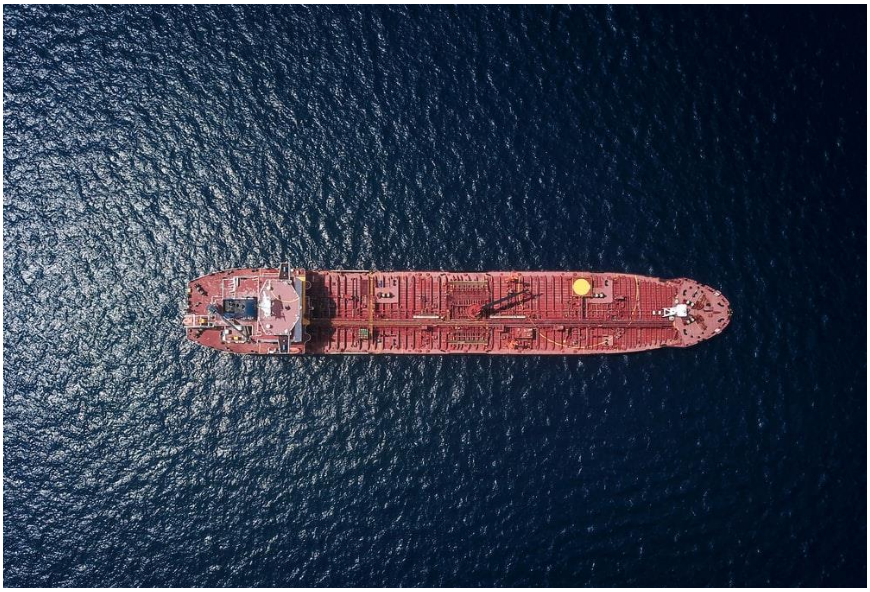

Document No: BS_WP6.2.0

Title: Analysis and Evaluation of the STM use case for tanker traffic

Date: 2021-12-28

Final

DOCUMENT STATUS

Authors

Name	Organisation
Luis Sanchez-Heres	RISE Research Institute of Sweden
Peter Sjögren	RISE Research Institute of Sweden
Staffan Bram	RISE Research Institute of Sweden
Julia Burgén	RISE Research Institute of Sweden
Roshni Pramanik	RISE Research Institute of Sweden

Review

Name	Organisation
Joakim Lundman	RISE Research Institute of Sweden
Jarl Hauge	Kystverket
Fredrik Kokacka	Sjöfartsverket
Mika Nyrhilä Mikko Klang	Fintrafic

Approval

Name	Organisation	Signature	Date
Joakim Lundman	RISE	JL	2021-12-28

Document History

Version	Date	Status	Initials	Description
1.0	2021-12-28	Approved	JL	Final report

INTERREG PROJECT NO: R103

Table of contents

Executive Summary

The main objective of the STM BALT SAFE project is to develop solutions that improve the safety and efficiency of tanker shipping and marine traffic in the Baltic Sea. The envisioned STM solutions were grouped into on-board solutions (Work Package 3), Vessel Traffic Service (VTS) solutions (Work Package 4), and automated ship reporting solutions (Work Package 5).

The STM solutions were to be validated through “use-cases” (i.e. application scenarios). Unfortunately, throughout the course of the project, COVID19 disrupted the development and deployment of the STM use-cases. Some of the STM use-cases could not be deployed (BIMCO STM clause and Estonian Icebreaker service), others were only deployed in simulated environments (Automated Ship Reporting), and the rest (S2SREX and STM VTS functions) were deployed to a lesser extent than initially planned.

The planned evaluation and validation work was modified to address the changes on the development and deployment of the STM use cases. For some of the use-cases, simulations or similar existing solutions were used as substitutes of the real-world use cases. For other use-cases, qualitative analyses became the main evaluation tools. Overall, the evaluation and validation work were an ongoing process throughout the project, adapting the employed methods and the subjects to the limitations imposed by COVID19.

Despite of the efforts by all work packages, the validation work is partly inconclusive. The information gathered for all but one of the use-cases (S2SREX) is not sufficient to validate the impact of the STM solutions on the environment and the safety and efficiency of marine traffic. Nevertheless, the evaluation work provides indications of the effects of the STM solutions, valuable insights into how to continue their development, and aspects to consider in their future evaluation and validation.

1 Introduction

The main objective of the STM BALT SAFE project is to develop solutions that improve the safety and efficiency of tanker shipping and marine traffic in the Baltic Sea. The envisioned STM solutions were grouped into on-board solutions (Work Package 3), Vessel Traffic Service (VTS) solutions (Work Package 4), and automated ship reporting solutions (Work Package 5).

The STM solutions were to be validated through “use-cases” (i.e. application scenarios). Unfortunately, throughout the course of the project, COVID19 disrupted the development and deployment of the use-cases. The disturbances forced modifications to the use-cases of each work package, and consequently, to what could be evaluated and validated.

The original purpose of the deliverable D6.2 was to present the results of the validation and evaluation of the STM use-cases according to the methodology documented and presented in the deliverable D6.1 [1] . However, because of the changes on the development and deployment of the STM use-cases, the original purpose of this deliverable had to be extended to include detailed descriptions of how and why the evaluation methodologies were modified.

For clarity and readability, Deliverable 6.2 is split into four documents (a main document, and three supporting). A single document presenting the STM use-cases, the modified evaluation methodologies, and the validation and evaluation results was deemed be too extensive and difficult to read. The four documents are:

- *D6.2.0 Analysis and Evaluation of the STM use case for tanker traffic* – A summary of the STM solutions and their validation results (*this document*).
    - D6.2.1 Validation of Work Package 3 – A detailed account of the evaluation methods and validation results for the STM use-cases of Work Package 3.
    - D6.2.2 Validation of Work Package 4 – A detailed account of the evaluation methods and validation results for the STM use-cases of Work Package 4.
    - D6.2.3 Validation of Work Package 5 – A detailed account of the evaluation methods and validation results for the STM use-cases of Work Package 5.

The text and results presented in this document are extracts and summaries of the information presented in the supporting documents (D6.2.1 [2], D6.2.2 [3], D6.2.3 [4]). The content is intended to present the complete, but compact, picture of the final validation work without the details.

Section 2 to 6 present the summaries of each of the STM use-cases and their validation results. Section 7 presents the final remarks regarding the validation of the STM BALT SAFE project.

2 WP3 UC1 Ship-to-ship route exchange via AIS

2.1 Background

Ship-to-ship collisions are events that threaten life, property, and the environment. Since all ship-to-ship collisions start as Close Quarter Situations (CQS), bridge teams use a wide range of information from several sources to timely predict and avoid a CQS. Ideally, the information used for predicting a CQS should be easily accessible, up-to-date, clear, sufficiently detailed, and accurate. Under the past couple of decades, the overall quality, and the number of information sources available to bridge teams, has improved dramatically. Electronic navigational charts and satellite positioning (e.g. GPS) have improved the determination of the current position of ships, while AIS has improved the awareness of the presence of other ships. However, information sources for the *planned* movements of a target ship are still limited. VHF radio and AIS are possible sources of information for the planned movements. While these sources should not be used for resolving CQS (i.e. anticollision), they can be used for predicting and avoiding a possible CQS in a timely manner. For example, by communicating the destination of a ship and therefore, an understanding of the route a ship will take. Unfortunately, communication through VHF radio is not necessarily clear, easy, or detailed; and it is not uncommon for AIS data to contain old information.

Ship to Ship Route Exchange (S2SREX) is a technical solution for broadcasting the monitored route of an STM ship. For simplicity, a ship that has an ECDIS capable of broadcasting its monitored route through a S2SREX will be referred to as an “STM ship” regardless of whether they are registered in a platform or not (e.g. Maritime Connectivity Platform or Navelink). *(i.e. ships with an STM compatible ECDIS software) to other STM ships in its vicinity through an AIS message.* Then, if an STM ship follows and broadcasts its monitored route, it will effectively communicate its planned movements, complementing VHF radio and AIS as an additional source of this kind of information that is easily accessible, up-to-date, clear, sufficiently detailed, and accurate.

S2SREX was initially developed during the STM validation project. During this project, several ships were installed with STM compatible ECDIS software that included S2SREX. However, the validation of the S2SREX solution was only based on full bridge simulations, and no analysis regarding the actual use of S2SREX in day-to-day operation was carried out.

The STM BALT SAFE project continues the validation of the S2SREX solution. Originally, the project’s testbed should span the entire Baltic Sea region (i.e. from the waters east of Denmark to the Gulf of Finland and the bay of Bothnia) and increase the size of the STM fleet (i.e. the number of ships with an STM compatible ECDIS software). Furthermore, the STM BALT SAFE project should focus specially on tankers and their traffic between Finland and Estonia.

2.2 Possible effects of the use-case

Considering only the description of the use-case and the problem it addresses, these are the envisioned possible effects of the use-case.

Safety

- Reduced number of Close Quarter Situations (CQS) avoidance manoeuvres between ships using S2SREX – due to accessible, clear, and detailed information of the ships’ future movements.

- Increased or decreased distance between ships using S2SREX when sailing – due to accessible, clear, and detailed information of the ships' future movements.
- Increased or decreased traffic misinformation – depending on the percentage of ships using S2SREX that share their routes and how well they follow them.
- Decreased VHF radio communication between ships using S2SREX – due to access to each other's route.

2.3 Changes

As part of STM BALT SAFE, the Electronic Chart Display Information System (ECDIS) software of 50 ships was to be upgraded for STM compatibility. COVID19 restricted the access to ships by non-essential personnel, limiting dramatically the upgrade of ECDIS software. At the time of writing, only 6 out of the 50 ships have been upgraded with STM functionality. This change means the total number of ships capable of using the S2SREX solution *increased* by 6 instead of 50 and that the evaluation methods have to be modified accordingly However, newer ECDIS-systems have the possibility to use S2SREX regardless if those were supplied through this project or not. For more details see D6.2.1 [2].

2.4 Evaluation methods

After the changes, four methods were used to evaluate the S2SREX solution:

- *Usage and congruence analysis* – A *quantitative* analysis to evaluate the effect of the S2SREX solution on traffic misinformation. Usage being a measure of whether the solution is usage, and congruence a measure of the match between the "shared" route and the "followed" or "intended" route (See Figure 1).
- *Traffic analysis* – A *quantitative* analysis to evaluate the effect of the S2SREX solution on the number of close quarter situation and the sailing distances between STM ships.
- *Literature survey* – A *qualitative* analysis to capture the insights of previous studies regarding the S2SREX solution.
- *Stakeholder interviews* – A *qualitative analysis* to capture the existing or envisioned benefits and drawbacks of the S2SREX solution according to stakeholders.

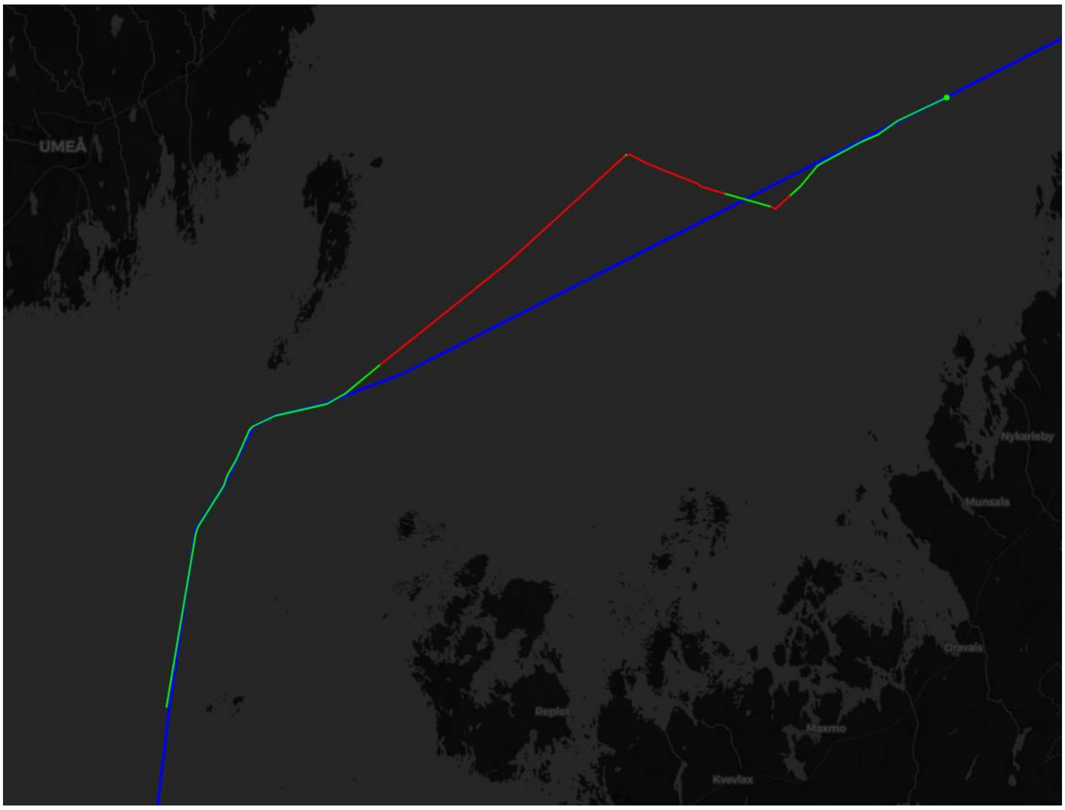

Figure 1 Example of a ship using S2SREX (blue: broadcasted route, green: route followed with good congruence, red: route followed with bad congruence).

2.5 Validation and evaluation results

Some of the evaluation methods indicate that S2SREX has a positive effect on safety to some extent. The *usage and congruence analysis* indicate that most of the ships actively using S2SREX decrease traffic misinformation, while one of the studies referenced in the literature survey stated that most navigators in an experiment considered S2SREX to contribute to their situational awareness. Nevertheless, except for the inconclusive *traffic analysis*, all the evaluation methods indicate issues and concerns with S2SREX regarding safety.

The key concern is the potential overreliance on the information and the risk of assuming that the “shared” route is the same as the “intended” or “followed” route. This concern was reported in the *stakeholder interviews* as well as in the *literature survey*. Regrettably, the *usage and congruence analysis* showed that differences between the shared and followed route (i.e. congruence of less than 100%) are not uncommon and therefore, there are plenty of situations where overreliance on the shared routes could lead to difficult or dangerous situations. Furthermore, while the *usage and congruence analysis* found that most ships actively using the S2SREX solution decrease traffic misinformation by broadcasting and following the monitored route, this finding does not imply that the receiving ships will not over rely on the information. Both overreliance and low congruence can be interpreted as “user errors” that can be addressed with proper training and procedures. While this interpretation may or may not be valid, transferring the blame from the technical solution to the user does not change the fact that in its *current state*, there are safety concerns with the S2SREX solution.

Besides the safety concerns, the *usage and congruence* analysis showed that the number of STM ships actively using S2SREX has decreased with time. Clearly, if

S2SREX is not used, it cannot have an impact on marine traffic, and the decrease on its usage suggests that the perceived benefits of the solution does not overcome its issues. The *stakeholder interviews* and *literature survey* identified some potential reasons for the decrease, such as usability (e.g. “cluttered” screens) and the belief of some shipowners and crews that the route is sensitive information. However, the interviews were not sufficient in breadth and depth to provide a full picture of the reasons for the decrease.

Overall, the contents of the evaluations were deemed sufficient to validate the S2SREX use-case. Unfortunately, the S2SREX use-case is not considered to have the envisioned positive effects on safety. While most of the ships actively using S2SREX decrease traffic misinformation, the number of ships using S2SREX has been decreasing since 2018. The decrease is an *indication* that the perceived benefits do not overcome the issues or concerns.

Future work regarding S2SREX should include in depth interviews with current and former users of the solution to determine the reasons behind its poor adoption and the low congruence events. The work here presented focused on the identification of these two issues and barely addressed their causes. Low congruence events and poor adoption could potentially be successfully addressed by informing the crews about the availability of S2SREX onboard the ships, training crews on how to use it, and supporting the establishment of onboard procedures. S2SREX is still a new solution and, as all other new solutions, it needs to be promoted and refined.

For more details see D6.2.1 [2].

3 WP3 UC2 BIMCO STM clause for voyage charter parties

3.1 Background

The Baltic and International Maritime Council (BIMCO) is the largest shipping organizations representing shipowners, managers, operators, and agents. Its aim is to protect its members by the provision of information and advice, while promoting the harmonisation and standardisation of commercial shipping practices and contracts. Two of the many offerings of BIMCO are standard voyage charter parties and clauses.

A voyage charter party is a contract stating the terms for the carriage of goods by sea between a charterer and shipowner (or operating owner) for one or several voyages. The terms of the contract are stated through clauses. Clauses, in turn, state rights, obligations, and provisions. BIMCO clauses supplement BIMCO's standard contracts to meet the specific needs of the involved parties. However, in many jurisdictions as e.g. Common Law, the parties enjoy so called "freedom of contract", allowing them to form the contract or amend wording of specific clause.

Chartered ships can be legally bound to proceed with "utmost despatch" and without deviations by, for example, a clause in a voyage charter party or the laws governing a specific contract. In other words, the ship must sail towards the loading and unloading ports as fast as reasonably possible within the limits imposed by safety and the ship's capabilities. If a shipowner were not to fulfil the voyage charter obligation, he or she could face legal consequences. Some mitigation can be arranged beforehand by various indemnification clauses in such voyage charter contracts.

Just-In-Time (JIT) arrivals are well recognized measures to reduce fuel consumption, voyage costs, and air emissions [5]. Unfortunately, these measures may be interpreted as a breach of the ship's obligation to proceed with utmost despatch. By the start of the STM BALT SAFE project, BIMCO had published two supplementary clauses related to speed optimization and JIT: Virtual Arrival Clause for Voyage Charter Parties [6] and Sea Traffic Management (STM) Clause for Voyage Charter Parties [7] (henceforward called "VA clause" and "STM clause" for brevity).

Both BIMCO clauses provide an exception to the obligation of proceeding with "utmost despatch". The clauses give the charterer the possibility to request that the ship adjusts its speed so that it meets a desired arrival time at a given destination. While the clauses differ on several details, the most relevant for the STM BALT SAFE project is the way in which the arrival time is communicated. In the STM clause, the shipowner and the charterer "use their best endeavours" to obtain and share information via an STM system. In the VA clause, there is no mention of sharing information about the arrival time nor the communication medium.

As part of the STM BALT SAFE project, STM clause was to be tested by: First, including the STM clause in voyage charter parties of STM ships. Second, using STM solutions to communicate the ship's Estimated Time of Arrival (ETA), the charterer's Requested Time of Arrival (RTA), and the response to the RTA (either its acceptance or rejection). Overall, this STM solution was envisioned to decrease the "run and wait" operations, where a ship rushes to a port just to anchor and wait for an available berth.

3.2 Possible effects of the use-case

Considering only the description of the use-case and the problem it addresses, these are the envisioned possible effects of the use-case.

Safety

- Reduced exposure to anchoring related incidents – due to reduction or elimination of anchoring.

Efficiency

- Increased or reduced profits – due to reduction of waiting time.
- Increased or reduced fuel consumption – due to speed changes.
- Reduced communication time – due to the use STM solutions to communicate RTA.
- Increased workload for agents to coordinate JIT arrivals

Environment

- Reduced environmental impact related to anchoring – due to reduction or elimination of anchoring.
- Increased or reduced air emissions – due to speed changes.

3.3 Changes

The STM clause use-case was not deployed or tested during the duration of the STM BALT SAFE project. This led to drastic changes on the validation methods. Data from maritime actors performing or working to enable some type of JIT arrival concept was used as a substitute for the one from STM ships, crews, and shipowners using the STM clause. This substitution was only feasible for the validation methods that did not strictly depend on the use of STM clause. For more details see D6.2.1 [2].

3.4 Evaluation methods

After the changes, two methods were used to evaluate the STM clause use-case solution:

- *Traffic analysis* – A *quantitative* analysis to evaluate the effect of JIT arrival practices on the anchoring of ships before a port call.
- *Stakeholder interviews* – A *qualitative* analysis to capture the insights of maritime actors practicing or working to enable JIT arrival.

3.5 Validation and evaluation results

The evaluation methods indicate that if the BIMCO's STM clause had been deployed it would have had a positive effect on safety, efficiency, and the environment. The *traffic analysis* indicates that existing JIT practices decrease the anchoring times outside a port. Reducing anchoring reduces the exposure of ships to related incidents as well as its environmental impact. The *stakeholder interviews* corroborated this finding and as well as the other expected effects of the solution: increased profits, reduced fuel consumption, and an increase on workload. Understandably, how a JIT practice affects workload is very dependent on its implementation. None of the interviewed stakeholders used digital solutions tailored for JIT arrival practices, and therefore, one could expect and even lower increase on workload if using the STM clause.

Overall, the contents of the evaluations were deemed insufficient to validate the STM clause use-case. Results and experiences from similar JIT practices are not sufficient. The STM clause use-case cannot be validated without deploying it and testing it.

It is the authors' opinion that one of the reasons why the STM clause has not been deployed is due to the fact that charterers and shipowners do not see the need for it. The STM clause was built on top of the VA clause to include the use of STM communication tools; however, if the VA clause and similar JIT clauses have a problem, it is not the communication medium itself, but rather the financial aspects regarding compensation and the mindset of the involved parties. Trust, compromise, concerns about the environment, and the willingness share the rewards and costs are critical for implementing JIT arrival. Concerns about the environment and a proactive approach towards future regulations are arguably the main driver for adoption of JIT practices.

JIT arrival in voyage charter parties is not a well stablished practice. Future projects engaged in mainstreaming it should focus on the financial aspects and on persuading charterers, shipowners, and port to try it (i.e. change their mindset). The report "Just in Time Arrival Guide: Barriers and Potential Solutions" [5] contains valuable information that could guide future work.

For more details see D6.2.1 [2].

4 WP3 UC3 Estonian icebreaker service

4.1 Background

The Estonian Maritime Administration ensures that icebreakers serve all ship traffic bound to Estonian ports in the event of ice-covered waterways. Icebreaking assistance is requested by the ship's agent through an online portal, which is afterwards approved or denied by the icebreaking service coordinator. If the request is approved, the ship is sent or communicated a point where to meet the icebreaker (aka. meeting or rendezvous point), waypoints to follow (aka. dirways), or a route through the ice-covered waterway (aka. ice-route). These types of ice navigation information are created by the Estonian icebreakers and at the time of writing, are communicated to the ship requesting assistance via VHF radio or email and through at least one intermediary. Figure 2 presents a diagram of the current information flow.

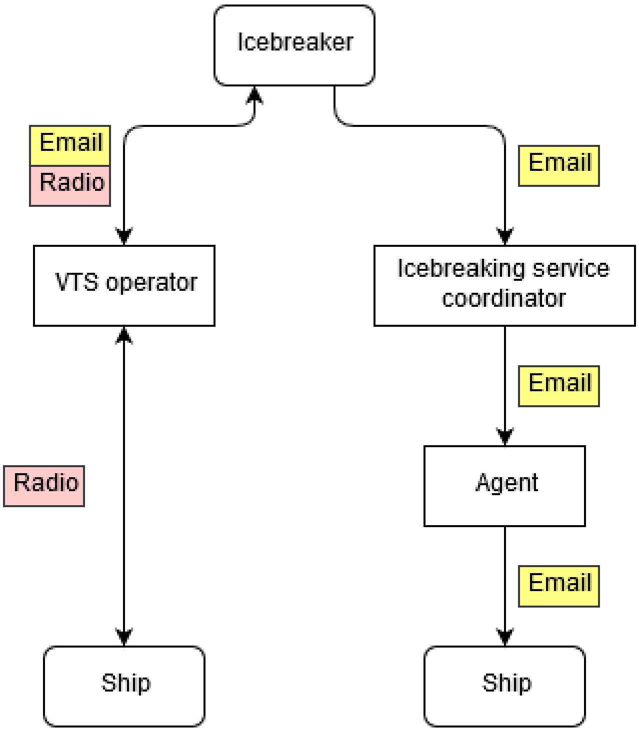

Figure 2 Current information flows for the communication of ice navigation information (meeting points and ice-routes). Double arrow lines indicate confirmation of message delivery.

Operational information should ideally be communicated in an easily accessible, up-to-date, clear, sufficiently detailed, and accurate way. Confirmation of the reception of the information is also highly desirable. The current communication flow used by the Estonian icebreaking service lack several of these qualities.

Communication through the icebreaker coordinator relies solely on email and has the ship 's broker as an unnecessary intermediary. While email is free of transmission errors and typically reach the recipients in seconds, it can easily be overlooked, forgotten, or discarded by mistake (e.g. spam filters and junk folders). Furthermore, while email can provide the sender with a confirmation that message has been read, this feature is not supported by all email providers and applications.

Communication through the VTS operator relies on radio or a combination of radio and email. Information communicated through radio can easily be difficult to understand or misunderstood due to background noise, language proficiency, and accent. Typically, closed loop communication is used to address these issues; however, transmission errors do occur. Furthermore, radio is a time-consuming method for communicating ice navigation information, as it requires reading long sequences of numbers.

As part of the STM BALT SAFE project, the Estonian VTS software and two Estonian icebreakers (MSV Botnica and Eva-136) were to be made STM compatible, enabling them to communicate ice navigation information through two STM communication tools: STM messages and STM route proposals. Figure 3 presents the envisioned communication flow via these STM solutions. The envisioned flow has two key differences with respect to the current one.

First, the communication of ice navigation information from the icebreaker to either the VTS operator or the icebreaking service coordinator is done through STM tools. This change would add confirmation and reduce the time, errors, and work necessary to communicate the ice navigation information. Additionally, because of the reduced difficulty on communication ice navigation information, the frequency and detail of some of this kind of information may increase.

Second, for the cases where the ship requesting ice breaking assistance is an STM ship, the communication of ice navigation information to the STM ship can be done through the STM tools. In such a case, confirmation would be added, the ship's agent would be removed as an intermediary, and the time, errors, and work necessary for communication would be reduced.

The STM Estonian Icebreaker Service use-case is henceforward referred to as "EIS use-case" for brevity.

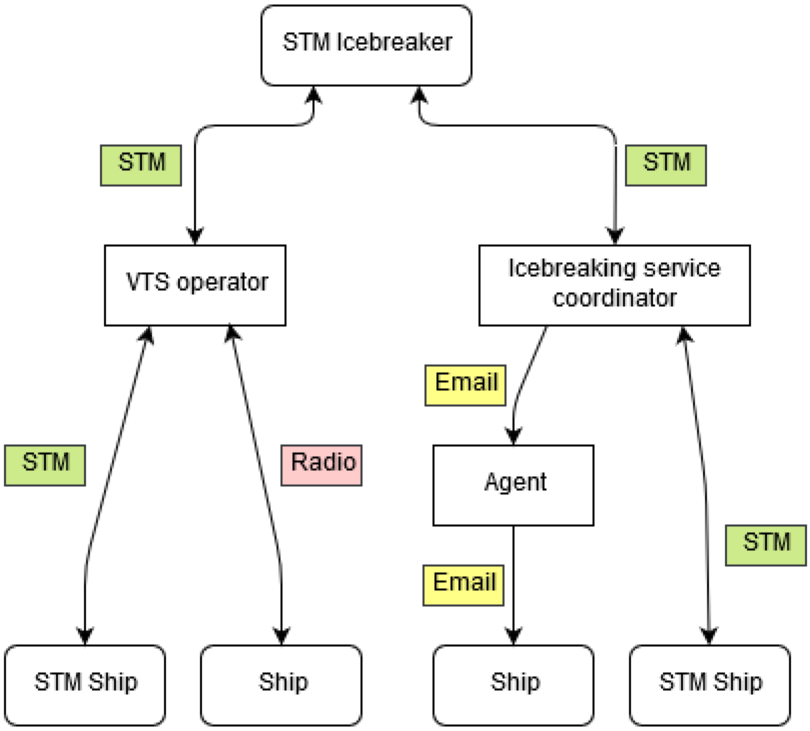

Figure 3 Envisioned information flows for the communication of ice navigation information enabled by STM solutions. Double arrow lines indicate confirmation of message delivery.

4.2 Possible effects of the use-case

Considering only the description of the use-case and the problem it addresses, these are the envisioned possible effects of the use-case.

Safety

- Reduced possibility of miscommunication – by relying more on STM solutions and less on radio and email.
- Improved situational awareness / shared picture – by increasing the communication of detailed ice navigation information.

Efficiency

- Reduced workload – by relying more in STM solutions and less on radio and email.

4.3 Changes

The installation of STM compatible software was not completed as planned due to the COVID19 pandemic. Out of the two Estonian icebreakers, only MSV Botnica was installed with an STM compatible ECDIS, and the delivery of the STM compatible VTS software to VTS Tallin was delayed until late November 2021. Because of these delays, the STM communication solutions could not be incorporated into the Estonian icebreaker service during the duration of project. Since the EIS use-case was never deployed, there is no data or experiences to be used on the analyses planned and described. No substitutions could be done either do the highly specific nature of the EIS use-case. All the original validation methods were discarded. For more details see D6.2.1 [2].

4.4 Evaluation methods

After the changes, one method was used to evaluate the Estonian icebreaker service use-case:

- *Stakeholder interviews* – A *qualitative analysis* to capture the existing or envisioned benefits and drawbacks of the EIS use-case according to stakeholders.

4.5 Validation and evaluation results

Since VTS Tallin received its STM compatible VTS software in the last month of the STM BALT SAFE project, the EIS use-case could not be validated. Data or experiences from similar or equivalent use-cases do not exist and could therefore not be used as a replacement.

The *stakeholder interviews* indicate that if it were to be implemented, the communication through the STM tools would have a positive impact on efficiency, if usability aspects, such as latency, are satisfactory.

For more details see D6.2.1 [2].

5 WP4 UC1-5 STM functions for VTS systems

The purpose of the STM functions for Vessel Traffic Services (VTS) is to allow digital communication and information sharing between the VTS Centre and ships in the controlled area, with an emphasis on simple creation and sharing of ship routes. Firstly, sharing more detailed route information between the VTS and ships is meant to support shared situation awareness between stakeholders, creating a clear and common reference for ship navigation. Secondly, more detailed, and digitally represented route information allows for the introduction of new automated functions, such as alerts for route conflicts. On the other hand, the introduction of any new technology will often have both benefits and drawbacks. Technologies that are introduced without sufficient consideration to end-user needs may not live up to their full potential. While STM services are meant to increase sea traffic safety further, it is important to study all their potential effects, both positive and negative, on Vessel Traffic Service Operator (VTSO) working patterns and practices.

The use cases presented in this chapters are STM functions for the VTS systems. The purpose of these STM functions is to allow digital communication and information sharing between the VTS and ships in the controlled area, with an emphasis on simple creation and sharing of ship routes. All five use cases are closely related and are presented in the same chapter.

5.1 Close quarter situation

5.1.1 Background

While not all Close Quarter Situations (CQS) between ships result in a collision, all collisions start as a close quarter situation. Unfortunately, CQS and possible collisions are difficult to predict without knowing the future movements or intentions of each ship.

To enable this, the VTS software can be equipped with a CQS monitoring function based on STM's Voyage Information Service (VIS). The function will predict CQS *between STM ships* by inspecting their shared voyage plans against a set of CQS definitions. The set of CQS definitions will enable the VTS operator to define CQS differently considering the size of the ships and their location (e.g. open water, fairway).

5.1.2 Possible effects of the solution

Safety

- Improved prediction and monitoring of possible CQS.
- Decreased time predicting and monitor CQS.

5.2 Cross-track alarm

5.2.1 Background

A ship's deviation from its route can be voluntary or involuntary. Involuntary deviations may occur due to a variety of reasons, such as tiredness and are always undesirable. Currently, it is difficult for VTS operators to identify involuntary deviations.

The cross-track error alarm function is based on STM's VIS and is to be implemented on the VTS software. The function will raise an alarm when the cross-track error of an

STM ship against its shared voyage plan exceeds the cross-track error in the route or a value determined by the VTS operator.

5.2.2 Possible effects of the solution

Safety

- Improvement in the detection or time to detection of involuntary deviations from the planned route.

5.3 Route proposals

5.3.1 Background

The VTS can provide navigational assistance and for instance clarify to a ship how it should navigate in the fairway. This type of assistance is done through radio and therefore, time consuming, prone to errors, and occasionally demanding due to language and tiredness.

Route proposals will enable VTS operators to send complete voyage plans to STM ships, as well as to suggest modifications to the voyage plans shared by STM ships and the reduce radio navigation.

5.3.2 Possible effects of the solution

Safety

- Improved navigational assistance – by providing clear and detailed navigational assistance through a STM route proposal instead of through VHF radio.

Efficiency

- Reduced workload – by providing less navigational assistance through radio and more as a STM route proposal.

5.4 Forbidden meetings

5.4.1 Background

Preventing traffic congestion or meetings at areas deemed unsafe is an effective way of preventing grounding and CQS. Currently, predicting the future presence of two or more ships in an unsafe area is done by the VTS operator with or without the aid of a traffic prediction system.

With STM, a function for predicting forbidden or inappropriate meetings of ships is possible. The function will be based on STM's VIS and will perform the prediction automatically. The goal of this solution is to improve the detection and facilitate the prevention of meetings or congestion in predefined areas.

5.4.2 Possible effects of the solution

Safety

- Improved prediction and monitoring of forbidden meetings.

- Decreased time predicting and monitoring forbidden meetings.

5.5 Automated route cross-check

5.5.1 Background

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. Currently, VTS services do not have the capacity to automatically cross-check a ships route.

STM's VIS 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.

5.5.2 Possible effects of the solutions

Safety

- Improved navigation information – by providing clear and detailed feedback about the voyage plan through STM's VIS.

5.6 Changes

At the project outset, the validation related to the use-cases in Work Package 4 was to entail pre-, during- and post-deployment validation. The deployment was impaired by COVID-19 in such ways that the access to ships was restricted for non-essential personnel, which in turn limited the upgrading of ECDIS software with STM functionality. Instead, the validation was limited to pre-deployment study, questionnaire, and a single simulation evaluation. For more details see D6.2.2 [3].

Given how few VTS operators had prior experience of STM functionality, individual interviews and simulations were chosen over a complete HAZID-setup. Through correspondences prior to and after interviews, as well as during simulations, many benefits of a more interactive investigation such as a HAZID were still achieved.

During the first simulator week the participating group was smaller than desired, due to issues with recruitment caused by the situation with COVID-19. During this week there were also issues with the simulator, causing some disturbances and making the Route Proposal service inoperative at times. Furthermore, in contrast to the STM BALT SAFE vision of service functionality as described earlier in this chapter, the following was not included in the software:

- There was no function that would enable the VTS operator to define CQS differently considering the size of the ships and their location (e.g. open water, fairway).
- The "forbidden meetings" function was not automatic, but instead had to be performed manually with a prediction tool, looking at the restricted area.
- Route Crosscheck (checking a route against other ship movements, grounds etc) was not automatic, but instead had to be performed manually.

5.7 Evaluation methods

As mentioned in the previous section, the following methods were used for evaluation:

- *Heuristic analysis* – An identification of potential hazards with the purpose to create themes for the interview study.

- *Stakeholder interviews* – Based on the heuristic analysis and the questions primarily dealt with all services deemed relevant for the role of the individual interviewee.
- *Simulator studies* – VTSOs were invited to use the STM services in a simulator. The evaluation methods used within the simulator studies were:
  - Observations of VTSOs during the simulator exercises.
  - Evaluation questionnaires filled in by participants.
  - Group interviews with participants.

5.8 Validation and evaluation results

A summary of the results of the Work Package 4 evaluation are presented per use case, but first three themes that applies to all use cases are presented. For more details see in D6.2.2 [3].

5.8.1 User adaption of STM services

The evaluation results suggests that STM usage is bound to vary between both nations and regions, depending on factors such as local geography, traffic patterns and differences in national VTS regulation, meaning that that implementation must be calibrated against the practical needs of local VTS operators. At the same time, a balance must be struck between allowing for local adaption of STM services and offering a uniform STM interface towards vessels moving between different control areas.

Regardless of how technically advanced the STM services become, their true functionality will be determined by how well they are adapted to VTS operator needs. Even though the objective of STM development is to enhance traffic system safety, a product that is poorly implemented with regard to usability and ergonomics may not live up to its full potential. On the contrary, if more information is made available to operators without making that information perceivable and usable, workload may increase and situation awareness may decrease, producing a negative net effect on safety.

5.8.2 Need for continued Human Factors validation

As STM services reach a higher level of development, it will gradually become easier to identify and evaluate effects on safety associated with Human Factors. While the first step towards effective implementation is to employ a user-centered process, it is equally important to engage in a continuous process of verification and validation, taking all relevant STM stakeholders into account. It is likely that some issues only become apparent when the services have been fully integrated in operations, and ideally, at that stage there should still be room for feedback and system revisions. Aspects of STM that are already known to require a human factors validation are, but not limited to:

- That the new information provided to operators is presented in a way that does not introduce confusion (e.g. cluttering of routes or poor visibility of ships).
- That alarms and/or alerts are relevant, useful and communicated effectively. Several different information levels might be necessary. It also appears that users need access to advanced alarm/alert filtering depending on factors such as ship attributes, environmental conditions and surrounding traffic.
- That predictive tools (e.g. prediction of future ship movements and associated conflicts) factor in prediction uncertainty, so that the operator is given a truthful representation of possible traffic development. As long as this functionality is employed manually by the operator, it can be used in periods of low intensity with few negative effects. If, on the other hand, predictive tools are automated

to an extent, that could result in a much large volume of alerts for situations that, in the end, resolve themselves without operator intervention.

- That dynamics in VTS-ship interaction may be affected as new forms of communication develop. For example, even if the purpose of the VTS Centre is only to “inform” ships about traffic conditions, creating and sharing routes via STM services might be regarded as something more than a friendly suggestion. This invokes a discussion around VTS authority and responsibility in the event of an incident that needs to be continued.

5.8.3 Close quarter situation predictor

Automatic close quarter situation predictions have not been possible to evaluate. Semi-automated close quarter predictions were possible using a slider tool that is projecting future movements of ships along their communicated routes. This was found to be useful and for predictions in the nearest future, it is also possible to consider non-STM ships, if they continue with a heading similar to their current vector.

Predictions are associated with a certain level of uncertainty, due to factors associated with both with the ship itself and overall traffic system dynamics. One prospect might be to visualize this uncertainty, as a way of supporting operator attention and decision-making.

5.8.4 Cross-track alarm

The relevance of a cross-track alarm is dependent on circumstances such as ship characteristics, surrounding environment and surrounding traffic. The cross-track might need to be dynamic, and change based on the surrounding circumstances.

5.8.5 Route proposals

Route proposals are seen as a useful service that can reduce voice communication over the maritime VHF band. It can prevent overload on VHF channels and reduce the risk of misunderstandings.

To decrease workload, the VTSO could be provided with a library of pre-defined routes. However, this can introduce risks such as choosing routes that are not suitable for the type of ship, or due to other factors such as weather conditions.

The VTSO might be reluctant to send route proposals (and approve routes) if it is not clear who is legally responsible.

5.8.6 Forbidden meetings

In the simulator, no fully automatic prediction of forbidden meetings was possible and consequently not evaluated. In the same way semi-automatic way that the VTSO could predict CQSs, he or she could also predict forbidden meetings.

By seeing the ships’ routes and being able to predict the traffic, STM is seen as a helpful tool to avoid forbidden meetings and improve safety. But with traffic prediction, the uncertainty increases the further into the future the VTSO sees. The success of forbidden meetings predictions is very dependent on the ratio of STM to non-STM ships.

5.8.7 Automated route cross-check

Automatic route crosscheck was not evaluated. However, in interviews a common fear was that any automated service now performed by a master mariner, pilot or VTSO would lead to inability to act accordingly when the system fails or noticing when it does fail.

Looking at manual route cross-check, the workload of the VTSO can increase too much if he or she must manually review routes. But by receiving the routes well in advance, the VTSO can go through routes during periods with low workload. Regulations should say how long in advance before reaching the VTS area the routes should be sent. Departing ships and ships with short trips may not be able to send routes in enough advance, which risk increasing the workload of the VTSO.

6 WP5 UC1-3 Automated Ship Reporting

6.1 Background

Reporting to national and international authorities is one of the many obligations of a ship's master. The IMO regulation that governs reporting is Resolution A.851(20), adopted on 27 November 1997. Complying with the reporting obligation is commonly referred to as *ship reporting.* Ship reporting obligations can be grouped into two types:

- *Pre-arrival or departure reporting* – reporting related to the arrival or departure from a port as required by public authorities and/or the port itself. The reported information is generally extensive. For example, it may include information related to the ship's arrival or departure, dangerous goods, waste, border control, and customs. Furthermore, depending on the level of harmonization within a country or region, the reported information may vary between different public authorities and ports. Member states of the European Union must harmonize the national reporting requirements and accept the reports through an electronic "single window", commonly referred to as a Maritime Single Window (MSW).

- *Mandatory Reporting Systems (MRS) or Ship Reporting System (SRS)* – reporting related to the entrance of the ship into an area monitored by one or several port authorities to ensure navigational safety. The reported information may be split into a "full report" and "short report". If so, the "full report" may contain information mostly about the ships voyage, condition, and cargo, and the "short report" mostly about the location of the ship (e.g. the crossing of a reporting line). Some examples SRS are:
    - BARREP – Barents Sea.
    - SOUNDREP – Sound of Öresund.
    - GOFREP – Gulf of Finland.

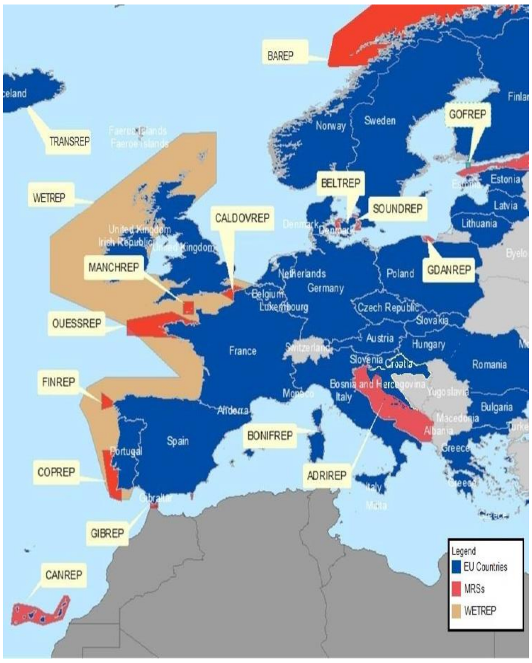

Figure 4 Mandatory Reporting Systems and jurisdiction.

The STM solution, Automated Ship Reporting (ASR), aims at automating both types of reporting. The automation was envisioned to consist of three functions or “use cases” [8]:

1. Determine Reporting Obligations – Before or during a voyage, an onboard system requests the reporting requirements and obligations to a shore-based service.
2. Data Collection – After receiving the reporting requirements and obligations through (1), the onboard system collects the necessary information automatically from sensors and/or by prompting the user to supply the missing information.
3. Data Reporting – After collecting the necessary information, the onboard system automatically creates and submits the reports according as per the received requirements and obligations.

The ASR solution is related to the one being developed by the Norwegian Coastal Administration (NCA) in the project SESAME solution II [9]. In this project, the Norwegian Maritime Administration (NMA) and the NCA represent the end-users of the technology and provide testbed locations. Other partners in the project are the University of Southeast Norway, the Western Norway University of Applied Science, the Norwegian University of Science and Technology, and SINTEF Ocean.

“Solution II” refers to the IMO e-navigation Strategic Implementation Plan (SIP), which identifies five solutions, the second being automated electronic ship to shore reporting. The automation of ship to shore reporting, as well as automation of other e-navigation services, is a key aspect of this project.

The idea is that SESAME Solution II and STM BALT SAFE results will both contribute toward the goal of complete automated ship reporting.

6.2 Possible effects of the use-case

Considering only the description of the STM use-case and the problem it addresses, these are the envisioned possible effects of the use-case.

Efficiency

- Reduction of the workload or effort necessary for ship reporting.
- Reduction on administrative burden of ship reporting.

6.3 Changes

The scope of the ASR solution was reduced. Initially, the solution was envisioned to include the development of onboard and onshore systems for pre-arrival and departure reporting (aka. Marine Single Window) and SRS. But, due to a lack of resources, only an onshore system for SRS was developed. The onshore system provides two services: one for handling requests of reporting obligations, and for handling the reception of reports. Because of the changes in the scope of the solution, most of the evaluation methods had to be discarded. For more information, see D6.2.3 [4].

6.4 Evaluation methods

After the changes, one method was used to evaluate the ASR use-case:

- *HAZID analysis* – A *qualitative analysis* to identify hazards related to the ARS solution.

6.5 Validation and evaluation results

The scope of the work carried out by Work Package 5 changed considerably during the duration of the STM BALTSAFE project. For example, work was added in the form of internationalisation. Due to COVID-19, the onboard system developed could not be deployed, or tested, to the extent required for validation. The systems, procedures and data sets developed for the intended use cases has been evaluated as-is.

The expected effects of reduced workload and administrative burden could not be corroborated based on the data of this project. Nevertheless, no evidence of the contrary could be identified in the deliverables of the work package. It has been studied in the past, proofing, that the administrative burden of ship reporting is well known. Therefore, it stands to reason, the main principle of the ASR is to reduce workload and administrative misses in managing data. As much of the data points needed in reporting is repetitive and semi-static, automating this task ought to reduce the administrative burden.

Nonetheless, and as pointed out in the performed risk identification, the system needs checks and balances to assure old or wrong data is not being fed into the system as this could cascade into other systems in a wholly integrated data chain. Sending data needs to be done with caution. As such the summaries points of the risk identification can be used in that further work towards ASR. Needless to say, the identified hazards need to be considered. Thus, the authors recommend that the results from the risk identification analysis are considered in the future development of the ASR solution. Security measures should be treated as critical functionality of the ASR solution. Further research ought to be spent on ship crew experiences of this system and broadening the participating organisations of future HAZID analyses.

For more information, see D6.2.3 [4].

7 Final Remarks

The main objective of the STM BALT SAFE project was to develop solutions that improve the safety and efficiency of tanker shipping and marine traffic in the Baltic Sea. The STM solutions were to be validated through “use-cases” (i.e. application scenarios). Unfortunately, throughout the course of the project, COVID19 greatly disrupted the development and deployment of the STM use-cases. Some of the STM use-cases could not be deployed (BIMCO STM clause and Estonian Icebreaker service), others were only deployed in simulated environments (Automated Ship Reporting), and the rest (S2SREX and STM VTS functions) were deployed in the real-world to an extent much smaller than the initially planned one.

The planned evaluation and validation work was modified to address the changes on the development and deployment of the STM use cases. For some of the use-cases, simulations or similar existing solutions were used as substitutes of the real-world use cases. For other use-cases, qualitative analyses became the main evaluation tools. Overall, the evaluation and validation work were an ongoing process throughout the project, adapting the employed methods and the subjects to the limitations imposed by COVID19.

Despite of the efforts by all work packages, the validation work is mostly inconclusive. The information gathered for all but one of the use-cases (S2SREX) is not sufficient to validate the impact of the STM solutions on the environment and the safety and efficiency of marine traffic. Nevertheless, the evaluation work provides indications of the effects of the STM solutions, valuable insights into how to continue their development, and aspects to consider in their future evaluation and validation.

References

[1] L. Sanchez-Heres and J. Hüffmeier, “D6.1 Evaluation method specification for the STM use-cases,” STM BALT SAFE, Gothenburg, 2019.

[2] L. Sanchez-Heres and P. Sjögren, “D6.2.1 Validation of Work Package 3,” STM BALT SAFE, Gothenburg, 2021.

[3] S. Bram, P. Sjögren, J. Burgén and R. Pramanik, “D6.2.2 Validation of Work Package 4,” STM BALT SAFE, Gothenburg, 2021.

[4] L. Sanchez-Heres and P. Sjögren, “D6.2.3 Validation of Work Package 5,” STM BALT SAFE, Gothenburg, 2021.

[5] GloMEEP Project Coordination Unit, “Just In Time Arrival Guide - Barriers and Potential Solutions,” International Maritime Organization, London, 2020.

[6] BIMCO, “BIMCO Virtual Arrival Clause for Voyage Charter Parties 2013,” BIMCO, 2013. [Online]. Available: https://www.bimco.org/contracts-and-clauses/bimco-clauses/current/virtual_arrival_clause_for_voyage_charter_parties_2013. [Accessed 26 11 2021].

[7] BIMCO, “Sea Traffic Management (STM) Clause for Voyage Charter Parties 2018,” BIMCO, 2018. [Online]. Available: https://www.bimco.org/contracts-and-clauses/bimco-clauses/current/sea-traffic-management-clause-for-voyage-charter-parties. [Accessed 26 11 2021].

[8] J. Hauge, “D5.1 Use case, processes and data formats for automated ship reporting,” STM BALT SAFE, Ålesund, 2020.

[9] “SESAME solution II,” 2018. [Online]. Available: https://sesamesolution2.org/. [Accessed 11 2021].

[10] J. Hauge , “D5.2 Automatic Ship Reporting pre-study and concepts document including use cases,” Norwegian Coastal Administration, Ålesund, 2020.

[11] J. Hauge, “D5.3 Prototype applications for ship reporting to MSW and SRS,” Norwegian Coastal Administration, Ålesund, 2021.

[12] L. Sánchez-Heres and J. Hüffmeier, “Use Cases and Application Scenarios,” RISE, Göteborg, 2020.

[13] L. Sanchez-Heres, P. Sjögren, S. Bram, V. Norrsjö, J. Burgén, E. Sandberg and R. Pramanik, “D6.2.0 Analysis and Evaluation of the STM use case for tanker traffic,” STM BALT SAFE, Gothenburg, 2021.

[14] L. Sanchez-Heres, P. Sjögren, S. Bram, J. Burgén, E. Sandberg and P. Roshni, “D6.2.0 Analysis and evaluation of the STM use case for tanker traffic.,” STM BALT SAFE, Gothenburg, 2021.

Using STM to increase BALTic Sea SAFEty

Making the Baltic Sea even safer by improving the situational awareness on ships and shore, building tools that automate work and provide decision support to prevent risk situations and accidents.

Making STM happen!

SAFETY - ENVIRONMENT - EFFICIENCY

Swedish Maritime Administration ◦ Fintraffic ◦ Estonian Transport Administration ◦ Norwegian Coastal Administration ◦ RISE Research Institutes of Sweden ◦ DNV

www.stmbaltsafe.eu
www.stmvalidation.eu/projects/stmbaltsafe

Interreg Baltic Sea Region
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND