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Impacts of standardized information sharing on maritime safety, efficiency and environment - STM Validation results

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Abstract

Sea Traffic Management, STM, is creating a new paradigm for maritime information sharing, offering tomorrow's digital infrastructure for shipping. STM is the concept of information sharing in real time, through a secure infrastructure, with standards that create interoperability among various actors such as ships, manufacturers and port actors, allowing information holders to retain own their valuable data and choosing those with whom they wish to share it.

The STM Validation project has validated the infrastructure, software and services on 300 ships, in 9 ports and in 5 shore centres. The results of the validation and the identified potentials and challenges are described. Improvements in safety, efficiency and reduction in environmental impact are discussed. The key building blocks for the STM success are triple-helix cooperation, open standards, long-term support from EU, relentless dissemination and flexibility to adopt new developments on digital transformation.

Keywords: digitalization; maritime; safety; efficiency; environment; collaboration

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1. Introduction

This paper aims to give a summary of the goals, results and conclusions of one of the largest e-Navigation project ever, in terms of large scale pilots. The STM Validation project ran for 3½ years engaging 38 partners and as many associated partners. It had a budget of about 43 million euro and was co-financed by the Connecting Europe Facility funding from EU with the TEN-T project number 2014-EU-TM-0206-S. It involved 13 countries in Europe and established test-beds in coastal Northern Europe and Mediterranean countries, involving 300 ships, 9 ports and 5 shore centres. It also used the European Maritime Simulator Network for specific scenarios where all involved ships had STM-capabilities.

The benefits of STM could lead to long-reaching changes in the shipping industry, reducing the number of accidents by 50 %, reducing emissions with up to 20% and affecting business models in the industry.

The paper also describe some recommendations for future research and actions.

2. Project Summary

Nowadays, 80% of the goods produced worldwide are distributed across the globe by maritime transport. In complex logistics chains, minor decisions may easily have major consequences. The shipping industry suffers from a lack of shared data between ships and ports, which could lead to monetary loss when vessels are delayed, fuel burned and sub-optimal routes are chosen. Operations in the maritime industry are characterized by infrequent interaction among an extensive number of actors. In many other industries, close partnerships have stimulated systems integration and general standardization of information exchange.

STM establishes a global maritime digital infrastructure where standard messages can be sent and received. Interoperability is achieved by specifying not only WHAT format the data should have but also HOW the exchange should be done. When actors follow this design principle they can connect seamlessly even on their first encounter. Shipping is often a series of first-occasion encounters, as ships visit new terminals and ports most of the time. Efficient and reliable data exchange among port actors can cut waiting times during port calls and assist in achieving just-in-time arrivals. In STM, information owners select the partners with whom they wish share data, thus avoiding business sensitivity issues.

The goal of the STM Validation Project was to develop and validate the infrastructure and the services using it, and to verify the functions and benefits. The benefits predicted in the previous MONLISA and MONALISA 2.0 projects defining and designing the STM concept include: common situational awareness among ships and shore actors, reduced administrative burden, green steaming and just-in-time operations.

The STM Validation project set up three test-beds. One test-bed was located in Northern Europe and another in the Mediterranean. Apart from these operational test-beds, the European Maritime Simulator Network (EMSN) was used to validate complex cases involving many ships. EMSN tests using 30 manned bridges supplied data on the behaviour of mariners and to compile their feedback on STM. The test-beds were supported by the development of a maritime digital infrastructure.

The validation of the port functions took place in parallel with current operations, whereas the ships and shore centres implemented services, many of which will remain operational after the project. Examples of functions and services include winter navigation services in the northern Baltic Sea, enhanced monitoring in the Strait of Gibraltar, port arrival synchronization in Limassol and ship-to-ship route exchange among 300 ships wherever they meet around the world.

2.1. STM port functions

The project introduced and validated a new way of information sharing in nine ports, Port Collaborative Decision Making, PortCDM. The idea is to collect timestamps on planned and actual from many port actors and thus identify and clarify differences around the coming actions in the port call process.

In the port test-bed, different surveys and living labs concluded that 92% of end users agreed with the statement that the use of STM is expected to contribute to a better shared situational awareness during port calls, which more than half of them identified as the key to enhanced collaboration. Bringing people together in real life workshops induced 40% of the participants to begin to collaborate with actors they had never communicated with before. One conclusion from the port tests is that data sharing and collaboration is critical in creating more efficient port calls and operations. The project established the PortCDM Council to stimulate continuing progress after the project, and which has had an uptake of 36 active members and 34 observers, derived from ports, authorities, private companies and international organizations.

2.2. STM services in use

The ship and shore centre test-bed implemented the following STM services:

- Nordic Pilot Route Service
- Baltic Navigational Warning Service
- SSPA Route Optimization Service
- SMHI Route ETA Forecasts
- Winter Navigation Service
- Ship-to-Ship route exchange
- STM SAR
- Enhanced Monitoring Service

Each service has its own individual purpose and benefits, which have been validated. Combined, they contribute to the overall goal of STM to improve safety, increase efficiency and reduce the environmental footprint of shipping in line with the IMO Sustainability goals.

Some services will remain operative after the validation process. Three examples are the Navigational Warnings in the Baltic Sea, the sharing of Pilot Routes in Sweden, Finland and Norway and the Winter Navigation services. The functions in the ECDIS on-board the ships will continue after the project duration. Ongoing and future implementation projects, e.g. STM BALT SAFE co-funded by EU INTERREG Baltic Sea Region, are committed to supporting the existing ships while also implementing new services and engaging more ships.

A cross-industry Developers' Forum was established during the project. Technical architects from competing companies solved common problems and the forum has been instrumental in making STM operational and interoperable. The forum will continue under the governance of the implementation projects.

End-user feedback from navigation officers on-board test-bed 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 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.

2.3. Simulator tests

The European Maritime Simulator Network, EMSN, was used to validate scenarios that involved many STM-enabled ships. Qualitative analysis of the data from simulations suggests that, generally, the STM services promoted navigational safety and efficiency, as these services have the potential to improve communication, decrease bridge crew workload, and increase the time to respond, plan and act accordingly in challenging navigational and traffic conditions. The results from various quantitative analyses indicate that the STM services are valuable in areas in which strategic navigation is applicable, i.e. where there are fewer temporal and spatial constraints. However, in areas with dense and regulated traffic and less room for strategic navigation, the value of the available STM services in improving traffic safety could not be directly demonstrated.

2.4. Maritime digital infrastructure

During the project, leading system suppliers of on-board navigation systems, e.g. Electronic Chart Display Information System, ECDIS, as well as Vessel Traffic Service (VTS) systems, maritime service providers and authorities agreed to adapt the standard formats used in STM. They joined forces to achieve interoperability in the exchange of ship voyage plans, time-stamps, such as estimated times of arrival to ports and navigational warnings, based on a common digital infrastructure.

The infrastructure provides solutions, such as a global, digital identity of users, vessels and systems, which is a serious bottleneck in commencing a digital maritime revolution across different companies and individuals. This is a prerequisite just as global, unique telephone numbers or email addresses are required to enable human-to-human communication on a global scale.

The common digital infrastructure was tested successfully and was thoroughly evaluated during three years of operations. One important output is the recommendations on how to further develop and mature the infrastructure.

2.5. Analysis and business perspectives

The analysis has reconfirmed the potential savings in time, fuel and greenhouse gas emissions (GHG). This is based on deeper and wider data analyses both from within and outside the project. The environmental aspect is gaining increasing attention and STM can play an important role in reaching the IMO goal of reducing GHG by 50% by 2050. However, to realize such benefits, business models need to change. One step in this direction is the new STM clause in the BIMCO standard contracts, developed and implemented during the project. The STM clause helps to distribute the value of fuel savings when ports and ships are better synchronized, stimulating more ships to adjust their speed and arrive just-in-time.

2.6. Subsequent steps

Four implementation projects have already commenced ahead of the completion of STM Validation. Real Time Ferries, co-funded by EU INTERREG Baltic Sea Region, will use the on-board knowledge of ferry delays to inform passengers, goods handlers and public transportation about the changes. EfficientFlow, co-funded by EU INTERREG Central Baltic, will implement STM in two ports in the Baltic Sea. It will also help ships to plan encounters in narrow passages at an earlier stage, thus saving fuel and enhancing safety. STM BALT SAFE will increase tanker safety in the Baltic Sea, taking into account the cross-traffic of ferries for the most part. STM in the Eastern Mediterranean, STEAM co-financed by the European Regional Development Fund and the Republic of Cyprus through the Research Promotion Foundation., will establish a shore centre in Cyprus and implement STM in the port of Limassol, exchanging information with ports in neighbouring countries. Partners will continue collaboration with the SMART Navigation project in Korea and with Sesame 2 in Singapore.

The overall project recommendation is that the concept and the infrastructure be made ready for implementation in the form of new and updated software, service and functions. However, continued support from public funding towards implementation would be useful in attaining a speedier adoption rate. Some of the benefits for the whole industry and individual users will be larger as the number of ships using STM reaches a critical mass.

The report also suggests continued work by project partners in international consortia and organizations, such as the International PortCDM Council. For the digital infrastructure, there is the Maritime Connectivity Platform Consortium and the non-profit industry group for STM. A new organization has been formed to develop and operate the European Maritime Simulator Network for future research, training and testing of new services.

The work on standards and on regulation must continue and intensify in IEC, IALA and IMO. It is important to get many of the project partner countries to unite in various actions to speed up the development. The STM Validation Project has spun off two standardization work items: transforming the route format developed in the MonaLisa2.0 project into the S-421 standard, and a work item taken up by IEC to create a standard for transfer of S-100 products, based on the Voyage Information Service interface developed by the project.

3. Project conclusions in more detail

Over the past decade, total losses in shipping have declined by more than a third (38%), according to the Allianz 2018 Safety & Shipping Review, driven by improved ship design, technology and advances in risk management and safety. However, the review points out that despite huge improvements in maritime safety, fatal accidents at sea persist. Human error continues to be a major driver of incidents and captains and crews are under increasing commercial pressure as supply chains are streamlined.

Moreover, the AGCS analysis shows bad weather directly contributed to at least 21 total losses in 2017, a figure that could further increase. Fuel markets, cargo, cruise ship and port operations were also disrupted, leading to natural catastrophes being ranked the primary risk by shipping experts in the Allianz Risk Barometer 2018. Again, the real-time information provided by the STM tools could help cut these kinds of risks

What's more, the new "Paris Agreement for the Shipping Industry", and the IMO regulation for the reduction in sulphur emissions by 2020 engages a call to action in terms of environmental sustainability to the extent that the shipping industry has an impact on climate change, both from the sea side and port side.

As regards port side outcomes, an in-depth analysis of shipping movements in nine European ports noted that cargo vessels of various types spent only 60% to 70% of their port time at berth. Only 40% to 65% of time at berth was used for operations. Obtaining a much higher degree of predictability for arrivals, cargo operations and departures would enable higher fleet and capacity utilization, thus affecting both ships and ports.

Considering the number of regular port calls made by ships, one might expect every port call to be primarily

repetitive and routine. It should be easy to forecast the different time and spatial dimensions associated with the events of the call. However, analysis of ship movement data shows that, irrespective of type of transport and type of port, the time spent in port is not similar and does not seem to follow any predictable pattern.

Unreliable forecasting of ship departure times, and when other ships can enter a port, find a vacant berth and start cargo operation, is a further consequence of these poor levels of predictability and has an impact on GHG emissions, as confirmed in this report.

To overcome this, actors in shipping need to collaborate and share data about plans and progress, enabling each port call to be managed and coordinated to minimize delays or conflicts for resources, as is currently the case.

These challenges drove the need to define and validate the STM concept.

Enabling data-sharing improves operations

Findings from the navigational part of the STM Validation Project end-user feedback, indicate that digital information sharing between shore-ship, ship-shore and ship-ship can improve situational awareness and improve operations on-board, in shore centres, maritime rescue and coordination centres, and VTS centres. According to the findings at the simulators, the utilized services have the potential to improve communication, decrease bridge crew workload, while perhaps simultaneously increasing the time to respond, plan and act accordingly in challenging navigational and traffic conditions.

The findings as to whether STM has reduced workload vary. Some services are considered to reduce workload while others are not, since not all services aim to reduce workload but, instead, the benefits of these services are related to, for example, safety aspects or enhanced operations on shore-side.

Numerical analyses indicate that the STM services are valuable in areas where strategic navigation is applicable, i.e. where there are fewer temporal and spatial constraints. In areas with dense and regulated traffic (for example traffic separation schemes) and less room for strategic navigation, the value of the available STM services in improving traffic safety could not, however, be directly demonstrated.

From the VTS Operator perspective, although the communication between ship and shore will increase, the STM Services will promote navigational safety and efficiency through the availability of additional navigational information, monitoring services and communications. Although it is important to study further the communication patterns between ship and shore to understand how workload, training, and procedures in the VTS station will be affected by STM, the innovative possibility to review ships' intentions well in advance before entering the VTS surveillance area would allow the VTS to work more proactively than is currently the case.

Additional testing is also required to understand if there is a shift of workload to other aspects of the maritime decision chain and how these services may make it necessary to adapt the present regulatory, organizational and management structure to the shipping domain.

However, it can be assumed that better use of data will help to address some of the safety issues in shipping, while over-reliance on technology on-board must be taken into account. As a result, continuous training is imperative to ensure the optimum balance between technology and human intervention.

Furthermore, STM in Ports, as a port-centric concept, enables all stakeholders in the port-call process to share data for significant events by the use of a common port-call message format (S-211). Actors obtain a common situational awareness for enhanced and synchronized planning. Actors are informed about upstream disruptions affecting their operations and inform those further downstream. Just-in-time arrivals, departures, and shorter turnaround times lead to more efficient use of assets and improved predictability of operating and delivery times. The productive time of operations can be increased through access to up-to-date status information leading to better-informed decision-making, thereby reducing unnecessary waiting times.

Cross-industry collaboration is key

One of the main successes of the STM project has been the cross-industry collaboration, as leading competitors among providers of ECIDS and VTS-systems have developed the services during the project and, as a result, are currently planning to establish an open non-profit consortium to operate and develop the maritime digital infrastructure established in the STM Validation project. The consortium includes project partners, associate partners, as well as other actors who see the potential of a common basis for delivering services and growing their software.

During the simulations, there were some negative comments about the usability difficulties of the ECDIS/STM client interface. This is to be expected because of the limitations in design specifications for these types of interfaces and could, in some circumstances, be due to a lack of familiarization with the experimental equipment.

The introduction of new technologies to already complex systems such as ECDIS is one of the most challenging aspects in any work environment and needs to be supported by training and rigorous user-interface testing.

So far, the digital service infrastructure provides standardized interfaces or reference services according to the SeaSWIM specification. However, standardization is a constantly ongoing and iterative process, where new input needs to be managed in a collaborative manner, gaining and re-gaining support from system suppliers and other stakeholders. Additionally, a continuous process of adapting, maintaining and further developing the principles and procedures of SeaSWIM in order to achieve a *common* digital maritime infrastructure is needed. Basically, the STM Validation Project laid the foundations for this, and needs to be further developed by joint efforts by interest groups and industry initiatives.

Indeed, the ongoing creation of an industry cluster has great potential to integrate the common maritime digital infrastructure in current operations. Already the obvious interest from such a broad industry group is a sign that SeaSWIM and the STM services have identified a significant need, although, it is important that the initiative is supported in parallel by new projects that continue the development of STM in innovative directions.

Considerable benefit is to be gained by moving towards a global implementation of STM in all ports, irrespective of any other coordinating mechanisms that may already be in place. There are clear advantages for all actors in the marine transportation chain to embrace the concept.

STM in Ports engages all key actors in the port-call process. All need to have a common understanding of their role in the transportation chain and the impact that their activities may have on others in it. This helps to break down any initial reluctance to share planning data among competitors when they realize that the common benefits outweigh the possible individual gains of acting separately.

As one of the deliverables of the STM validation project, the International PortCDM Council (IPCDMC) (www.ipcdmc.org) has been established to provide a sustainable international governance body for STM in Ports. This paves the way for harmonized collaboration and data sharing of port-call operations for the maritime community on a global level by supporting regional and local implementations.

Improved situational awareness and predictability means substantial savings

Some conclusions from practical end-to-end usage of the various test-bed services prove that certain 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. Specific tests for the Ship-to-Ship Route Exchange service may enhance the officer's situational awareness and shows a tendency to improve navigational safety in traffic situations when used as a tool for supporting decision-making and situational awareness at a longer range, i.e. during strategic navigation.

However, there are several risks, notably over-reliance on or misinterpretation of the data and potential confusion/uncertainty when the “route” and “intention” are implicitly assumed to be same thing that could be involved when using the service.

The simulations highlighted the many benefits, challenges and risks associated with the implementation of the STM services from the point of view of experienced seafarers. These were generally eager and supportive of further development and implementation of STM services even in the earliest stages of development, provided that proper training was offered and that safety was prioritized ahead of costs in shipping.

The validation of STM in Ports identified considerable potential savings across various aspects of the transportation chain. Improved predictability of operations offers port and ship operators potential economic gains. The validation also showed that the optimization of assets and resources at the port level could be better achieved if port calls were managed in line with the principles underlying STM in Ports. If all the actors involved inform each other at the earliest opportunity about their plans and similarly notify any subsequent disruptions, this would allow downstream port call actors to coordinate more effectively. Everyone would be kept informed in real-time or near real-time through a common, digital situational awareness picture prior to, during, and after a particular port call.

The enhanced situational awareness provided by data sharing is valuable and beneficial, providing positive effects for operations, including making better estimates for ETAs and ETDs, improving work procedures, reducing the time spent on information gathering, and a reduction in administrative workloads. Overall, these results would lead to the savings showed in the STM Validation Project.

List of Abbreviations

| | |
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| ECDIS | Electronic Chart Display and Information System |
| EMSN | European Maritime Simulator Network |
| ETA | Estimated Time of Arrival |
| ETD | Estimated Time of Departure |
| GHG | GreenHouse Gas |
| IALA | International Association of Marine Aids to Navigation and Lighthouse Authorities |
| IEC | International Electrotechnical Commission |
| IMO | International Maritime Organization |
| IPCDMC | International PortCDM Council |
| PortCDM | Port Collaborative Decision Making |
| SAR | Search And Rescue |
| SeaSWIM | System Wide Information Management (for Sea) |
| STM | Sea Traffic Management |
| VTS | Vessel Traffic Services |

References

STM Validation project: Deliverables and Reports. Available at <https://www.stmvalidation.eu/documents/>