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Smart Tanker Shipping supported by STM BALT SAFE

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Abstract

The sensitive Baltic Sea region has one of the highest shipping intensities in the world. There are many tanker ships and crossing traffic of passenger ships and narrow passages. According to HELCOM, shipping accidents happen and may in the worst-case scenario have an extreme impact on the environment. Measures in the field of safety of navigation are needed to reduce accident risks. There is a need to improve the exchange of information between ships and between ships and shore for increased situational awareness and as a catalyst for improved safety of navigation, optimized capacity utilization and just-in-time operations.
STM BALT SAFE (2019-2021) contributes to increased safety of navigation in the Baltic Sea by providing Sea Traffic Management (STM) enabled maritime services to the tanker traffic in the Baltic. The project addresses the recently amended HELCOM recommendations 34 E/2 "Further testing and development of the concept of exchange of voyage plans as well as other e-navigation solutions to enhance safety of navigation and protection of the marine environment in the Baltic Sea region". Tanker shipping will be made more efficient and safer by making them STM compatible hence given the ability to send and receive voyage plans with other ships and with public authorities in Baltic Sea countries. By the STM BALT SAFE project, the institutional capacity of the public sector on supporting and developing safety of navigation services and efficiency of transport is enhanced.
The project will build on the methods, results and the maritime service infrastructure developed in previous projects like EfficienSea II, MONALISA 2.0 and STM Validation project and encompasses exchange of voyage plans and integration of STM functionalities in VTS shore centers. Services for enhanced monitoring of maritime traffic, different automatic reporting services to Ship Reporting Systems e.g. GOFREP and SOUNDREP as well as automated reporting to Maritime Single Windows, are developed and tested in the project. Different services that optimize the ship´s voyage and decrease the administrative burden will also be developed and tested within the project.
The standard clauses for shipping are currently being developed to be efficient when using Sea Traffic Management to optimize the sea traffic. These new clauses for Charter Party contracts to enable just-in-time shipping will also be tested and validated in practice within the STM BALT SAFE.
The project is implemented by a Baltic Sea wide partnership of public administrations from Norway, Sweden, Finland, Estonia and Denmark supported by various stakeholders from the entire value chain. It is the purpose of this paper to present the current activities of the recently initiated project and outline the expected results when utilizing STM-enabled services.

Keywords: Sea Traffic Management; Route Optimization and Exchange; Safety; Tanker Traffic; Information sharing; Smart Shipping; Tankers; Baltic Sea; STM Services;

1.1.1. Nomenclature

AIS	Automated Identification System
ASM	Application Specific Messages
BIMCO	BIMCO is the largest of the international shipping associations representing shipowners, earlier BIMCO was an abbreviation for Baltic and International Maritime Council
CGS	Close Quarter Situations
FSA	Formal Safety Assessment
GOFREP	Gulf Of Finland REPorting scheme (supported by the VTS's in the Gulf of Finland)
HELCOM	HELsinki COMmission
IEC	International Electrotechnical Commission
IHO	International Hydrographic Organization
IMO	International Maritime Organization
INS	Information Service
ISO	International Organization for Standardization
KPI	Key Performance Indicators
NAS	Navigational Assistance Service
SMCP	Standard Maritime Communication Phrases
SOP	Standard Operating Procedures
STM	Sea Traffic Management - Sea Traffic Management is the idea of sharing information and collaborating to optimise the maritime transport chain while increasing safety and sustainability.
VTS	Vessel Traffic Services

2. Introduction

The aim of the STM (Sea Traffic Management) Baltsafe project is to improve the safety and efficiency of navigation of the tanker shipping segment by means of STM by a.o. provide ships and VTS (Vessel Traffic Services) centers with improved situational awareness. The project offers involved ships added-value services like for example route optimization, enhanced monitoring and automated reporting by providing a digital infrastructure and environment to operate in as well as developing and testing new digital VTS services which will improve the speed and accuracy of ship-shore information exchange, as clearly exemplified in (Lind, Hägg, Siwe, & Haraldson, 2016). The just finalised STM Validation project but even other projects showed that there are challenges related to prove scientifically the positive impact of digitalisation and automation of new tools and services in shipping on safety, environment and ship efficiency.
The primary aim of validation and verification is to analyze and validate the use case of STM for tanker shipping, with major focus on safety of navigation. A serious approach to verification will contribute to ensure safe and successful adoption of any new technology and will also help securing expected benefits with respect to safety, efficiency and environmental sustainability. Based on the services that will be applied to the use cases, relevant evaluation, validation and verification methods will be derived in the first stage of the project. The aimed impact on safety is taken as the basis as well as the effects on efficiency and sustainable transport of tankers in the Baltic Sea for this evaluation. The main methods consist of Pre/Post data analysis (i.e. before and after introduction) and Interview-based analysis of perceived values which give a picture of the effects that the services have achieved.
Relevant safety assessment methodologies will be applied to describe the relative changes in safety that the services will imply. Typical hazards connected to the tanker shipping will be described as well as root causes, consequences and risk-reducing measures. Cost-benefit considerations are made in the safety assessment. The output of the validation and verification describes and highlights the impact that automated services derived based on the STM platform gives on tanker traffic in the Baltic.
A typical passage through a fairway implies various information exchanges between stakeholders such as pilots, pilot boat crews, tug owners, tug crews, agents, terminal operators, port authorities, cargo owners, ship-owners as even partly indicated in the figure below. The introduction of decision support and automated services including route exchange, automated reporting and advanced flow control of shipping traffic, needs to incorporate clearly the user-perspective and strengthen the success factors, such as processes and systems implemented in shipping

based on human contributions as suggested by (Hollnagel, Wears, & Braithwaite, 2015). This implies further challenges to provide evidence of improvements by the services provided by the STM BALT SAFE project.

Figure 1: Tanker leaving the port of Brofjorden assisted by pilots and a tug having various interests and drivers, involving various stakeholders that could benefit from coherent information sharing and automated processes

Shipping in general and tanker shipping specifically have become safer throughout the last century. Reasons for this development, as shown in figure 2 are diverse and are summarized by

- Better trained people
- Regulations
- Follow up and control
- Societal change in perspective on safety and valuing human life's and the environment – risk acceptance
- Quality and safety management system
- New technology, and
- An increased situational awareness leading to safer shipping

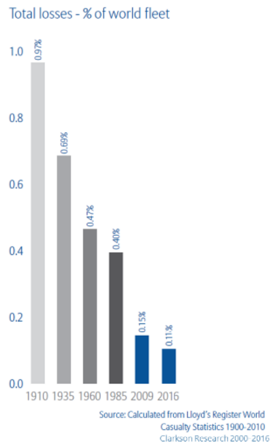

Figure 2: Improvement of shipping safety based on loss statistics of the world merchant fleet

STM services used in the project try to support the industry trends making use of societal digitalisation and IoT services which are the basis for smart shipping.
Smart crews have the training, familiarization and competences to perform their tasks on ships with the support of smart organisations.
Organizations that use collective learning practices are well prepared to progress in the future, they will be able to develop any skill required to succeed. New technologies, procedures and automated processes are embedded in the **smart organisations** valuing high experience transfer, knowledge and skills. Thus, organizations that will progress in the future will be "smart organizations", companies exploiting the collective expertise and talents and abilities of people to learn how to succeed as a team. Learning becomes a way of life and an ongoing process, not a specific part of the career of a person.
Smart ships make use of data and technology to create efficiencies, ensure safety, improve sustainability, create economic development, and enhance quality of work life factors for crews and passenger living and working on the vessels. It also means that the vessel has a smarter energy infrastructure and makes higher degrees of automation feasible.Strengthening the infrastructure and communication between vessels and vessel to shore will strengthen the smart ship approach.

3. Methods

The various operational services that are applied to the use cases are taken as the basis for analysis. During the first part of the project this activity is aimed to describe the relevant evaluation methods for the different services that were derived in close collaboration with the service providers. The services are described shortly below, their expected impact on safety and efficiency is formulated and connected to the end-user needs. Nevertheless, STM

functions augmented to a vessel's navigation system need to adhere to applicable performance standards with respect to presentation, interface, communication and data transfer, as set out by IEC, ISO, IHO and IMO. KPI's (Key Performance Indicators) for the services will be established and means of evaluation for the services identified. The final step of this first activity is to establish valid test procedures for the assessment, evaluation and validation of the services in the context of marine safety and efficiency for tankers in the Baltic Sea.
Two main analysis approaches - dependent on expected effects and nature of developed services/tools are used:

1. Pre/Post data analysis (i.e. before and after introduction)
    a. Traffic analysis, based on ship tracks, primarily AIS
    b. Simulation of effects using simulation software
    c. Operational data/logs from STM piloting
2. Semi-structured interview-based analysis of perceived values
    a. Perceived risk
    b. Other perceived values reported by different stakeholders

4. Use cases for evaluation

The BaltSafe project works on a wide range of services improving safety, efficiency and reducing environmental impact, as shown in the figure below. The use cases are part of the project evaluation and described here in more detail:

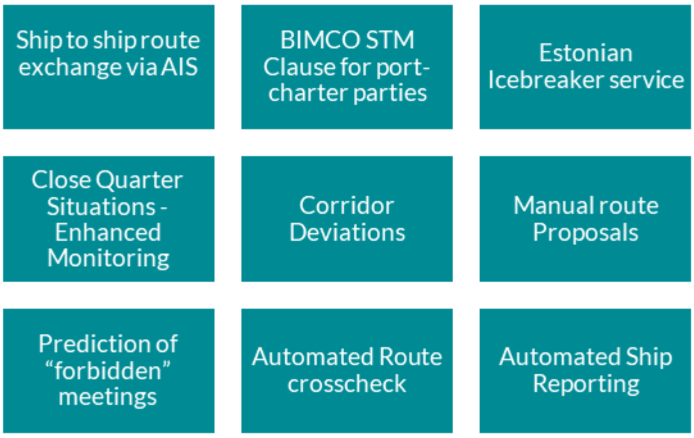

Figure 3: Use cases part of the project evaluation

4.1. Ship to ship route exchange via AIS

Ship to Ship Route Exchange (S2SREX) is a technical solution for broadcasting a ship's route to other ships in its vicinity through AIS. This technical solution was developed in the STM validation project with the purpose of facilitating the avoidance of close quarter situations. As part of the STM validation project, a group of vessels were equipped with S2SREX and its functionality tested in the project's testbed.
The STM BALTSAFE continues the testing of the S2SREX functionality. The project's testbed spans the entire Baltic Sea region (i.e. from the waters east of Denmark to the Gulf of Finland and the bay of Bothnia) and increases the number of S2SREX-equipped vessels. The STM BALTSAFE project focus specially on tankers and their traffic between Finland and Estonia.

4.2. BIMCO STM Clause for port-charter parties

Currently, port-chartered vessels are contractually obligated to arrive without unreasonable delay to a stipulated arrival location within the confines of a port. This contractual obligation leads to "run and wait" operations: chartered vessels sail as fast as possible just to wait on-turn for a berth at the port if none is immediately available. To reduce the costs and emissions associated with "run and wait" operations, shipowners and charterers developed the virtual arrival concept. In this concept, a vessel is given a reserved time slot for loading and/or unloading by a port. The virtual arrival concept received support from BIMCO in form of the Virtual Arrival Clause. BIMCO's Virtual Arrival Clause allows the adjustment of the speed of a chartered vessel to arrive at a loading or discharging point at an agreed date and time. BIMCO's STM Clause is distinct from, and does not supersede, or replace BIMCO's Virtual Arrival Clause. BIMCO's STM Clause is a virtual arrival clause with features that meet the needs of STM arrangements.

4.3. Estonian Icebreaker service

The Estonian Maritime Administration ensures that all vessel traffic bound from and to Estonian ports is served by icebreakers in the event of ice-covered waterways. Depending on the ice situation, vessels requesting ice assistance to the VTS receive from it either a location to meet with the icebreaker (aka. meeting point or rendezvous point), waypoints to follow (aka. dirways), or a route through the ice-covered waterway. The VTS service requests

and receives the meeting points, dirways, and routes from the icebreakers. Currently, the communication between vessels, the VTS, and the icebreakers is done through email and VHF radio.
As part of the STM-Validation project, the communication system IBNext for icebreaking services was integrated into the SeaSWIM environment. The integration enables STM-compliant vessels to send and receive RTZ route files, as well as STM text messages, to icebreaking services with access to IBNext. The purpose of this integration is to improve the communication between vessels and icebreaking services by reducing the number of manual tasks and therefore the possibility of errors and misunderstandings.
The Estonian icebreaking service and VTS do not have access to IBNext, and therefore cannot currently use STM text messages and route exchange to improve their communication with vessels requesting ice assistance. STM BALTSAFE Work Package 3 will develop a solution where the Estonian VTS acts as the communication relay between the icebreaking services and the vessels in need of ice assistance, enabling STM text messages and route exchange.

4.4. Close Quarter Situations - Enhanced Monitoring

Noticing, monitoring, and, if necessary, guiding ships in risky situations are the core tasks of a VTS. Two fundamental risky situations are vessel groundings and Close Quarter Situations between vessels. Grounding can be straightforwardly predicted by comparing the course and speed of a vessel with the distance to obstacles in said course. Compared with grounding, CQS are much more difficult to predict due to the inherent lack of knowledge regarding the intentions.
One of the deliverables of the STM validation project was the ship to shop route exchange solution (S2SREX) that enables vessels to share upcoming sections of their route through AIS. Despite its name, S2SREX enables vessels to share their routes with more than just other vessels, for example VTS.
In the STM BALTSAFE project, S2SREX will be implemented in VTS software and coupled to the VTS software's CQS prediction algorithm. The goal is to improve the detection and resolution of such situations.

4.5. Corridor Deviations

Preventing grounding and risky situations can be accomplished by monitoring traffic for suspicious behaviour. One of such behaviour is cross-track error: the lateral deviation of a vessel from its planned route.
One of the deliverables of the STM validation project was the ship to ship route exchange solution (S2SREX) that enables ships to share upcoming sections of their route through AIS. Despite its name, S2SREX enables all vessels to share their routes with more than just other vessels, for example with a VTS.
In the STM BALTSAFE project, S2SREX will be implemented in VTS software and coupled to an algorithm for monitoring the cross-track errors of STM vessels that are sharing their routes. The VTS software will notify the VTS operator after a certain cross-track error threshold, aiding the operator at detecting suspicious behaviour. After the notification, the VTS operator may choose to contact the vessel to determine if the deviation was planned or not.

4.6. Manual Route Proposals

Noticing, monitoring, and, if necessary, guiding ships in risky situations are the core tasks of a VTS. Preventing grounding and risky situations can be accomplished by checking the planned route of a vessel.
One of the deliverables of the STM validation project was the ship to ship route exchange solution (S2SREX) that enables ships to share upcoming sections of their route through AIS. Despite its name, S2SREX enables all vessels to share their routes with more than just other vessels, for example with a VTS.
In the STM BALTSAFE project, S2SREX and STM messaging will be implemented in VTS software enabling the smooth sharing of routes in RTZ format.

4.7. Prediction of "forbidden" meetings

Preventing traffic congestion or meetings at areas deemed unsafe is an effective way of preventing grounding and CQS.
One of the deliverables of the STM validation project was the ship to ship route exchange solution (S2SREX) that enables ships to share upcoming sections of their route through AIS. Despite its name, S2SREX enables all vessels to share their routes with more than just other vessels, for example with a VTS.
In the STM BALTSAFE project, S2SREX will be implemented in VTS software and coupled to an algorithm for

detecting the future presence of two or more ships in an unsafe area. The goal of this solution is to improve the detection and facilitate the prevention of meetings or congestion in predefined areas.

4.8. Automated Route Crosscheck

Noticing, monitoring, and, if necessary, guiding ships in risky situations are the core tasks of a VTS. Preventing grounding and risky situations can be accomplished by checking the planned route of a vessel considering the vessel's dimensions and draft, as well as the depth and contours of the fairway.
One of the deliverables of the STM validation project was the ship to ship route exchange solution (S2SREX) that enables ships to share upcoming sections of their route through AIS. Despite its name, S2SREX enables all vessels to share their routes with more than just other vessels, for example with a VTS.
In the STM BALTSAFE project, S2SREX will be implemented in VTS software and coupled to an algorithm for crosschecking the vessel's route considering the vessel's dimensions and draft, as well as the depth and contours of the fairway. By doing automatically, the vessel receives positive feedback about its route without direct communication with the VTS operator.

4.9. Automated Ship Reporting

A ship's master has the obligation of reporting to national and international authorities under certain conditions. Complying with this obligation is commonly referred to as *ship reporting*. Traditional ship reporting is commonly considered to be taxing, cumbersome, and error prone, as it requires a great deal of time and attention from the ship master due to the large number of unharmonized paperwork. To remedy this and other situations regarding information, IMO introduced the e-navigation Strategy Implementation Plan. The plan describes five solutions, out of which "Means for standardized and automated ship reporting" is directly connected to ship reporting. STM BALTSAFE address this solution through the implementation of automated ship reporting for the pre-arrival and departure reporting in the Maritime Single Window (MSW) of Norway and Sweden respectively as well as the Ship Reporting System in the Gulf of Finland (GOFREP) and the Sound between Denmark and Sweden.
The most important element for realizing the beneficial effect of STM-enabled services is the establishment of the use cases, which precedes the analysis and is described in the following section.

5. Analysis

The analysis performed so far in the project are based on the use case descriptions and background collection of data. Many of the use cases imply many stakeholders and traditional approaches which are established internationally in the whole industry. The analysis has covered the background as an interpretation of the tool/solution and use-case defined, the expected measurable effects of the tools/solution including possible measurements, identification of possible confounding tools/solutions, a description of the zero alternative that the use-case is compared to, a reasoning for the choices made to measure the effects and finally an identification of the necessary data input that will be used in the measurements and possible complementary data.

6. Results

The analysis of the various use cases reveals that there are a wide range of data that need to be collected in order to identify the impact of the services provided. Some of the data are clearly quantitative and include AIS data, time spent on reporting, etc, while others relate to more soft values and perceived changes. By limiting the analysis clearly to the use cases and the relative change from the zero-option to the defined changes made by the service implementation, it is expected to derive a scientific proof of the improvements made. The expected impact can subsequently by calculated based on established methods for air emissions avoided, reduced fuel consumptions or reduction of close quarter situations, while some changes are clearly qualitatively such as quality of reports received. As the use of STM services are rather new to the industry, a challenge arises due to limited use of the applications and services and the familiarization of the users which the project tries to overcome. Long term effects and changes in the industry during the course of the project overlay and impact the outcome and need to be considered.

7. Conclusions

It can be concluded that scientifically prove improvements in safety, efficiency and environmental impact by automated functions and digitalization is a demanding task. While many services intuitively suggest better processes, the complexity of the tasks and possible adverse effects need to be considered. The expected results of the project, as demonstrated through the use cases can be summarized as follows:

1) Technical advances have supported the crews onboard ships by navigating more safely and efficiently and providing the evolving VTS centers with better and more reliable information. While overall the technical services have contributed to the reduced risk for shipping accidents, not all designs are made with the end-user needs and success factors of the operators in mind, which implies new risks and inefficiencies.
2) Assessment, evaluation and validation of the new services are challenging tasks and a quantification of the services is challenging while various qualitative methods can be applied. Also, a clear formulation of the zero-option in a socio-economic approach is demanding.
3) Increased situational awareness onboard ships and in VTS centers can allow for better decision making. Knowledge of intended routes can help to reduce the risk for close-quarter situations and near misses as well as providing improved services from VTS centers to the shipping industry.
4) Tanker traffic in the Baltic is safer as compared to other ship types and to other regions. Success factors are identified to increased automation, regulations and especially vetting. Potential for further improvement of tanker safety relates to the avoidance of collisions and contact accidents, which could be supported by STM services.
5) Efficiency of tanker traffic could be significantly improved by means of new BIMCO contract clauses, “virtual notice of readiness”, route optimization and flow management. These enable the potential of increased efficiency, whereas significant changes of the industries business models will have to be made, which are possibly not being completely implemented within the timeline of the project.
6) Administrative burden onboard ships and onshore could be minimized by STM services and especially ship reporting schemes.
7) Effective use of ice charts will increase the safety and transport efficiency and ice routes improve tanker shipping efficiency and decision making.
8) Challenges remaining relate to cybersecurity, certainty and quality of data provided, overload of data/ unfiltered provision of data to operators, human-machine interface, user centered design of services and end-user feedback.

The scientific proof of this evaluation is the remaining task of the STM BALT SAFE project that will run another 1.5 years.

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