) has been sent on AIS as Binary Broadcast Messages (BBM) to other ships within AIS range.

The benefits with large-scale testbeds with systems from many different manufacturers implemented in real systems used in everyday operations cannot be overestimated. Surely, it has taken a lot of effort to test new functions in real operations given the number of ships and services involved. However, it pushed the solutions developed to be as mature as possible, facilitates future implementation and safeguards that the chosen technical solutions are not proprietary, as they have to be accepted and approved by other actors in the eco-system.
5.2 Standardisation and compliance with international guidelines

The STM Validation testbed has several linkages to IMO’s e-navigation Strategy Implementation Plan (SIP) – Update 1. Sharing a ships’ voyage plans has proven to be useful in many different operational services for example the Pilot Route Service, the Winter Navigation Service and the Baltic Navigational Warning Service. In their turn the different operational services supports several of the identified maritime services, which are described by IMO as the means of providing electronic information in a harmonized way.

IALA’s Service Guideline G1128 for maritime services that has been implemented in the service ecosystem within STM has proved to create vendor independent interoperable information exchange of voyage plans, navigational warnings, port call messages and text messages. The service interface documentation can serve as an input for standardizing APIs to facilitate implementation of services based on standardized payloads as defined by IHO/IEC product specifications. Furthermore, it could act as a best practice for the future development of maritime services within e-navigation.

Further standardization, updates of relevant regulations and industry buy-in are important to pave the way for even broader market adoption to proceed from project to large-scale implementation. Accordingly, and as an outcome of the project results and findings, the service interface, the communication protection measures and the service lookup functions are proposed to IEC as a new work item for standardization.

5.3 Conclusions on STM enabled operational services

The testbed mainly consisted of already existing services that have been digitalized and distributed by new means. This facilitates service discoverability, consumption and visualization for concerned stakeholders, see Figure 50. The operational services implemented during the testbed are to be considered as initial examples of potential future services.

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![Figure 50](image)

*Figure 50 The service eco-system enables service producers to publish their services and facilitate for service consumers to discover and use (consume) them. The*
information owner has the ability to control access to the information/service and the communication is secure.

Findings from end-user feedback indicate that digital information sharing between shore-ship, ship-shore and ship-ship can improve situational awareness and improve operations onboard, in shore centres, maritime rescue and coordination centres and VTS centres. These improvements are created by operational services such as optimized routes, pilot routes, ice routes, SAR search areas and patterns, selected navigational warnings and synchronized arrival times.

Figure 51 During the e-navigation underway conference in the beginning of 2018 the voyage plan from DFDS cruise ship Pearl Seaways was shared with Horten VTS who could monitor the ship’s progress according to her plan. The voyage plan was at the same time shared with Baltic Navigational Warning Service that provided Pearl Seaways Navigational Warnings along her route that were displayed directly in the ECDIS.

According to questionnaires and interviews with navigation officers on testbed ships and shore centres the exchange of voyage plans directly from ships´ ECDIS, see Fel! Hittar inte referenskälla., has been useful. For navigation officers the benefits of integrating information of higher quality (i.e. accuracy and timeliness) are similar for most services. For example, the route optimization services have been found useful to get the optimized routes directly into the ECDIS without having to use stand-alone applications. This is also the case for winter navigation where ice-waypoints and ice routes are made available directly in the navigation system. The operational benefits are related to easier route planning which enables reduced administrative burden, misunderstandings and human errors.

In addition, other services such as the Nordic Pilot Route Service, the Baltic Navigational Warning Service and Enhanced Monitoring from shore centres demonstrated improved situational awareness and operational safety. These conclusions come from practical end-to-end usage of the different testbed services. Figure 52 and Figure 53 gives some example of the perception of the services among navigation officers that has responded to the questionnaires.
The responses to whether STM has reduced workload are more diversified. Some services are considered to reduce workload while others are not, see Figure 54. This was expected since not all services aimed to reduce workload onboard but instead the benefits with these services are related to safety effects or enhanced operations on shore-side for example enhanced monitoring and port call synchronisation. The services with the highest numbers in reduced workload are the winter navigation service and the Nordic pilot route service. One possible reason for this could be that...
these services are similar to existing services and procedures and therefore the step to use a new similar service is not that big. In addition, future usability refinements are hoped to further reduce the effort to use all the services. Complete statistics are available in annex A.

Looking at the VTS part of the Shore Centres, no absolute conclusions can be drawn from the voyage management testbed since not many enough of them have appeared in the same VTS area at the same time. However, the STM services that could be useful for VTS operations have been tested in a simulated environment. The results from the simulations, included in the project report STM_ID3.3.6. EXTENSION_EMSN Test Report_Evaluation of STM services_Human Factors_Including_VTS_SC, clearly indicated a change in the work of the VTS. Given the possibility to review the intentions of the ships well in advance before entering the surveillance area of the VTS made it possible for the VTS to work more proactively.

The fact that the same data, in this case the voyage plan, is used onboard and ashore creates a shared situational awareness. This awareness can be used for more effective operations and monitoring. Interviews with VTS operators and VTS managers of Tarifa VTS, Kvitsøy VTS and Tallinn VTS indicates that it is generally believed that most, if not all, of what was found during the simulations is believed to be the case in real life as well.

The service with the biggest potential impact on efficiency in terms of reduced costs is port call synchronization between ship and port, to achieve just-in-time arrivals. This has been demonstrated by the possibility to provide updated arrival time in a digital bi-directional communication, which means that both the ship and port can inform each other about planned and preferred arrival times. In the case of

![Figure 54 Rating by navigation officers on testbed ships if STM testbed services has decreased their workload](image)
synchronization in the Port of Rotterdam, the ship’s arrival time is taken directly from the source in the voyage plan and presented in the port’s planning system.

The number of port synchronization events in the testbed has been too few for any thorough analyses. The reasons for this are several. Some examples are lack of schedules (arrival times) in the ships’ voyage plans, few port calls to ports in the project, several actors that needs to be coordinated and contractual and business related barriers. However, on occasions, the information flow within STM has proven to provide earlier information to the ship about ports earliest possible time to handle the ship. This information has been used to reduce ships’ speed to eco-speed, thereby reduce costs for bunker consumption, and at the same time reduce Greenhouse Gas (GHG) emissions. Depending on contract terms, this cost reduction could be for either the charterer or the shipping company itself.

As mentioned above one obstacle to achieve port call synchronization during the testbed has been the lack of schedules (arrival times) in the ships’ voyage plans. This is mainly related to operational procedures and lack of incentives to provide a schedule and not only a geographical route. In current operations a schedule might be created during route planning but this schedule is not necessarily used when the route is loaded for monitoring. In addition, HMI to set a schedule and to keep it updated throughout the voyage needs to be further refined to stimulate a wider usage.

Incentives to include a schedule could be achieved by increasing the number of services that use the schedule information and that provide benefit back to the ship based on the schedule information. Examples of such services could be Navigational Warnings and a broad adoption of port synchronization services in ports and by making use of the updated arrival information in more services where arrival notifications is included. A consideration for future STM work related to IMO is to consider amending the existing revised ECDIS performance standards (resolution MSC.232(82)) with a requirement about the possibility to add a schedule to the route.

Ship-to-ship exchange of route messages, containing up to seven route legs, has been a test within the test, as it does not use the digital infrastructure for exchange but the on-board AIS equipment. The feedback on its usefulness, effect on situational awareness and safety has been positive from the voyage management testbed. However, there are refinements necessary when it comes to human machine interface HMI related aspects and how/when routes are to be presented to OOW.

5.4 Conclusions on the service ecosystem from an operational perspective

To reach the STM concept full semantic interoperability is required and a large share of the project efforts has been related to achieving and maintaining this interoperability. Semantic interoperability is not only the ability of two or more computer systems to exchange information, but also the ability to automatically interpret the information exchanged meaningfully and accurately. This allows useful results to be produced, as defined by the end users of the systems.
Figure 55 gives the different layers and areas in which interoperability is required. This complex process has been facilitated by agreeing within the partnership on detailed specifications, guidelines, design reviews, interoperability tests, and exemplifying with reference service instances etc.

![Interoperability Layers Diagram]

*Figure 55 Interoperability has been achieved by ensuring interoperability in several layers related to infrastructure, services and operational aspects.*

The XML Schemas used today in the voyage management testbed fulfills the main goal to achieve common understanding of the information exchanged, but still Guidelines have been developed to achieve operational and semantic interoperability. The detailed use of the information exchange format in an operational dynamic context is achieved with the combination of XML Schema and Guidelines.

Several supportive documents and how-to descriptions were produced along the way, as new issues were detected. All of these documents are publicly available on the STM Validation web site, [https://www.stmvalidation.eu/developers-forum/](https://www.stmvalidation.eu/developers-forum/). Further, regular developer forum meetings were established as a means to share information and knowledge between technical experts in the partnership. It is expected that technical governance, including registry maintenance necessary for maintained service discoverability, will be required also in the future to sustain interoperability.

The developed services have proven possible and suitable for deliverance through the service ecosystem, with its focus on exchanging standardised messages between actors. Services that requires streaming data, such as sending ships’ most
important operational navigational parameters ashore with high frequency has not been included in the testbed.

The testbed has also verified that authorization, where the information owner can control access to information, is working in practice. Examples of this is different actors that have made requests for ships’ voyage plans but where the request has been rejected together with an access denial notification stating the need to be approved, authorized and added in ship’s access control list. One limitation in the voyage management testbed has been the limited technical support for hierarchical levels in the maritime digital infrastructure with no possibilities to register for instance subsidiaries or departments of registered organizations.

![Image of navigation system](image)

**Figure 56** The text and buttons in the red box indicates the access request that is displayed in the navigation system. The ship is the information owner and can choose to either grant or deny access.

Another example of improvement need is the current lack of human acknowledgement. The testbed systems have implemented message acknowledgement on a technical level. This means closed loop communication between systems including information to operators that message has been delivered is available. However, closed loop communication also needs to be supported on a human level, i.e. allowing a message to be acknowledged when the human at the other end has received it.

A third example is that STM ship systems have established capability to generate Unique Voyage IDs (UVID) but better handling and processes of when and how to generate new IDs and when to keep an existing UVID are needed. These IDs are expected to facilitate a connection between the sea voyage and hinterland logistic operations related to a ship’s cargo but it has not yet been possible to validate this concept.
5.5 Considerations and recommendations for STM development and implementation

On a general level, the implemented services have indicated to support the goals set up for STM and described in the STM final report. However, it should be kept in mind that they do not encompass all functionalities needed to cover the complete STM concept. In the coming phases of STM more and new kinds of operational services, based on new payloads and information services/APIs are needed. Further focus needs to be put on refinement of both operational services as well as components related to the architecture such as information services and cyber security precautions and solutions. These refinement findings have been collected and noted in technical notes to make sure they can be taken into account in further STM development.

The refinement aspect also goes for many of the systems developed by partners in the project. The systems have from time to time been too unstable and better software quality assurance is needed, which is also true for those systems having been type approved before installation and brought into use. All of these findings from the STM Validation project gives an excellent platform for STM development and will be further refined in projects such as STM EfficientFlow, Real Time Ferries and STM Balt Safe.

To reach a more long-term sustainable use, the new functions and services need to be included in the ships’ ordinary operational routines and procedures such as voyage planning procedures. In order to reach this stage services need to create enough value for the shipping company to encourage and maintain usage of them. Even though end-user feedback through questionnaires indicates positive effects it is expected that the value and number of existing services is not yet sufficient to sustain operations without further refining development, initiatives or other incentives. In some cases, a higher degree of automation, to relieve from the need of operator action or input, might be possible due to the increased knowledge that has been gathered within the project. In addition, more user-friendly systems are needed to make service usage easier and more intuitive and to further decrease the workload and the administrative burden.

A mandated capability of sharing of voyage plans, according to defined standards, could also be a mean to speed up adoption onboard ships and ensure a long-term sustainable usage. This would require regulatory changes. Examples of relevant resolutions and regulations for a mandated capability of sharing of voyage plans includes but are not limited to IMO Assembly Resolution A.893 (21) on Guidelines for voyage planning, Revised Performance Standards for Electronic Chart Display and Information Systems (ECDIS) – Resolution MSC.232 (82) and SOLAS regulation V/34. This requires a very careful review and further investigation.

Risks associated with the introduction and misuse of technology as a new aid to navigation, for example so called radar and ECDIS assisted accidents, are well known and must be taken into account. To minimize these risks the project has followed recommended Software Quality Assurance (SQA) and Human-Centred
Design (HCD) principles. These are described in IMO guideline on Software Quality Assurance and Human-Centred Design for e-navigation (MSC.1/Circ.1512).

Although training and updated operating manuals has been included in the testbed further measures like specific equipment familiarization and more training in correct usage and handling of new/modified equipment will be necessary. This is also confirmed by the received feedback from the testbed, which shows that usability and Human-Machine Interface aspects needs to be improved. This result was expected since the provided functionality is new and innovative. However, design of better functionality requires a first version to be made available to enable end-user feedback for further system improvements according to a feedback loop part of HCD principles.

It is also recognized that harmonization of the user interface for navigation equipment and information used by seafarers to monitor, manage and perform navigational tasks will enhance safe and effective navigation.

If some STM related functions, for example exchange of route plans, are to be mandatory functions, the variations across different manufacturers’ equipment should be minimal. The functions should also be incorporated as detailed in SN.1/Circ.243/Rev.2 on Guidelines for the presentation of navigational-related symbols, terms and abbreviations, amendments to the Recommendation on Performance Standards for the Presentation of navigation-related information on shipborne navigational displays (Resolution MSC.191(79)) and also draft MSC.1/Circ. [...] on Guidelines for the standardization of user interface design for navigation equipment.”

In conclusion, findings from end-user feedback indicate that digital information sharing between shore-ship, ship-shore and ship-ship improves situational awareness, increases operational safety and improves operations in, shore centres, Maritime Rescue and Coordination Centres, VTS centres and onboard ships.

The ambition and technical innovation level within the testbed has been high. Integration of systems from different suppliers in a de-centralized eco-system is a quite complex task and the validation phase of STM has included development and implementation of components in several layers to reach interoperability. The number of partners and systems that are now interoperable is a major achievement. Taken into account also the positive effects expressed by end-users the validation outcome is to be seen as a success. Some services, for example the Pilot Route Service, and the infrastructure as a whole are now mature for industrialization and to be taken into large-scale operation.
6 Publications

Technical papers
Several technical papers from the project are available at http://stmvalidation.eu/documents/

Reports
Reports from the project are available at http://stmvalidation.eu/documents/

Communication material
The project has several forms of communication material e.g. several videos, flyers, press releases and presentations describing the project. These are available at http://stmvalidation.eu/press-room/.
7 Reference material

NA
8 Appendices

Annex A: End-user feedback as a basis for voyage management validation.

Annex table of contents
- Background
- Method
- Data collection
- Results of questionnaires
- Validation of the hypotheses set up in the voyage management testbed
- Questionnaire form sent to ships
- Additional questionnaire responses
- Interviews

Background
The STM voyage management testbed consisted of an increasing number of ships as presented in Figure 9 in the testbed report. The purpose with the testbed was to get a chance to validate and test the STM services in a real operational shipping context. The overall goal of the STM Validation project is to enhance efficiency, safety and sustainability in the maritime sector. To do this the STM supported services were formed to be as effective tools as possible in the quest for these goals. In this annex, the data and results of feedback from end-users will be presented. In chapter five of the report, the results and conclusions of the validation efforts are discussed.

Method
For each of the eight operational services included in the validation of the voyage management testbed, see section Questionnaire form sent to ships for included services, a number of hypothesis have been put up with aim to validate them against feedback and data collected from the testbed participants.

The starting point was to form hypotheses that, if they were proven to be correct, would validate the positive effects of the STM services. Should the hypotheses be proven wrong, this would equally efficient point out the shortcoming of the STM services and hopefully point at areas that can be improved.

The hypotheses, and the answers to the hypotheses, have been organized according to Key Performance Areas (KPA) e.g. Safety, Efficiency, Sustainability and Security. After sorted in KPAs the hypotheses have been relayed to Key Performance Objectives (KPO). This is done to specify goals that, if fulfilled, is believed to contribute positively to each KPA.
Quantitative and qualitative methods have been used when validating the hypotheses. The main source of data that has been used for the validation are questionnaires that was sent out to testbed ships. The questionnaires are of quantitative nature and it was possible for the respondents to complement their answers with comments. The questionnaires have been complemented with qualitative interviews that enables a deeper understanding of the answers provided.

The results from the voyage management testbed are combined with results from other activities within the project into a general STM context and further analysed in the STM Final Report.

Information on testbed participants and respondents
The respondents to the questionnaires have been navigation officers onboard the ships that have been upgraded with STM functionality. That means that all results are from their perspective and there has been no means of posing follow up questions. The total number of participants in the testbed is not exactly known but assuming one master and three navigation officers onboard each ship working on 1:1 relief system gives eight participants per ship. With 270 STM capable ships, this gives a total of more than 2 100 participants. It is unknown how many of these have used STM functionality and that not all of these have been respondents to interviews or questionnaires. In total 165 questionnaires have been answered. The largest group of respondents, 61%, is second officers. As it is a second officer who normally is in charge of the navigation this is an expected percentage. Remaining respondents are captains 24%, 3rd officers 12% and chief officers 3%. The respondents have an average of 9,4 years of experience as navigation officers.

Reliability and validity
Logging of data traffic and service calls is considered very reliable due to the high amount of data and the semi-automated logging procedures. Compared to the extensive data logging, the number of interviews and questionnaires are lower and therefore have a lower reliability.

The data log files concerning service usage and information exchange is valid for statistics about overall usage. However, it should be noted that “calling” a service can be automated, and actual usage of the service response onboard ship is not measured by this data. As an example, it has not been possible to verify in what extent navigation officers has used pilot routes sent out to the ship. This is also reflected in the questionnaire responses where the respondents have had the possibility to respond not applicable or that they never used a specific service.

As it is not possible to know if the respondents have understood and used the services the way they are intended to be used or not there are major uncertainties in the reliability of the results of the questionnaires. An example of uncertainty is how the received feedback should be interpreted. For example, ship-to-ship route exchange was found useful 85% of the respondents and 76% thought it increased
the awareness of the traffic situation but it is difficult to know whether the respondents actually met other ships in situations where there was a benefit of using other ships’ route information or if it was just a nice to have function.

For ship-to-ship route exchange function it was recognized already when forming the hypothesis that it was necessary to know whether the information was considered in the decision making process or not and this was included as a question. 57% answered that they considered the information when making decisions and this is lower compared to the usefulness question. This indicates that some functions and services can be found useful even if not directly considered for decision-making. It could also be lower because the kind of traffic situation where route information could be considered has not emerged during the testbed.

Interviews can be structured to ensure validity, but much of the respondents feedback have concerned Human Machine Interface (HMI) and functionality in respective navigation system, which is of less relevance for validating the testbed results. Feedback on HMI in specific navigation systems has not been included in the voyage management testbed analysis but has been forwarded to respective system supplier to, if possible, be included in future software releases.

**Data collection**

During the included testbed period, questionnaires were sent out every month. This means all ships equipped before 2019-03-26 has been given the possibility to respond to the questionnaires. Out of the 643 sent questionnaires, 165 were answered giving a response rate of 26%. The questionnaire was formed to give the officers the opportunity to answer questions about the services they stated that they had used.

Six interviews have been carried out as face-to-face interviews when possible and over telephone when face-to-face meetings could not be arranged due to logistical difficulties. The interviews have been of semi-structured nature where free answers have been valued. The answers from the interviews have been used as qualitative validation and quotes can be found under each hypothesis.

Logfiles of data exchange have been used as indicators to identify which ships have used the different services and hence know which ships to contact for a qualitative interview. The logfiles have also been used in a technical validation of the maritime digital infrastructure. These findings and recommendations are to be found in chapter 4.4.7.

**How the questions in the questionnaire are formed and structured**

The main source used to verify the hypotheses are the answers in the questionnaires. The questions have been formed in accordance with the previous mentioned KPAs Efficiency, Safety and Environmental Protection. Some of the questions can be used as indicators in two or three of the KPAs. In general questions covering aspects as “useful” and “assist” are classified as supporting hypotheses regarding efficiency. Questions including “safe” or “safety” indicates that these questions is within the KPA Safety. The KPA Environmental Protection has few questions of its own pointing directly at actions for lowering emissions. However,
quite a few of the questions regarding safety can also be used for validating environmental protection since the safety at sea affects the risk of accidents, which could cause substantial damage to the environment. In addition, some of the questions regarding efficiency will lead to a more efficient flow in synchronizing ship and port operations giving synergies of lower emissions due to reduced fuel consumption.

Results of questionnaires
In this section, the answers to the questionnaires have been grouped and compiled into diagrams. In the questionnaire the first questions have been about whether the participant have used the service at all, if so they have been directed to further questions regarding that particular service. The questions have been formed with the aim to validate if the services contributes to either/or efficiency, safety and sustainability.

Question “Was the service useful?”

As is indicated in the diagram the majority of respondents considered STM services useful. 398 answers were received and out of these, an average of 80% answered positive regarding the usefulness of the STM services.
Question “Did this service make you feel more safe?”

As safety is dependent on many factors it was not asked if a service increased the safety but rather if the perception of safety was increased. With experienced deck officers the figures are likely to be reliable but with the uncertainties presented in reliability and validity section.

275 respondents answered the question about safety and out of these an average of 75% answered positive regarding the safety introduced by the STM services.

Question “Did the service increase your awareness of the traffic situation?”

To increase the situational awareness, without creating information overload, is one of the goals with STM and the ambition is to provide the navigation officers with vital information just in time.

As indicated in the diagram, the majority of respondents considered STM services to increase situational awareness. 279 respondents answered the question and out of these, an average of 73% answered positive regarding the increased situational awareness with the STM services.
Question “Did this STM tool assist you in your duties on the bridge?”

As indicated in the diagram, the majority of respondents considered STM services to be of assistance in the work on the bridge. 399 respondents answered the question and out of these, an average of 74% answered positive regarding the assistance by the STM services.

Interesting is that the two services with the highest numbers, ETA Window and Winter Navigation, are services that are existing already but that are communicating in a new way. One reason for this could be that the way of presenting information directly in the ECDIS, giving the opportunity to compare and merge routes is helpful in the daily work on the bridge.
Reduced workload is another goal of STM and some of the services sets out to facilitate voyage planning and execution of the voyage. As is indicated in the diagram 399 respondents answered the question and out of these, an average of 50% answered positive regarding the decrease in workload. The numbers differs from service to service more compared to other questions, some services are considered to reduce workload and some are not. This could be explained by the focus of the actual service. For example, Port call synchronization could rather help the port actors organize their work and lead to reduced fuel consumption rather than to reduce workload. Enhanced monitoring sets out to enhance VTS and other shore centers but not onboard the ship itself.

The decrease in workload are expected to increase as the equipment gets more user friendly and the officers get more used to the tools. With uncertainty of how to use the services, the workload can at first increase until the operational procedures are settled but then hopefully to decrease.

As this was a question that only was applicable to one service, the numbers are no further aggregated.
Validation of the hypotheses set up in the voyage management testbed

The hypothesis of the voyage management testbed have been set up to validate the KPAs and KPOs of the STM concept. In this chapter, each hypothesis for the voyage management testbed is presented. The answers from both questionnaires, interviews and in some cases statements from end-users examples from the testbed are related to the different hypotheses to either support or not support the hypothesis.

KPA 1: Safety

1.1 KPO: Improve situational awareness for the officer on watch.

1.1.1 Hypothesis: A common understanding between the officer and the pilot leads to a better bridge team.

Hypothesis tested by questionnaire question: 24

Interview with two Swedish maritime pilots.

- 8 out of 10 times the route from the boarding point is not planned in a satisfying manner.
- Normally the routes are planned by the pilot and only briefly communicated to the officers.
- Having a route in the ECDIS and radar that is not corresponding to the route planned by the pilot is a disturbing factor.
- Many times the draught given to the pilot on beforehand is not accurate which can lead to a re-planning of the route once on board.

What benefits would you expect if the ship had the pilot route before you go on board?

The planned pilot route before pilot boarding would lead to:

- The ability for the OOW to integrate the pilot route in the monitored route hence showing it in the ECDIS and radar.
- The route will be crosschecked according to existing procedures, which will lead to a greater understanding of the route by the officers on board.
- Giving the OOW/Captain a chance to be involved in the planning.
- Giving the OOW/Captain a better situational awareness.

By having a well-informed OOW/Captain the bridge team is strengthened.

By sending a route with a clearly stated draught it will give the OOW a chance to react if the draught isn’t accurate.

Questionnaires gives us that 80% of the respondents stated that the Nordic Pilot Route service made them feel more safe.
1.1.2 Hypothesis: Sharing areas to be showed visually on the screen leads to better understanding and simplified navigation.

Hypothesis tested by question: 18, 19, 21, 22

Statements:
“With Baltic Navigational Warning Service, it is very efficient to see the areas directly in the ECDIS. However, with all NW markings it tends to clutter up the display.” /1st mate Tanker

Case study:
Example of how route information and possibility to send areas have been used in the testbed.
Tarifa VTS received a route from a ship that were to pass through an area of a fire exercise.
Tarifa sent out a navigation warning with an area message.

The ship received the area, amended their route, and sent a corrected route back.

The vessel were very pleased for the assistance provided and they understood the importance of sharing with us their voyage plans with schedule. /VTS-operator, Tarifa.

1.1.3 Hypothesis: Shared ice routes leads to a better view of the compliance to the ice routes.
Hypothesis tested by questions: 27, 28, 29, 30, 31

Statement:
“When the ship receives a dir-way (ice route), they will be more alerted and aware of that their normal route is not an option any more. To forget about it sort of.” Second mate, IB.

1.1.4 Hypothesis: Sharing routes via AIS leads to better planning and less close quarter situations.
Hypothesis tested by questions: 5, 6, 7, 8, 9, 10

Statements:
“I have not had the reason to act on the information given by another ship since I only saw other ships routes in the traffic separation in the Gulf of Finland. An important aspect is to be able to choose which routes to see, not to clutter up the display. I recons that the feature already now increases the safety a little but when all ships sends routes the safety will be greatly improved. A risk is overreliance in the information given.” /1st mate, Tanker

“The information is really good to have but in crowded waters, it clutters up the display. It would be better if you had to turn the others routes on manually.” /2nd officer, Tanker

1.1.5 Hypothesis: Enhanced monitoring will lead to a reduction of probability of incidents/accidents in monitored areas
Hypothesis tested by questions: 12, 13, 14, 15, 16

Statements:
“Yes to spot where ships will pass each other to determine if it is going to be tight. If you can foresee that, you can also inform the ships of their options. An accident is more often than not a series of events and small mistakes leading to catastrophe”. /VTS-operator, Gothenburg

1.2 KPO: Improve situational awareness for shore centre operators.

1.2.1 Hypothesis: Enhanced monitoring will lead to an early detection of dangerous situations in monitored areas
Hypothesis tested by questions: 12, 13, 14, 15, 16 (These are the same questions as in the previous question, Enhanced Monitoring Service and traditional VTS service are overlapping each other.)

Statements:
“As the route are send on beforehand we can detect early if it isn´t safe and the ship has time to change the route and avoid hazards”/ VTS-operator, Kvitsøy
“We have send routes that weren’t safe to Tarifa VTS and it has been detected every time!” / Officer, Tanker.

1.2.2 Hypothesis: Route crosscheck will lead to less grounding causation probability (no-go areas, air draught) 
Hypothesis tested by questions: 12, 13, 14, 15, 16 (again the same questions have been used to validate another hypothesis since the functions of Enhanced Monitoring, Rout Cross Check and VTS are so closely linked to each other.

Statements:

“It is good to get a second opinion especially from someone with local knowledge.” /2nd officer Tanker.

“To get a route crosscheck from someone with local knowledge is valuable. Especially when sailing into VTS-areas.” /VTS-operator, Norway

1.2.3 Hypothesis: Sharing of VP with VTS leads to a shared mental picture. 
Hypothesis tested by questions: 12, 13, 15, 16 (also VTS related questions).

Statements:

“As the ship’s sharing its intentions, the VTS know the plan. If all ships where to do that then the VTS operator could look in to the future predicting the traffic situations that will arise.
If all ships also share the route with each other, everyone would be able to predict the future. As it is now they have to settle with where they are now and do more or less qualified guesses of where the ships are going.
It is easier for the VTS operator to give recommendations as the VTS-operator knows the full picture and can share a route accordingly.
For example, no one knows Buskärsknöte, it is hard to spell but plays a vital role in navigating in the fairway to Gothenburg. If you send a route, it is no longer a necessity for the ships to know local names.
To know when ships plan something out of the ordinary. For example, going out from Gothenburg Stena Jutlandica takes a shortcut over in the wrong lane in the separation when possible. This saves them a lot of fuel. It would be quite a scary sight to see this big ferry on the wrong side! But if you see that that was her plan all along it would be fine.” VTS-operator, Gothenburg

1.2.4 Hypothesis: Sharing search patterns between MRCC and SAR-units will lead to a more complete search. 
Testing new STM functions in real SAR operations could be dangerous if using new not yet fully matured features and with no supporting operational procedures. Therefore, SAR could not be included in the
questionnaire sent to merchant testbed ships. Instead, tests in the form of exercises have been held.

Exercises with SAR units, receiving information from MRCC, shows that sharing the SAR coordinators intentions to the SAR unit is very easy to conduct. The result by using STM is also that it very easy for the SAR unit to receive and understand the SAR coordinators instructions. This in all will give a more complete search. Exercises also shows that the possibility to send out more “tailor made” information specific to each unit is increased.

Statement:
"The STM tools made it possible to transfer many times more data to the units from the JRCC. Fact/text, areas, track lines and to get a confirmation via text in the system. It would not have been possible to do this without the STM function." / MRCC SAR-coordinator

KPA 2: Efficiency

2.1 KPO: Simplifying navigation

2.1.1 Hypothesis: Receiving pilot routes will lead to simplified route planning.
Hypothesis tested by questions: 23, 24, 25, 26, 27

Statements:
"I find that it saves time when going to a new port. It is also very easy to use. In case of known ports I use it to compare with our own route." / 2nd officer Tanker

"Nordic Pilot Route is a good feature; I would have used it as comparison to the one we had planned ourselves. I also thinks that it would make the information exchange between the captain and the pilot more effective." / 1st mate, Tanker

2.2 KPO: Reducing administrative burden

2.2.1 Hypothesis: Less administrative work finding information lead to more time for navigation.
Hypothesis tested by questions: 7, 9, 21, 25, 29, 34, 40. In this case, all questions regarding decrease of workload were assumed to lead to an answer if the Officer of the watch were allowed more time for navigation.

Statements:
"Pilot route service is very good especially going in to Stockholm where there different fairways. Simplifies the planning. / Navigation officer, Pusher."
“When going to a new port and don’t know the way, Pilot Route Service saves time and is easy to access.”/ Navigation officer Tanker

2.2.2 Hypothesis: The SAR-units receiving search areas leads to shorter response time.

Statements:
“When the SAR units already have the information in the navigational system, the crew can concentrate the efforts to start the search. This absolutely leads to shorter response time. After live tests, the Crew respond with 4,4 on the scale 1-5 to that question.

Statement:
“That search area and/ or text related to the mission are presented in the system when crew arrives onboard, is a clear advantage and simplifies the navigation significantly as well as eliminates misunderstandings. However, exchanging text messages between JRCC / SAR unit as a chat function is in most cases not possible given the environment on board, (small unit, high see, dark, inexperienced crew, etc.) With those units voice communication is preferable.” /SAR unit navigator

2.2.3 Hypothesis: Sending ice routes leads to less administrative work
Hypothesis tested by questions: 27, 28, 29, 30, 31

Statement:
“When you send WP over AIS/e-mail you still need to transfer them manually to the AIS/e-mail, from the AIS/e-mail to a paper and then to the ECDIS, which gives, room for mistakes three times (has happened from us as well). On some vessel the e-mail is only read by the captain and not updated all the time.”/ 2nd mate, IB
“It is of big help. When we are busy, it helps by making the workload much less. We do route cross check before sailing but after that it is only to go!” Navigation officer, Tanker

“Without STM the normal procedure is to get an email with the dir. way coordinates. Then they transfer the coordinates manually into the ECDIS. This is ok if there are one or two waypoint but when there are more, it helps a lot to get them directly to the ECDIS.” /Navigation officer, Pusher

2.2.4 Hypothesis: Route exchange ship to ship will lead to a reduction in workload for the users during navigation.
Hypothesis tested by question: 7
Questionnaires gives us a result where 55% do not see a decrease in the workload.

2.2.5 Hypothesis: Enhanced monitoring will lead to a reduction in workload for the shore centers operators.

This hypothesis have the basis in the prediction that with the ability of enhanced monitoring the VTS operators will be able to “discard” the ships following their pre-planned route. Since there were not enough ships at the same time in a VTS area, this hypothesis could not be validated.

2.3 KPO: Increasing energy efficiency

2.3.1 Hypothesis: Port call synchronization leads to a more energy efficient sailing.
Hypothesis tested by question: 35.

Example and case study of how Port call synchronization has been used in the testbed:
A ship is approaching Gothenburg, the route with a schedule shows that the ship have an estimated time of arrival at 2300 LT.
A port call optimization action is started and involved actors conclude that the ship will not have a berth until two days later at 1200 LT.
A recommended time is sent to the ship.
The ship reduces the speed from 12 to 8 knots.

KPA 3: Sustainability

3.1 KPO: Decreased energy consumption

3.1.1 Hypothesis: Efficient voyage planning leads to less pollution.
The possibility to test the route optimization services have been limited and no conclusion can be drawn.

3.1.2 Hypothesis: Area Management will lead to facilitate just in time visibility of the environmentally sensitive areas on board
Hypothesis tested by questions: 35, 36
See 1.1.2. In the same way it is possible to send safety messages, it is also to send environmentally sensitive areas. It will then lead to a similar effect as described with the safety areas.
Questionnaire form sent to ships
This periodical questionnaire was sent out to the ships participating in the testbed once a month between September 2018 and March 2019. Ships name can occur several times as it was encouraged to fill a questionnaire every month and that each officer onboard filled it out.

Periodical questionnaire

Dear participant, to evaluate the STM concept we need your help! In STM Validation testbed we are testing a number of different services in the STM way of presenting things. We would really like to know what you think.

Thank you for your time.

1. Identification: Ships name:
2. Position: Captain, Chief officer, 2\textsuperscript{nd} officer, 3\textsuperscript{rd} officer (Tickboxes)
3. Years of experience:
4. Which STM services have you been using?
   Route exchange ship to ship
   Enhanced monitoring
   ETA window (by SMHI)
   BNWS- Baltic Navigation Warning Service
   NPR-Nordic Pilot Route
   Winter Navigation (Direction ways in the ice infested waters in the Baltic Sea)
   Port call synchronisation
   Route optimisation

   Checkboxes for each service *Not applicable *Never *Sometimes *Often
   For the answers Sometimes and Often the “service specific questions” should appear for each service chosen. For “never”, the respondent is sent to question 43. For “not applicable”, there is no follow up questions. If only “not applicable” is ticked, the respondent will be sent directly to the Thank you page.

5. Regarding the service: Route exchange ship to ship
   Was the service useful? Y/N
6. Did this service make you feel more safe Y/N
7. Did this service decrease your workload Y/N
8. Did this service increase your awareness of the traffic situation? Y/N
9. Did this STM tool assist you in your duties on the bridge? Y/N
10. Did you consider ship to ship route exchange in your decision-making in traffic situations? Y/N

11. Regarding the service: Enhanced monitoring
To which shore center did you send your route?

Gothenburg
Tarifa
Kvitsoy
Horten
Royal Danish Navy

12. Was the service useful? Y/N
13. Did this service make you feel more safe Y/N
14. Did this service decrease your workload Y/N
15. Did this service increase your awareness of the traffic situation? Y/N
16. Did this STM tool assist you in your duties on the bridge? Y/N

17. Regarding the service: ETA window
Was the service useful? Y/N
18. Did this service decrease your workload Y/N
19. Did this STM tool assist you in your duties on the bridge? Y/N

20. Regarding the service: BNWS- Baltic Navigation Warning Service
Was the service useful? Y/N
21. Did this service decrease your workload Y/N
22. Did this STM tool assist you in your duties on the bridge? Y/N

23. Regarding this service: NPR-Nordic Pilot Route
Was the service useful? Y/N
24. Did this service make you feel more safe Y/N
25. Did this service decrease your workload Y/N
26. Did this STM tool assist you in your duties on the bridge? Y/N

27. Regarding this service: Winter Navigation (Direction ways in the Baltic sea)
Was the service useful? Y/N
28. Did this service make you feel more safe Y/N
29. Did this service decrease your workload Y/N
30. Did this service increase your awareness of the traffic situation? Y/N
31. Did this STM tool assist you in your duties on the bridge? Y/N

32. Regarding this service: Port call synchronization
Which port did you call on?
Valencia
Gothenburg
Limasol
Barcelona
Umeå
Rotterdam
33. Was the service useful? Y/N
34. Did this service decrease your workload Y/N
35. Did this service increase your awareness of the traffic situation? Y/N
36. Did this STM tool assist you in your duties on the bridge? Y/N

37. **Regarding the service: Route optimization**
   Which service did you use?
   - SSPA
   - CIMNE
   - SMHI

38. Was the service useful? Y/N
39. Did this service make you feel more safe Y/N
40. Did this service decrease your workload Y/N
41. Did this service increase your awareness of the traffic situation? Y/N
42. Did this STM tool assist you in your duties on the bridge? Y/N

43. You stated that you never use some of the STM-services even though they were applicable, please let us know why. Open text
   
   Thank you for helping the STM-team improve! If you have any more thoughts, please send us an email on: stm@sjofartsverket.se
Additional questionnaire responses

NOTE: only responses not already included in the statistics in results of questionnaires section is included. The number of each question is according to the numbering in the questionnaire.

1. Identification

Number of respondents: 121

SCA Östrand, Astina, Baltic Bright, TERNVIND, M/T Nimbus, Neptunus, Finnpulp, PRIMA QUEEN, STEEL, finnpulp, Prima Queen, Finnmill, Brianna, Aniara, M/V ELEKTRA, Salome, MORNING CHORUS, M/V Aniara, Oberon, SALOME, Helena Kosan, Manon, Neptunus, Lexus, Stena Danica, Scali Sanlorenzo, Nordic Nelly, Don Carlos, MV Elektra, Salome, MSC LETIZIA, SALOME, MV Salome, FEDORA, MSC BRIANNA, MSC ELBE, Scali Del Pontino, Bergen Star, Finnmill, M/T Nimbus, TOSCA, MSC Meline, MSC MELINE, Prima Queen, Prima Queen, Nimbus, Astina, Astina, MSC MARYLENA, Olympiysky Prospect, MSC Meline, M.V. ELEKTRA, Nordic Inge, ELEKTRA, ARABIAN BREEZE, Morning Chorus, SALOME, Manon, BORE BANK, Elektra, DON JUAN, TERNVIND, Helena Kosan, DON CARLOS, Kristin C, Kristin C, DON PASQUALE, MSC Giovanna, DON PASQUALE, DON JUAN, Kimberly C, DON PASQUALE, Lexus, KELLY C, Bergen Star, PARSIFAL, DON QUIJOTE, Morning Chorus, MORNING CHORUS, Figaro, Helena Kosan, Stena Danica, Chemical Voyager, Nimbus, Finnfellow, Finnfellow, MARIT, Tosca, SALOME, SALOME, Marinus, Nordic Nelly, MT TERNVIK, PARSIFAL, Astina, Scali Sanlorenzo, MORNING CHORUS, SCALI REALI, MSC Meline, Scali Del Pontino, SCALI DEL PONTINO, Scali Del Pontino, M.V. Manon, Prima Ballerina, MSC Marylena, MSC CLEA, MORNING CHORUS, MORNING CHORUS, MSC CATERINA, DON CARLOS, Bergen Star, MSC LETIZIA, MSC CHANNE, LEXUS, TURANDOT, TURANDOT, Morning Chorus, Bergen Star, Scali del Teatro, Tessa Kosan, Tessa Kosan, Tellus, KIMBERLY C., Lexus, Stena Danica, NATIG ALIYEV, Ternvag, Scali Del Pontino, FINNSKY, MT Astoria, MARIT, MSC Asli, MSC CLEA, DON JUAN, DON QUIJOTE, M.T. MARINEX, MSC Marylena, UKKO,, Astina, Sibur Voronezh, Kristin C, MT MARIT, T/B ARTEMIS, Ternsea, mv Figaro, MSC GIOVANNA, DON QUIJOTE, Stena Danica, Helena Kosan.
2. Position
Number of respondents: 149

<table>
<thead>
<tr>
<th>Position</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Captain</td>
<td>24%</td>
</tr>
<tr>
<td>Chief officer</td>
<td>3%</td>
</tr>
<tr>
<td>2nd officer</td>
<td>61%</td>
</tr>
<tr>
<td>3rd officer</td>
<td>12%</td>
</tr>
</tbody>
</table>

3. Years of experience
Number of respondents: 148

<table>
<thead>
<tr>
<th>Min value</th>
<th>Max value</th>
<th>Average</th>
<th>Median</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>40</td>
<td>9.6</td>
<td>6</td>
<td>8.5</td>
</tr>
</tbody>
</table>
4. Which STM services have you been using?
Number of respondents: 142

<table>
<thead>
<tr>
<th>Service</th>
<th>Total number of responses</th>
<th>Not applicable</th>
<th>Never</th>
<th>Sometimes</th>
<th>Often</th>
</tr>
</thead>
<tbody>
<tr>
<td>Route exchange ship to ship</td>
<td>136</td>
<td>6.6%</td>
<td>28.7%</td>
<td>52.2%</td>
<td>12.5%</td>
</tr>
<tr>
<td>Enhanced monitoring</td>
<td>135</td>
<td>10.4%</td>
<td>32.6%</td>
<td>31.9%</td>
<td>25.2%</td>
</tr>
<tr>
<td>ETA window (by SMHI)</td>
<td>134</td>
<td>17.2%</td>
<td>40.3%</td>
<td>27.6%</td>
<td>14.9%</td>
</tr>
<tr>
<td>BNWS - Baltic Navigation Warning Service</td>
<td>135</td>
<td>31.9%</td>
<td>47.4%</td>
<td>14.1%</td>
<td>6.7%</td>
</tr>
<tr>
<td>NPR - Nordic Pilot Route</td>
<td>135</td>
<td>24.4%</td>
<td>47.4%</td>
<td>15.6%</td>
<td>12.6%</td>
</tr>
<tr>
<td>Winter Navigation (Direction ways in the ice infested waters in the Baltic sea)</td>
<td>134</td>
<td>34.3%</td>
<td>54.5%</td>
<td>9.7%</td>
<td>1.5%</td>
</tr>
<tr>
<td>Port call synchronisation</td>
<td>135</td>
<td>14.1%</td>
<td>51.1%</td>
<td>20.7%</td>
<td>14.1%</td>
</tr>
<tr>
<td>Route optimisation</td>
<td>137</td>
<td>10.2%</td>
<td>39.4%</td>
<td>29.9%</td>
<td>20.4%</td>
</tr>
</tbody>
</table>
11. Regarding to the service "Enhanced monitoring". To which shore centre did you send your route?

Number of respondents: 73, number of selected shore centres: 112. Note: This implies that each respondent have had the possibility to choose several shore centres and therefore the total percentage according to the figure exceeds 100%.

- Gothenburg: 78%
- Tarifa: 41%
- Kvitso: 5%
- Horten: 5%
- Royal Danish Navy: 23%
32. Regarding to the service "Port call synchronisation". Which port(s) did you call at?
Number of respondents: 40, number of selected ports: 50. Note: This implies that each respondent have had the possibility to choose several ports and therefore the total percentage according to the figure exceeds 100%.
43. You stated that you never use some of the STM-services even though they were applicable, please let us know why.

Number of respondents: 85

<table>
<thead>
<tr>
<th>Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Due to problems with installation we have not been able to use it uptil today</td>
</tr>
<tr>
<td>I do not understand the use of it. More klicking on the computer and less lock ut. Jetty's are sometimes change during pilotage and it is not allways sutiable to make navplaning when you are inbound for the jetty/pilot onboard. When we share routs with other ships it is sometimes to much lines in the charts.</td>
</tr>
<tr>
<td>Haven't had the chance to try it yet.</td>
</tr>
<tr>
<td>The STM is still in developing so some options are N/A due to lack of other parties participate in this program.</td>
</tr>
<tr>
<td>Short voyages, and more knowledge need to understand how it works</td>
</tr>
<tr>
<td>They are buggy and dont work good.</td>
</tr>
<tr>
<td>I had not have need yet for those services.</td>
</tr>
<tr>
<td>I didn't know that these functions were already operational.</td>
</tr>
<tr>
<td>I have only tested route exchange on open water, but it could be helpful in archipelago</td>
</tr>
<tr>
<td>Please be noted that in present moment the STM under test and nobody know how to really use it. We sent and shared our passage plan only with one SC Tarifa and received back same passage without changes. We will see in the future and send next feedback in few month.</td>
</tr>
<tr>
<td>Not all are useful, route sharing between ship to ship and route monitoring between ship in traffic could be useful to determine the other ship's route however in congested traffic it might also give confusion if too much display on ECDIS PPI. It requires good internet connection which is not good most of the time. It also give additional workload.</td>
</tr>
<tr>
<td>We never use Baltic Navigation. Because currently we don't have Baltic Trade</td>
</tr>
<tr>
<td>Vessel trading</td>
</tr>
<tr>
<td>New to STM, still learning how to use, and find it a bit confusing since User Manual not really that user friendly, especially the TEXT MSG part.</td>
</tr>
<tr>
<td>Have no need for them from this source , at the moment. maybe in future.</td>
</tr>
<tr>
<td>For route optimization we have not sent in calculated frontal area of the ship etc. and the STM has not been implemented very much so far since we have had some other problems with the Transas that we have had to prioritize.</td>
</tr>
<tr>
<td>Was not applicable for our sailing area and regarding winter navigation - Since STM was installed on board, winter did not came.</td>
</tr>
<tr>
<td>1- Ship to Ship routes exchange makes clustering over our own route and may cause confusion for the users.</td>
</tr>
</tbody>
</table>
Route planning normally is studied much time before than route commence, STM-services send their alternatives just when vessel share the route with them. Sometimes nothing change and is not based on vessel own experience is an overall results of many routes shared. Sometimes distance, weather and traffic are not the only parameters of route optimization.

| I never try yet we have newly installed STM |
| We don't have Baltic Voyage |
| Don't often operate in Nordic waters. Not been in Europe since Installation of STM. |
| Areas of voyage |
| Not navigating in ice |
| It is my first time to use it on a vessel so I have not yet had time to check out all functions. |
| DUE VESSEL NOT YET PASSING ON THIS TRAFFIC AREA AND PORT. |
| I didn't know they where operating yet |
| I do not see the big benefit some of this things I get from other places and I do not like extra job |
| you need to increase the strength of the Wi-Fi signal and make the sensor work more stable so that the signal is not lost. |
| Company policy don't allow to share our own route to other ships. Route optimization feature was not used as trading patern doesn't include the ports which allows it. Procedures for Baltic nav.warnings and ETA window are not understood by deck officers. |
| BNWS,NPR, WINTER NAVIGATION. We haven't sail on that area. |
| All my service experience i do sailing with ECDIS and i defiantly use to it. Implementation of new option is certainly good. However on board crew and myself didn't got any training or proper manual of the system on how to use it. I got a word with mates and looks like most of them dint interested to study new system as they been sailing without it some years already. Many years ago i so same situation with implementation of ECDIS. So my conclusion - proper manual book with clear explanation of the basics needed. Or some CBT / on-line training. |
| PS i also notice a very good idea with iPad and wifi transmitting ( TRANSAS system) of ships data on bridge - it can be a very good steps for future implementation a specially for the boarding pilots, cadets, crew, passengers. Just imagine Pilot board the vessel open his Ipad and he got all information of the navigation situation with original data from ships equipment. |
| Haven't try yet, need more familiarization. |
| We don't have Baltic sea Voyage |
| Because STM onboard is not fully functional. For the time being we can only use the route sharing. We try to communicate with the other vessel using the chat room but no vessel reply just to test if it is working. |
We have no manual how to use this service. We need to figure out our self how it works. I don't like when we receive other ships routes automatically. Even if we uncheck or delete the route it jumps back on the screen suddenly. We are on a fixed route and schedule and I like to use our own made routes. The navigational warnings service would be usefull but i don't like that i have to generate a schedule to use this service. When i activate next route the STM service is sending several route suggestions that i don't need. We are not using pilot in Finland so also there i will use my own route and now i have to click down a lot of route suggestion every time.

Some services are redundant to the onboard programs used.

Used another sources to have this information.

To many options becoming ineffective action.

Our trading area is covered by TSS, no alternative routes can be used.

For ship to ship route sharing, we can make their route as reference since we have our own previous route for our current voyage.

And for route enhancement, we did activate the service Gothenburg SC when we call in Gothenburg but we received no message from them.

The system just installed.

Vessel is trading in Mediterranean and Marmara sea.

Because mostly I am working on a coaster vessels.

Due to this passages are quite short and some services provided by STM not really applicable for this type of trading.

The system is newly installed. Need to enhance on this operation and read the manuals for self improvement.

WE HAVE JUST STARTED TO USE STM- SERVICES. RECENTLY WE WERE VERY BUSY WITH PORTS. ONLY NOW WE HAVE A BIT LONGER PASSAGE. WE HOPE IN THE FUTURE WILL BE TIME AND OPPORTUNITY TO USE THESE SERVICES. BRGDS JURIJ

Vessel has no trade route on Baltic Sea.

The STM-services is good.

Program is new to us and most of it still doesn't work on our system. we are also still working our way thru it. maybe in the future will understand more of it.

on our route we have no use for this

The system has been installed however the operators have not received training and instructions if any are difficult to follow.

The replies we receive such as in Enhanced Monitoring do not supply anything new, it is the same waypoints we used and many information is erased so we would need to type all again.

Training is needed for the STM operators to be able to make it work.

More accessability is required. Takes more work to dig in to the ordeal that it is using it.
That being said, it is an ordeal.

In our line traffic and knowing the relevant ships routes anyway it is not necessary.

We were informed of it lately and we are new to this. Still there are lot of things for us to know in this and how we can make the maximum out of it.

They were not applicable on our ECDIS system.
On that time we were not sailing in the winter time or using nord pilot advice.

Not yet installed the last time I was on board the vessel.

Ice service is not applicable for us since we don't navigate in those kind of water. We haven't felt the need to use route sharing because we have a lot of our own routes stored. And route optimising might be a bit tricky for us to use due to the fact that some of our captains has PEC(pilot exemptions) on many places which means we can go different ways than ships that needs to have pilot. But feel welcome to give us som easy guideance on how to use the stm anyway!

Some STM-services never use for the time being due to vessel has no trade route on baltic area.

From ship point of view it STM give workload and more frustration. For example it is sometimes very hard to click away the STM-route from a other ship. You need several attempt and you need to hold the cross exactly correct and this can be a problem depending on scale and so on. And after short time the SMT-rout from the other ship will comeback and you need to do it again.

No nearby ships with STM, seldom only and sometimes not on my watch.

Ship doesn't navigate in the areas.

Since I come onboard I never use STM, we cannot connect to shore centre.

On board STM has never been used as we cannot establish connection with any SC. The problem has been brought forward to Transas and Tarifa SC who is always checking the STM status on board as we are unable to send VPS. The only feature we are able to use is the Chat Messenger communicating with Tarifa SC.

never used this STM onboard due unable to connect between ship to shore center.

We are out of European waters in a couple of months. Your system is base on European water exchange information regarding about port calls and traffic information. We will be there on next two weeks in European water and see how we can participate in there.

One more things is we had sent message to other ship and received message from some ships but in the message box the time was different with actual time. we don't know how to correct it.

We had sent test message to your STM service in Gothenburg SC and we didn't receive back message.

Thanks for your question.

We had not heavy ice on the route yet.

plan to use in the future

Vessel not calling yet to Europe Area.
Vessel have no call in Europe.

<table>
<thead>
<tr>
<th>Trade Route</th>
</tr>
</thead>
<tbody>
<tr>
<td>once have radio confirmation with Tarifa CS</td>
</tr>
<tr>
<td>due to trade area</td>
</tr>
<tr>
<td>It's not in our trading area.</td>
</tr>
<tr>
<td>Not trading in the Area.</td>
</tr>
<tr>
<td>Short voyages. STM-services onboard our vessel is a distraction not a service</td>
</tr>
<tr>
<td>Not used due to trading area and port of calls of the vessel.</td>
</tr>
<tr>
<td>It is just newly installed onboard and under observation for the time being.</td>
</tr>
<tr>
<td>Since I come onboard Scali Del Pontino STM is not working.</td>
</tr>
<tr>
<td>Portcall sync and ETA window was never applicable. (also some bugs in the system)</td>
</tr>
<tr>
<td>Vessel's frequent port calls make us quite preoccupied, which explains that some of the services were not fully utilized.</td>
</tr>
<tr>
<td>Vsl not trade in baltic area.</td>
</tr>
<tr>
<td>STM are good in ship to ship route exchange however it might give confusion when plenty route displaying on ecdis or radar PPI if all ships in the vicinity exchange their route. ETA may also give confusion to VTS if different ETA was set up to AIS, it's like duplication or system redundancy.</td>
</tr>
<tr>
<td>Not applicable for trading area.</td>
</tr>
<tr>
<td>This system is not safe and increase workload</td>
</tr>
<tr>
<td>Now STM service is testing on board our vessel. STM service is good and easy service.</td>
</tr>
<tr>
<td>We have just started using the STM. Still learning.</td>
</tr>
<tr>
<td>Vessels trade route are not on those areas.</td>
</tr>
<tr>
<td>Not of any use to us in our operation.</td>
</tr>
<tr>
<td>they are not applicable/needed due to our vessel commercial way.</td>
</tr>
</tbody>
</table>
Interviews

Interview with VTS Operator Anders Johannesson, Gothenburg shore centre

Q: Does sharing of VP with VTS leads to a shared mental picture?

As the ships are sharing its intentions, the VTS know her plan. If all ships where to do that then the VTS operator could look in to the future predicting the traffic situations that will arise.

If all ships also share the route with each other, everyone would be able to predict the future. As it is now they have to settle with where they are now and do more or less qualified guesses of where the ships are going.

It is easier for the VTS operator to give recommendations as the VTS-operator knows the full picture and can share a route accordingly.

For example, no one knows where Buskärsknöte is; it is hard to spell but plays a vital role in navigating in the fairway to Gothenburg. If you send a route, it is no longer a necessity for the ships to know local names.

To know when ships plan something out of the ordinary. For example, going out from Gothenburg Stena Jutlandica takes a shortcut over in the wrong lane in the separation when possible. This saves them a lot of fuel. It would be quite a scary sight to see this big passenger ship on the wrong side but if you see that that was her plan all along it would be fine.

This hypothesis have the basis in the prediction that with the ability of enhanced monitoring the VTS operators will be able to “discard” the ships following their pre-planned route. Since we hadn’t that many ships at the same time in a VTS area, we cannot validate this hypothesis.

Q: Will enhanced monitoring lead to a reduction of probability of incidents/accidents in monitored areas?

Yes to spot where ships will pass each other to determine if it is going to be tight. If you can foresee that, you can also inform the ships of their options.

An accident is more often than not a series of events and small mistakes, which leads to catastrophe.

Q: Will route crosscheck lead to less grounding causation probability?

To get a route crosscheck from someone with local knowledge is valuable. Especially when sailing into VTS-areas.
Interview with Captain Andrzej Otto of general cargo ship Karla C

-I can see the future with STM it is a great advantage

Q: have you used port call synchronization?
We sent a route with ETA to Rotterdam, it works. As we had pilot on arrival, the RTA sent back was a confirmation of the time.

Q: What did you think of port call synchronization?
Quite good, it would be better if more ports were connected.
We know in a couple of minutes if our ETA fits the port.
A good thing to know a couple of hours before then we have a chance to slow down. The agent isn’t informing you before. Many times, you come to the pilot boarding ground and they tell you to wait. If the weather is good it is ok, in bad weather it is not so good. Normally we slow down and drift or we run up and down, waiting. Knowing the time on beforehand would save fuel. It would also increase safety not having many ships in a small area running up and down.
Now in Algeciras we came to pilot boarding point and had to wait 1.5h.

Q: Have you used the enhance monitor service in Tarifa?
I will contact Tarifa next time passing.
NWS/VTS sending out caution area. One more system? It is good in additional to Navtex and the notices in the ECDIS. We can never get to much information.

Q: What do you think about enhance monitoring?
Well it is a big brother feeling but if it is for safety reasons it is ok.

Q: What do you think about Ship-ship AIS?
It is a good idea. When passing areas with crossing traffic etc. It is good to know the movement before it happens. Of course, it improves safety. To know where the ships will be half an hour ahead is an advantage.
Interview with Denmark Jalandoni, 2nd officer of Pusher Steel

Q: What do you think of Winter Navigation Service?
It is of big help. When they are busy, it helps by making the workload much less. They do route cross check before sailing but then it is only to go!
Without STM the normal procedure is to get an email with the dir. way coordinates. Then they transfer the coordinates manually into the ECDIS. This is ok if there are one or two waypoint but when there are more, it helps a lot to get them directly to the ECDIS.
Sometimes they get the dir. ways before the route and can consider them in planning the route. Sometimes they get them during the voyage and have to adjust the route accordingly.
Before they have tried WNS and tried to chat with Ymer. Worked fine.
Yesterday it was Frej assisting them.
Route-exchange have been tried before with GBG. And Gbg send back that it was well received.

Q: What do you think of Enhanced Monitoring?
Know what route they are following. The ability for the VTS/Icebreakers to amend the route is a big help.
He thinks that it is a good idea. All information are helpful.

Q: What do you think of Nordic Pilot Route Service?
Mr Jalandoni sent the next route as we spoke. He received the pilot routes for both Rahé and Luleå back.
“Cool!”
Very good especially going in to Stockholm where there different fairways. Simplifies the planning.
Interview with 2nd officer Jacob Olsson, tanker ship Astoria.

Q: Have you used STM services?
STM has worked well and has been helpful to some extent.
One of the best things is that is so simple to send routes, we have been exchanging routes with our sister ships.

Q: Have you been using Winter Navigation Service?
We didn’t use it this time since there wasn’t much ice on the Swedish side. There were no direction ways issued.
Last time we were up in the Northern Baltic, we got direction ways from Icebreaker Oden via the STM Chat. It is preferable to the BaltIce page as that requires better connection.
Normally we get the direction ways on e-mail and enter them manually into the ECDIS.
WNS does not decrease the workload as we have entered the waypoints of the direction ways manually as well just to compare. When you get used to the service, trust it and no longer feel the urge to double check. Than I am sure, the workload will decrease.

Q: Have you been using Pilot Route Service?
I have not used but I have tested it. It worked; we received pilot routes for Åbo and Kokkola. It is perfect for ships that have not called on that particular port before. It is good to have the same mental picture as the pilot.
Interview with Asle Njåstad VTS operator at Kvitsøy VTS.

Q: Do you find the enhanced monitoring service useful?
Yes, but it would be even more helpful if the routes were checked automatically against a normal route tool.
As we have restrictions in length in our fairways and it is very good to be able to check on beforehand that the officer has chosen the correct route for their length.

Q: How does enhance monitoring affect VHF communication?
It most certainly reduces voice communication. To send a text message along with a route suggestion is preferable to VHF.
One issue is that with voice communication the VTS operator gets a check in with the captain to know if he/she is alert and understands instructions.
When it is short notice messages, VHF is still preferable.

Q: Will the new way of communication lead to less misunderstanding?
I think so as you do not need to use complicated local names for places to tell them how to sail.

Q: How would you send suggested routes?
We would build up a library for the different alternatives. If there were a change that would be viable for a longer period, we would add amended routes to the library. If it were for a short period, we would amend each one sent to us.
Interview with Hans Hansen, HSSEQ Manager, Lauritzen Kosan

The ships opinion of STM is within the range: “It’s good for nothing” to “It is the future”

A clear trend is that the ships that used the STM tools the least, says that it is no good and the ships that used it a lot, thinks that it is the future.

Hans thinks that it would be very good to have a shore user that can pick up the routes of the companies ships to give the company better information on the planed routes with schedules. From shore, you would then know if they are in time to each waypoint. It would also be good to be able to monitor time for instance from pilot to berth to be able to update the predicted times and in that way optimize the turn around.

PRS seems like a very good service, Hans says but unfortunately, they do not have ships running on Swedish ports. Not with STM anyway. Once Kaarstø in Norway gets PRS they will try it out.

Route optimization haven’t been used since their weather supplier has not jet joined STM. We could try SSPA calculated route out.

Route exchange ship to ship is a good feature but it clutters up the screen even with only three ships. It would be good if you had to activate the routes manually instead of deactivating them.

Route exchange as service. Ships being able to share routes with each other saves a lot of time and effort.

Enhanced monitoring is very good as an extra check. Our ships have sent routes with faults just to check and Tarifa spotted it every time!
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