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Table of contents

ACRONYMS

AIS – Automatic Identification System

ASM – Application-Specific Messages

BRM – Bridge Resource Management

CCTV – Closed-circuit television

CDM – Collaborative Decision Making

COP – Common Operating Picture

CPA – Closest Point of Approach

CRM – Crew Resource Management

CQS – Close Quarter Situation

DSS – Decision Support System

DST – Decision Support Tools

ECDIS – Electronic Chart Display and Information System

ETA – Estimated Time of Arrival

ETD – Estimated Time of Departure

GOFREP – Gulf of Finland Reporting scheme (supported by the VTS's in the Gulf of Finland)

IALA – International Association of Lighthouse Authorities and Aids to Navigation

IEC – International Electrotechnical Commission

IMO – International Maritime Organization

INS – Information Service

MSI – Maritime Safety Information Service

NAS – Navigational Assistance Service

OOW – Officer on Watch

Port CDM – Port Collaborative Decision Making

RTZ – Route plan exchange format

SMCP – Standard Maritime Communication Phrases

SOLAS – Safety of Life at Sea

SOP – Standard Operating Procedure

SOUNDREP – The Sound Reporting scheme (supported by the VTS The Sound)

SRS – Ship Reporting System

STM – Sea Traffic Management

STCW – the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers

TCPA – Time to Closest Point of Approach

TOS – Traffic Organization Service

VDES – VHF Data Exchange System

VHF – Very High Frequency, radio frequency range. Common way of communicating at sea to sea & sea to shore

VM – Voyage Management

VTS – Vessel Traffic Services

VTSO – Vessel Traffic Service Operator

XTD – Cross-Track Distance

DEFINITIONS

Administrative burdens are defined as "administrative work which in the opinion of the stakeholder is not adding value proportionate to the resources the stakeholder will have put into the work to comply with specific rules and requirements".

Application-Specific Messages Application-Specific Messages (ASM) are messages that have been developed to allow the exchange of information via the Automatic Identification System (AIS) in addition to the standard set of messages defined in ITU-R M.1371-4, *Technical characteristics for an automatic identification system using time-division multiple access in the VHF maritime mobile band.*

Automatic Identification System – radio modem that automatically exchanges static (identity) and dynamic (navigation) data between ships and may transport ASM data structures.

Common Operating Picture – The combination of all information collected to the VTS centre. It is the information stored and presented on displays to the VTS operator.

Cross-Track Distance – The distance of a ship from route centerline. Same as cross-track error. Maximum value defined in RTZ. See also VTS-defined XTD

Decision Support System, referring to the technical support system at hand in an operational environment in the vessel traffic service or at bridge. It can incorporate several decision support tools, such as electronic charts, alarm system and predictor systems.

Electronic Chart Display and Information System – ECDIS is today's ships navigation system. In STM-context, the same or parallel computer is used for planning, sending, and receiving voyage plans.

Enhanced Monitoring – Enhanced monitoring will be an anomaly detection to detect if planned schedule is not kept or if ship deviates from planned route that is transferred to operators in a shore centres. Thus, shore centres can monitor that ships are following their planned route and foresee possible dangerous situations and suggest route modifications (geographic and/or speed) due to traffic or other impeding conditions.

Fairway Library – Database containing all routes leading to port in a respective VTS area. Existence and utilization of fairway library is an assumption made for user stories. Fairway Library contains reference routes.

Flow Line – A passage line used to mark the timing of ships passages in Flow Management

Flow Management Services will support both onshore organizations and ships in optimizing overall traffic flow through areas of dense traffic and areas with navigational challenges.

Flow management – Flow management supports the optimal coordination of multiple ships in congested geographical areas. Flow management will support both VTS control and ships in optimizing overall traffic flow through areas of dense traffic or those with particular navigational challenges. FM's objective is to improve the overall flow of maritime traffic through superior information sharing and coordination. The concept of flow management was defined in STM Validation.

Information Service (INS) – An information service is a service to ensure that essential information becomes available in time for onboard navigational decision-making. See IALA VTS Manual for exact definition.

Navigational Assistance Service (NAS) – Navigational Assistance Service is a service to assist onboard navigational decision-making and to monitor its effects. See IALA VTS Manual for exact definition.

Route - a way or course taken in getting from a starting point to a destination. Shipping routes are the paths taken by ships across the world's seas. They are channels down to a hundred meters wide up to unrestricted, defined by compulsory points of passage (capes, straits, channels), physical constraints (current speed, depth, presence of reefs) and geopolitical contexts.

Route broadcast – Ships can broadcast the next 7 waypoints and the last passed waypoint through AIS.

Route exchange – Ships can choose to share their route with other ships, the electronic charts will show the surrounding ships routes for easy understanding of the situation. The standard format of the routes for exchange is RTZ used in conjunction with ECDIS to IEC 61174. Routes can be exchanged by means that support standard operating procedures. http://www.cirm.org/rtz/index.html

Route Planning - can be defined as a method of deriving or computing the most cost/time/environmental effective route involving several waypoints/ nodes/stopovers by minimizing the distance traveled or time taken. In ECDIS and in bridge systems route planning is defined as the operation of entering a route in a chart – checking for grounding hazards, areas where special conditions exist, navigational hazards and checking for geometry. Route plan is part of voyage plan. See also voyage plan.

Schedule - The estimated timing of a voyage, i.e., ETA/ETD of waypoints, speed on legs, etc.

Sea Traffic Management – A concept based on common standards and secure infrastructure enabling interoperable services to enhance the aggregation of the seaborne and shore-based functions (sea traffic services, maritime space management and sea traffic flow management) required to ensure the safe and efficient movement of ships during all phases of operation.

Ship domain – An operational zone around, above or below a ship within which an incursion by another fixed or moving object, or another domain, may trigger reactions or processes.

Ship Reporting System – SRS aims to keep a vigilant eye on the sea traffic. In cases of rendering help, the systems enable to give pieces of information about navigational hazards, medical advice, directing the closest ship towards the ship in peril, and defining the area of searching SRS may be voluntary or obligatory.

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Shore center – In a shore (control) centre the monitoring of several ships or a dedicated area is performed by educated operators.

Standard Operational Procedure – The documentation governing the VTS service. It defines everything pertaining the management, development, and operations of a VTS.

STM BALT SAFE – An EU co-financed project in which the present work has been written. The STM BALT SAFE is a follow up project following MONALISA, MONALISA2.0 and STM Validation aiming to implement findings from previous projects.

STM Messaging – Capability to send text messages between STM- compatible equipment in ship and on shore.

STM compliance implies that ships are equipped with STM compatible bridge systems or VTS with STM compatible VTS systems

Tactical Voyage plan - A Dynamic Voyage plan in conning mode (tactical execution) The ship is under captain's command and decisions are based on navigational and safety knowledge taken on legal basis (COLREG). The tactical voyage plan can be transmitted between ships to increase situational awareness and enhance the planning of alternative legs to avoid close encounters.

Traffic Organization Service (TOS) – A traffic organization service is a service to prevent the development of dangerous maritime traffic situations and to provide for the safe and efficient movement of vessel traffic within the VTS area. See IALA VTS Manual for exact definition

Vessel Traffic Management - Vessel Traffic Management provides Vessel Traffic Service (VTS) to merchant shipping and other marine traffic and maintains safety radio operations. Vessel Traffic Services, a shore-based support service, are provided by the VTS Centres. The centres' surveillance areas are typically provided in constrained/ confined/ congested waters and in those with high shipping traffic intensity.

Vessel Traffic Services - VTS – are shore-side systems which range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to extensive management of traffic within a port or waterway.

VHF radio - Very High Frequency radio, the primary means of communication for VTS and vessels.

Voyage Management concerns strategic, tactical, and operational decisions about a voyage, such as planned and executed routes of a certain ship and its interaction with nearby ships in a given position. It focuses on the initial planning phase of any sea voyage and the ability to monitor the execution of that plan. VM supports improved route planning, route exchange, and route optimization before and during the maritime voyage. Especially in this phase, VM connects ships, adds intelligent processes and new tools to enable all stakeholders to increase their situational awareness during the voyage, providing faster, more secure, and transparent information exchange. VM was defined in STM Validation.

Voyage Management Services provides support to individual ships in both the planning process and during a voyage, including route planning, route exchange, and route optimization services.

Voyage plan – Same as Passage Plan. A representation of the planned way to get from point A to point B, consisting of a list of waypoints (geometry) and information associated with the legs between waypoints, plus a schedule, describing the planned time axis of a ships voyage. It is a complete description of a vessel's voyage from start to finish. The plan includes leaving the dock and harbor area, the route portion of a voyage, approaching the destination, and mooring, the industry term for this is “berth to berth.” SOLAS chapter V states that voyage plan shall identify a route which:

–Takes into account any relevant ships' routing systems

–Ensures sufficient sea room for the safe passage of the ship throughout the voyage

–Anticipates all known navigational hazards and adverse weather conditions; and

–Takes into account the marine environmental protection measures that apply, and avoids, as far as possible, actions and activities which could cause damage to the environment

VTS Area – Area in territorial waters in which VTS is provided to the merchant fleet.

VTS Authority – The national authority responsible for delivering vessel traffic services.

VTS centre – Premises that are equipped with technology to provide vessel traffic services.

VTS-defined XTD – XTD that is defined by the VTSO. Relative to the route line. Ship-defined XTD appears originally in the RTZ.

VTS Instructor – Person involved in training of VTS Operators and/or Supervisors.

VTS Operator – The watchkeeping person in the VTS. Referred to as VTSO later in the text.

VTS Supervisor – The leader for a shift of VTS operators.

VTS System - In the context of this work VTS system refers to the system used by the VTS operator when surveilling sea traffic. In this work it is also assumed that this system is STM compatible i.e., it holds the possibility to receive and share voyage plans with the vessels in the RTZ format.

VTS tools – Set of functionalities presented and described in STM BALT SAFE work package 4 documentation.

Waypoint A position marking the intersection between two legs in a voyage plan.

1. General Information

1.1. Introduction to STM BALT SAFE project

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 as a catalyst for improved safety of navigation.

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 ships are made 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 is built on the methods, results and the maritime service infrastructure developed in previous projects and encompasses exchange of voyage plans and integration of STM functionalities in VTS shore centres. 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 are also developed and tested within the project.

The more ships that are be equipped and the more VTS centres that will have the capability to exchange voyage plans and distribute and consume digital STM services, the more interesting it will be for the industry to provide innovative technology and services.

The project is implemented by a Baltic Sea wide partnership of public administrations from Norway, Sweden, Finland, Estonia, and Denmark. The STM BALT SAFE(R) project involves Russia in the EU project. Today, a national and separate e-navigation project is running in Russia, and the goal is to strengthen the cooperation between the parties. Through this project, Russia was able to participate in the meetings of the EU project.

1.2. Purpose of Work package 4

The objective is to provide VTS services digitally to create means to increase navigational safety, reduce administrative burden and information overload, reduce miscommunication due to external interference and to simplify work procedures. By improving capacity and interaction between ships and VTS centres by developing systems and operational concepts to support digital distribution of Vessel Traffic Service (VTS) using STM Tools, the WP will enable the harmonized delivery of digital VTS services in the Baltic Sea region. Project partners operates VTS centres in 4 Baltic Sea countries. The results will be made available to all VTS centres in the Baltic region.

Today most of the information from VTS is delivered to ships using voice over VHF radio. The WP considers how to provide information to the mariners more efficiently and effectively. Only limited amounts of this information can be delivered to vessels using traditional communication means. The ability to access ships actual voyage plan opens up for a whole new dimension in monitoring and prediction of vessel movements. In the Project, these services are brought to wider implementation to address the call and the needs in the Baltic Sea.

After upgrading the traffic monitoring systems in the Shore Centres testing of the developed services is carried out in the normal operations with the test ships and VTS operators.

The WP will define the how the STM tools can be used to enhance the VTS services (Information, Navigational Assistance and Traffic Organisation Services) and other public services. These STM compatible services could include e.g., route exchange, enhanced monitoring, route cross check, flow management, pilot route service and distribution of weather and ice information or navigational warnings. The delivered services will vary in different areas; some of the services may also be delivered outside of the traditional VTS areas.

1.3. Previous deliverables

First deliverable *Report on the operational concept of STM compatible VTS services* describes the environment where vessel traffic services are currently working and also describes the current VTS-services including different service levels. Information given in the first deliverable is vital to understanding the context of the project, it provides the rationale for why it is necessary to provide new services that increase the safety in the mentioned domain. Drafts of new services to be developed are also included.

Second deliverable *Operational and technical use cases of STM compatible VTS tools* is written report defining the STM compatible VTS tools that will be developed and used during the project. The shore centre systems were to be upgraded to support the defined requirements. The deliverable was to be used as technical document for procurement purposes.

STM SOP document was compiled to provide all participating project partners with standard operating procedures concerning the use of STM tools. The purpose of the document was to point out how the new forms of STM information sharing can be brought in to daily VTS work. The document also aims to give guidance in how to merge the STM VTS SOPs in to already existing national regular VTS SOPs.

Previous deliverables are summarized later in this document

Chronological list of previous deliverables:

- BS_WP4.1 Report on the operational concept of STM compatible VTS services/ 15.01.2019
- BS_WP4.2 Operational and technical use cases of STM compatible VTS tools / 30.06.2020
- BS_WP4.3 APPENDIX A STM VTS SOPs / 8.3.2021

1.4. Different formats for routes

A concept that needs to be clear in this work is the route. Basically, a route is a route regardless of it is presentation method or format. It will always be a route connecting two places with intercepting lines and waypoints. But in this context, it is particularly necessary to be able to distinguish between different ways of *expressing* a route.

- **The basic route**, just any route. It describes the way from point A to point B, in any other format than RTZ, including a line drawn on a paper chart and files from ECDIS in proprietary file formats. Assumed to be originated from the vessel or its representative.
- **The RTZ route** is a route expressed in the route plan exchange format - RTZ, independent of which RTZ version used. This Route Plan Exchange Format is based on standardizing a single route plan (IEC 61174 v.4 Annex S.1). The latest schema files can be retrieved from http://cirm.org/rtz/index.html. When writing, available versions was the original 1.0 and Publicly Available Specification (PAS) 1.2, which incorporates version 1.1 that was developed, implemented, and tested by participants in the STM project. During the timeline of this project version 1.1 is used with STM extensions. See below.
- **As a generic idea**, the RTZ has a need to ensure that there is a possibility to keep extensions from different manufacturers in single file (IEC 61174 v.4 Annex S.4.1). **The STM Route** is written in RTZ version 1.1 with STM extension as defined at https://www.seatrafficmanagement.info/developers-forum/schemas/ in section “RTZ FORMAT + STM EXTENSION” and can be shared by STM compatible vessels and VTSes.

1.5. Methodology

This document has been produced by incorporating mixed methods research. There is limited amount of suitable literature to reflect the project findings in operative context and due to this fact, the similar experience of authors is the main source of qualitative data.

Mixed methods research is the combination and integration of qualitative and quantitative methods in the same study. The overall purpose and central premise of mixed methods studies is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems and complex phenomena than either approach alone

This document is not a research paper in its entity, but it is reasonable to describe the method used as this document provides some qualitative findings and results. Quantitative method was also used when gathering data for analysis provided by Research Institutes of Sweden considering the simulation exercises.

2. Executive Summary

This document provides an outlook on the activities of WP4, mostly concerning the testbed phase but covering the details of the whole project timeline. Document is divided to chapters each covering certain feasible entirety.

General information part provides the reader with necessary background information for the understanding of the subject being addressed. The purpose of WP4 is briefly described along with previous deliverables. Document is built in a way where reader with little or no knowledge of the subject could comprehensibly familiariaze itself with the subject. Subject-specific acronyms & definitions are also included in the beginning.

Document explains the concept of STM compatible VTS services and operational processes. It includes the detailed functional descriptions of all of the services along with use cases supporting the development. Standard operating procedures were also compiled to have common understanding how new developed capabilities shall be uniformly utilized in day-to-day VTS operations.

Key part of the document and activities of WP4 is the technical and operational realization of the testbed and simulator exercises. Technical and operational implementations of new capabilities and equipment are described by each partner. New published services are also described.

Simulator exercises became vital part of the project as the prevailing pandemic conditions have hindered the development of shipboard capabilities and VTS-system development. Simulator exercises were made to have enough data for the analysis of the project, the standard operating procedures were tested and evaluated in the simulator trials. Simulator setup, staff, personnel participating in test, VTS area in question and the actual simulations are described in this document.

Project delivered results of which reflections and conclusion were made along with recommendations concerning future projects and the platform economy in maritime cluster.

3. Operational concept of STM compatible VTS services

The deliverable ”BS_WP4.1 Report on the operational concept of STM compatible VTS services” lays out the concepts for the work package 4. This chapter is a summarized excerpt of previous deliverable, it is included here to provide the reader of this document a comprehensive understanding of the project without the need of revisiting previous deliverables.

The document identifies a set of new services to be considered for VTS’ to implement.

<table>
<tr><td>Automatic route checking</td><td>VTS will have capability to perform automatic route check that considers the ships domain, draught, and route plan with XTD-limits. Benefits of this service will be increased awareness of traffic and increased traffic monitoring support. Performing route check contributes to the safety of the business.</td></tr>
<tr><td>Use Case: Route Crosscheck (automatic)</td><td>Ship sharing route

1. Ship shares its VP with VTS using STM-compatible equipment

2. Receivers’ equipment shall send acknowledgement “route received” to ships equipment

• VP must be visually presentable in VTS software

3. STM-compatible shore system performs automatic route check

• Route check considers ships draught and XTD-limits in relation to fairway limits, AtoNs and depth contours

4. A) If VP has been validated by the STM-compatible shore system concerning the variables above, system sends “route checked” to ships STM-compatible system.

4. B) If VP has not been validated due to variables above, system sends notification of hazards within variables above with location</td></tr>
</table>

	• Location of hazards shall be shown visually in ships system
Identification of close-quarter situations	Identification of close-quarters situations contribute to the safety of the traffic. This solution will use the flow management capabilities developed in STM EfficientFlow.
Use Case: Close Quarters Situation	Meeting between two ships 1. Two ships (Ship A and Ship B) will have CQS if present voyage plans are followed 2. Both ships share their VPs (including planned speeds) with VTS using STM-compatible equipment 3. Meeting points to be calculated in STM-compatible system and presented in VTS software • VTS uses their own software to ensure meeting points with actual and/or planned ship speeds. Actual speed will be used for the current leg and planned speed for other parts of the route. Optionally, calculation can be done using actual and VTS software speeds (e.g., schedule calculated based on AIS speed and/or historical data). • To prevent getting CQ alerts constantly when normal meetings take place, only true route plans from ships are used even if simulated routes would be at hand due to the inaccuracy of simulated routes.
Predicting unsafe meeting points	Extension of flow management capabilities developed in STM EfficientFlow
Use Case: Predictions	Meeting with two or more ships in area where it's unsafe/forbidden to meet or where there will be congestion 1. Two or more ships will meet in unsafe/forbidden/congested area if present voyage plans are followed

	2. All ships share their VPs (including planned speeds) with VTS using STM compatible equipment 3. Meeting points to be calculated in STM-compatible system and presented in VTS software • VTS uses their own software to ensure meeting points with actual and/or planned ship speeds. Actual speed will be used for the current leg and planned speed for other parts of the route. Optionally calculation can be done using actual and VTS software speeds • Unlike with the CQ's, simulated routes can be used in addition to STM- or other ship-sourced RTZ-routes. The assumption is that the meetings considered in this user story are taking place in relatively tight fairways, that makes the accuracy of simulated routes well enough to be used in this context.
Sending route proposals	VTS shall be able to send route proposals to ships. Typical example of use of this service is ship approaching port that has two fairways and due to variables, such as draught the route made by the ship is unsuitable.
Use Case: Route proposals	Ship using wrong/unsuitable route 1. Ship enters to monitoring area/ is to enter the area 2. VTSO checks visually the route and observes / gets notification from system of a CQS / somehow finds a need to changes in the planned route 3. VTSO opens FairwayLibrary and copies a link to an RTZ-route snippet that represents the altered path VTSO sees proper for the situation (select) 4. VTSO communicates the need for alteration to ship using STM Messaging/ RTZ/ the best possible means available (deliver)

	5. VTSO pastes the link to the RTZ-route snippet to STM Messaging and sends it to the ship 6. OOW receives the link, downloads the snippet from the FairwayLibrary 7. OOW attaches the snippet to the voyage plan and uploads the updated version to navigation system 8. VTSO receives acknowledgment of changes from the system 9. VTSO checks the new route plan visually and sends acknowledgment to the ship
Detection of route corridor deviation	VTS system shall be able to detect if ship is deviating from her monitored route XTD-limits.
Use Case: Route Corridor Deviations	Ship drifts outside its route XTD-limits 1. (make basic level assumption first) 2. Ship enters area 3. Ship drifts slowly away from its planned route 4. Still navigating in safe waters, with a heading that is not too wrong, ship crosses areal default alert limits or ships planned XTD 5. VTSO gets a notification of deviating vessel from the system 6. VTSO focuses on the situation, analyzing that there is no obvious reason for the vessel not to follow her planned route 7. VTSO follows for a while the situation with no changes or excuse for the deviation 8. VTSO contacts the ship using STM Messaging/conventional means letting them know that an un-obvious deviation from the the planned route is noted, asking if everything is OK

	9. OOW acknowledges that everything is OK and ships course will be altered to lead to the original route plan 10. OR OOW observes first time the deviation and detects a fault in her navigation equipment's 11. Or OOW informs VTSO that there is a conflict with the rudder under repair
Distribution of AtoN-faults	Distribution of AtoN-faults to STM-compatible onboard systems will provide more information for ships navigating the fairways. AtoN-faults shall be visually presented in the ships STM-compatible equipment. Technical solution is using the Baltic Navigational Warning Service.

4. Operational and technical use cases of STM compatible VTS tools

Similar to previous chapter, this chapter is a summarized excerpt of previous deliverable. It is included here to provide the reader of this document a comprehensive understanding of the project without the need of revisiting previous deliverables.

In order to support STM BALT SAFE-project the initial definition of the situation and mapping of the compatible VTS-tools was made. A report was compiled by participants of the respective work package using their own expertise in defining the current traffic status. This document provides operational and technical use cases for the development of STM capabilities, extending to the previous document and providing more technical point of view for the development.

The deliverable built on top of the need identified in the previous deliverable.

Roles in relation to these services where identified and use cases based on these where developed.

The document defined use cases on two different levels:

User stories: The user stories describe the operational scenarios where the VTS operates. They provide a broader context for the situations where the VTS tools are needed. The use cases described in chapter 6 takes these stories and defines how they are reflected in the work inside a VTS and the corresponding VTS-System.

Use cases for VTS tools: The user stories in previous chapter gave the overall operational scenarios whereas this chapter focuses on the inner working of a VTS. The use cases describe how user stories are realized in the VTS.

4.1. User stories

The overall user stories were used to verify the identified services with VTS operators.

Route Crosscheck	VTS will have capability to perform automatic route check that considers the ships domain, draught, and route plan with XTD–limits. Benefits of this service will be increased awareness of traffic based on true plans instead of assumptions, and increased traffic monitoring support. Performing route check contributes to the safety of the business.
Close Quarters Situation (CQS)	Identification of close-quarters situations contribute to the safety of the traffic. This solution may use the flow management capabilities developed in STM EfficientFlow.

Predictions	VTS uses their own software to identify meeting points with actual and/or planned ship speeds. Actual speed will be used for the current leg and planned speed for other parts of the route. Optionally calculation can be done using actual and VTS software speeds.
Route proposals	VTS shall be able to send route proposals to ships. Typical example of use of this service is ship approaching port that has two fairways and due to variables, such as draught or present traffic situation, the route planned by the ship is unsuitable even though passed the pre-checks made by ECDIS or any other instance.
Route Corridor Deviations	VTS system shall be able to detect if ship is deviating from her XTD or VTS-XTD limits

The different cultures in different VTSs resulted in very different perception on the practical implications on how to embed the different services in day-to-day operations. This gave reasons to look closer on the standard operating procedures (SOP).

4.2. Use cases for VTS tools

The user stories gave the overall operational scenarios whereas this chapter focuses on the inner working of a VTS. The use cases describe how user stories are realized in the VTS.

UC 1: Analyze traffic	The VTS-system monitors and analyzes the changing maritime traffic situation and environment. The system analyzes the information and raises events when a situation is occurring.
UC 2: Monitor traffic	The VTSO monitors traffic in designated area by visually inspecting the common operational picture, calculated by the VTS system.
UC 3: Analyze situation	Based on identified situations in the UC 2 monitor traffic, the operator analyses the situation and decides on actions to take.
UC 4: Manual route crosscheck	The VTSO performs a visual inspection of a route plan submitted by the ship and sends a response to the ship.

UC 5: STM Messaging	The VTSO communicates with the OOW using digital STM messaging function provided by STM

Additionally, a set of rules or parameters that a system needs to implement as part of their use cases.

The document laid out suggestions on how various vendors could implement the described services including suggestions how to a) build using current VIS implementation or b) alternatively modifying the VIS implementation.

5. Standard Operating Procedures

To realize the user stories (chapter 4.1, User stories), STM Standard Operational Procedures for Vessel Traffic Services were created (BS_WP4.3 APPENDIX A STM VTS SOPs / 8.3.2021). Despite its tough name, the aim was not to present complete step-by-step instructions on how to carry out the processes at the centres and onboard, but a high-level overview to present the idea and introduce the terminology to VTS supervisors, instructors, managers, and authorities in general, with guidance on how the data exchange and information sharing by means of STM functionalities, can be utilized in a VTS context. Creating more structure to these activities improve the information exchange capabilities and utilization, somewhat similarly to businesses improving productivity and reducing costs with standard operating procedures.

It was discovered that apart from being extremely simple actions utilizing things familiar to everyone, explaining the whole thing profoundly to anyone was quite challenging. Although it is every nation own cause to arrange the VTS services to meet the local culture, equipment, and operating environment, it was obvious that some kind of vocabulary and structure was needed to be able to communicate the matter overall. First to promote the idea and structure for VTSes, second to promote available services to vessels changing VTS providers constantly.

5.1. SOP description for VTS in general

The main parts of the STM VTS SOPs are the definitions and clarifications, and the descriptions of the SOP's. The presentation mode for the latter was selected to be flowcharts.

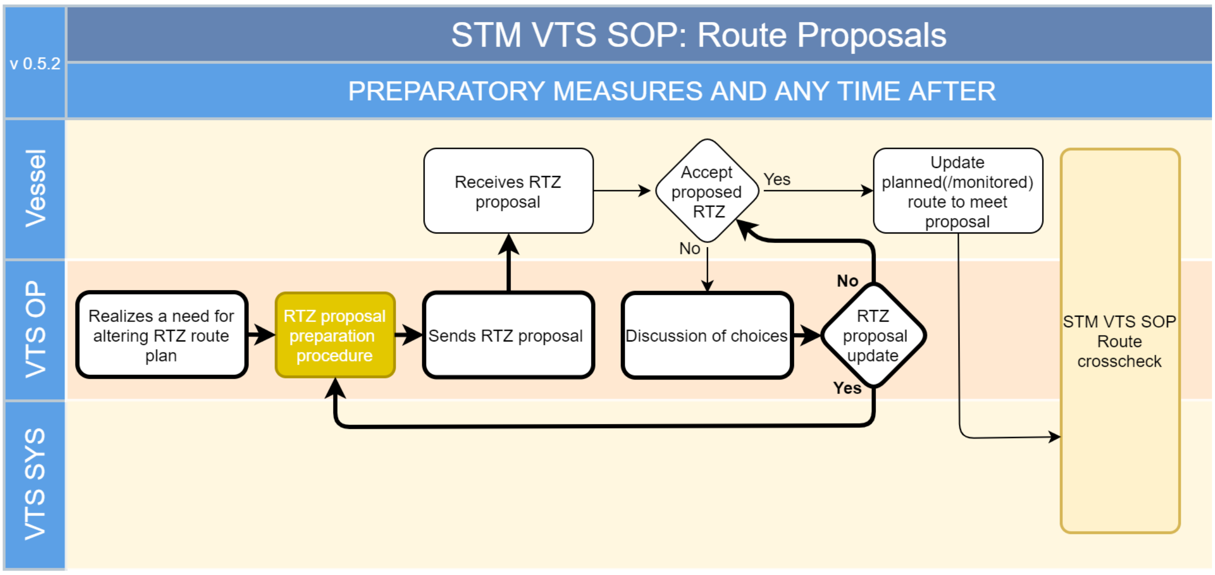


Figure 1. SOP Flowchart for Route Proposals

The key to reading the flowcharts is chronologically from left to right to catch the timely flow, and events happening in three different layers; one describing the vessel, one the VTS operator, and one assuming what the VTS system might do.

Different shapes and colorings refer for different actions or sources. For example, the diamonds are choices, and the beige boxes refer to another operation that has its own flowchart.

The controllability of the layers varies a lot. It is strongly desired that the vessels layer would remain untouched in all the participating VTS centres. That way, the services would look the same for the vessels, drawing a consistent picture of the whole area, making it easy to understand the differences between areas with one glance rather than studying the nuances between different VTSes one by one. The VTS Operators layer is an educated guess of how the process might proceed in an average VTS site. Its purpose is to get the idea understood, and it may be freely adjusted to meet the local habits and needs. The bottom layer, VTS system, is the least significant layer in these flowcharts. Recognizing that we could not possibly have the knowledge of the approach of different software solutions, nor any volition to guide the technical development in any direction but for the best possible future, as well as understanding that even though most of the work is done by machines, the systems internal calculation methods or logics are not very interesting for the end-user. The description of what might happen under the hood was mostly left to the Operational and technical use cases of STM compatible VTS tools.

Flowcharts were made for all the five user stories, one to describe their interdepencies, and a couple examples how they could affiliate a regular VTS's own standard operational procedures.

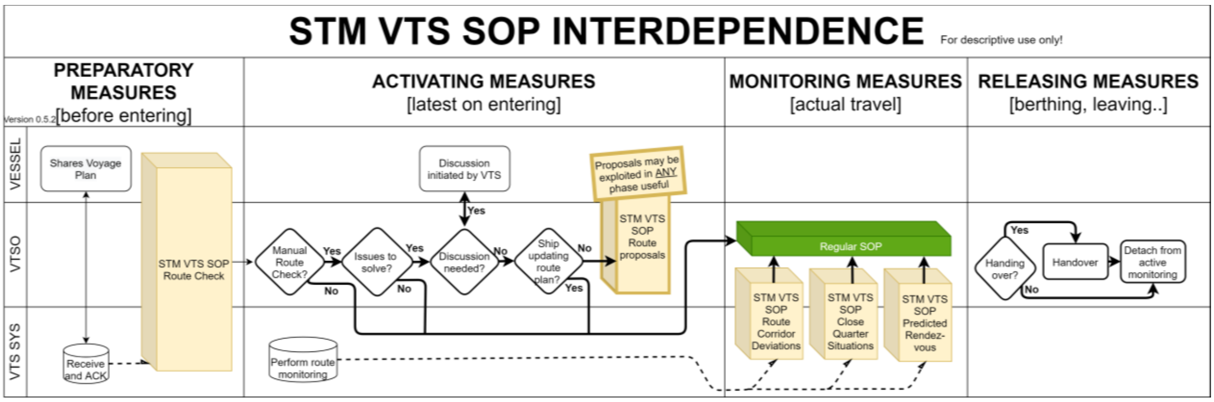


Figure 2. STM VTS SOP Interdependence

5.2. SOP description for vessels in general

To keep the shipboard operations as straightforward as possible, it was found that there was no actual need to explain the STM VTS SOPs very thoroughly for the crews. Since the usage of STM coast stations is determined mainly by the locations, and the extra services at this stage are more like a cherry on the pie, the description was kept as short as follows

5.2.1. Service classes in Enhanced Monitoring Service

Due to e.g., technical, and cultural differences, as well as the early stage of pioneering, the level of Enhanced Monitoring service may vary between different VTS centres. The level of service is declared in following text in each VTS section. By default, all the Enhanced Monitoring Services listed here are at the vessel's disposal without separate request, just sharing the voyage plan with the VTS in question.

The services are divided as follows:

STM VTS Route Crosscheck

VTS crosschecks the vessels route plan at latest when arriving to area. Crosscheck may be automated, manual, or both.

VTS Route Proposals

In case the route plan must be altered, VTS has a way to deliver route proposals to the vessel in ready-to-use format, that the vessel can accept or reject, and take to active monitoring.

STM VTS Route Corridor Deviations

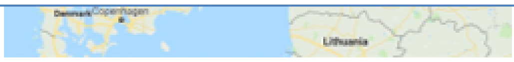
The VTS follows the vessels travel against the actual route plan of the vessel, instead of educated guess based on historical statistics.

STM VTS Predicted Rendezvous

The VTS predicts meetings in undesirable locations in fairway area. Utilizes also educated guesses of future movement of vessels that has not shared their voyage plans.

STM VTS Close Quarter Situations

The VTS predicts unnecessary small CPAs on open water areas, based on relevant vessels actual route plans.



Tallin SC Service coverage area

4.2.3 Finland VTS

Receive VP. STM Text Message and STM acknowledgments not available. Enhanced Monitoring services available in all coastal VTS areas 24/7 as following:

Route Crosscheck: **Manual**

Route Proposals: **No**

Route Corridor Deviations: **Yes, on open water manual, at fairways automated**

Predicted Rendezvous: **Yes**

Close Quarter Situations: **No**

Figure 3. The descriptions of the services were kept as compact as possible. Above an example of one coast station.

5.3. SOP arrangements for individual VTS

The original plan was to arrange a model course for participating VTS personnel, but due to Covid-19, it turned out impossible to do such in reasonable time by any means. Therefore, the Heads of participating VTS's were encouraged to introduce the idea and working orders to their personnel. Since the level of technical readiness varied a lot from centre to centre, and the body of STM VTS SOPs is somewhat simple, this approach proved to be good. A review of local arrangements is in chapter 6. Technical and Operational realization of the testbed.

5.4. STM VTS SOPs Adaptation Training

Even though the model course was impossible to arrange, the material to guide adaptation training was created for future use.

The document was written to comply with *IALA Model Course V 103 -5 The Revalidation Process for VTS Qualification and Certification.* Chapter 2 "Adaptation Training" was particularly been considered since that is the chapter giving guidance about how to introduce changes in daily VTS work. The IALA document states that:

"A process of Adaptation Training will be implemented whenever significant changes are expected or have been made, concerning equipment, regulations, operational procedures, the VTS environment or any other matter which is relevant to the performance of the VTSO."

The document focuses on the technical (how to perform) and the operational (when and for what purpose) aspects of the STM VTS functions. Although the possible risks and downsides with new technology always must be stressed and scrutinized the final decision of starting using STM, and to what extent, must lie with the competent authority and the VTS authority nationally. Legal aspects, to what extent the STM tools should be used and what back up measures that must be used as well is up to each responsible competent authority and VTS authority to decide.

The scope of this document is to show what is possible to do and how to train people to do this. The document is published as an appendix to this report, *BS_WP4.3 APPENDIX B, STM VTS SOPs Adaptation Training.*

6. Technical and Operational realization of the testbed

This chapter describes the technical and operational implementations by each partner. Implementations include new STM-services as well as descriptions of the procurements and new equipment. Operational capabilities e.g., how are we using them is also described in this chapter.

6.1. Fintraffic Vessel Traffic Services

Solution in Finland was implemented to present VTS software in use. Supplier received the tender as they are the sole provider that could integrate the new capabilities to Fintraffic´s existing VTS-software. This solution was selected to have the new capabilities in the operational software and thus available for all the VTS-operators in day-to-day work. The integration to Fintraffic´s operational systems was also chosen with project lifecycle in mind, 3rd party equipment and/or software wouldn’t have any use after the project testbed phase.

Technical solution is part of MARITAS, Maritime Traffic Authority System provided by Navielektro Ky, a private company based in Kaarina, Finland. Navielektro provides high-end situational awareness, surveillance, and communication systems for both civilian and military purposes. Their operations include software development and maintenance as well as manufacturing and maintenance of sensors. Navielektro aims to provide its customers with complete, integrated situational awareness solutions that span everything from operations centres to sensor networks.

In picture below is visualization of ships route in Fintraffic's VTS-system.

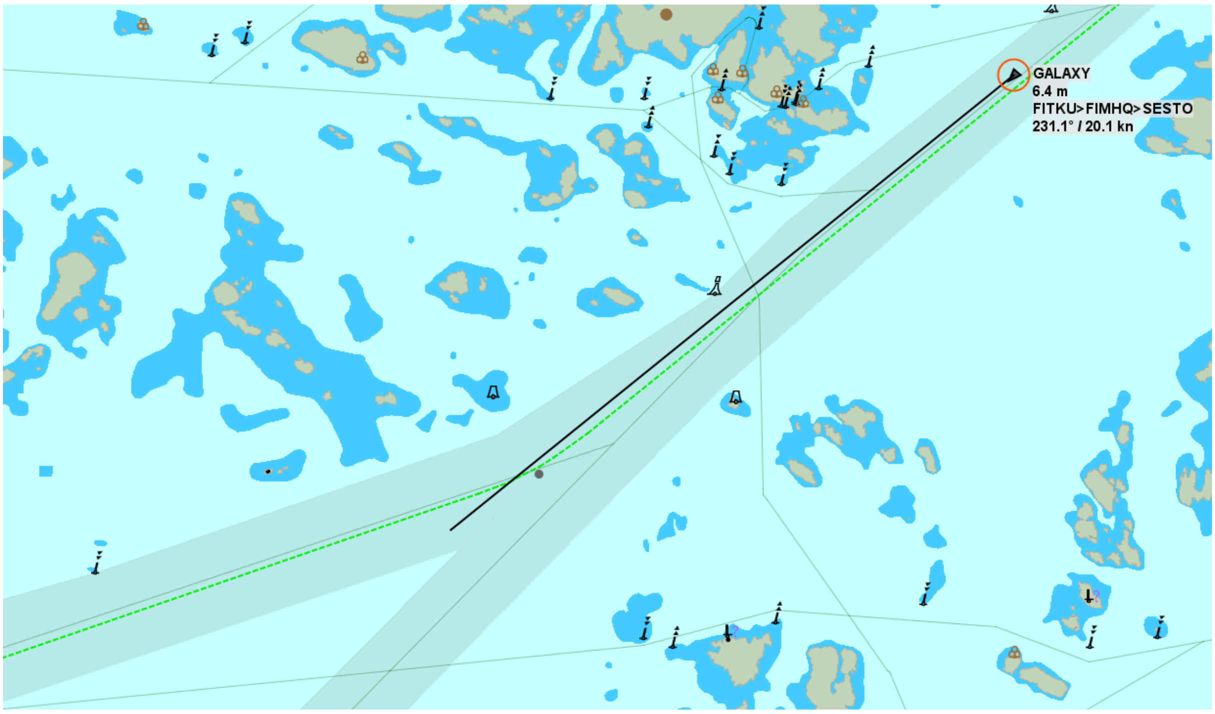


Figure 4. Visualization of ships route in VTS system

In present system version, many of the STM VTS SOP functionalities has already been implemented with a slightly different approach, within a system called "simulated routes". Practically, all ships have been assigned to an estimated route, and the functions have been run against the assigned route-estimation. Now, an additional layer has been added to the system, to visualize the actual route-plan of the vessel, and the route line is then assigned as the vessels "simulated route". Therefore, most of the implemented STM VTS SOP functionalities are not causing major changes to daily routines but changing the basis of the assumptions to clearly more solid direction.

In some parts, the STM VTS SOPs are managed with the already implemented functionalities, utilizing the 'simulated routes', and in some parts manually, utilizing the layer visualizing the route-plan. All of the STM VTS SOPs cannot be executed with present capabilities.

The services of STM VTS SOP's in VTS Finland are:

- Route Crosscheck: Manual
- Route Proposals: No
- Route Corridor Deviations: Yes, on open water manual, at fairways automated
- Predicted Rendezvous: Yes
- Close Quarter Situations: No

The key part of the implementation project were the functionalities relating to route distribution. Fintraffic VTS also managed to publish new added value service titled Aton Faults Service that provides ships with AtoN faults and navigational warnings essential for their voyage in return for their route.

6.2. Saint-Petersburg Vessel Traffic Services, Russia

As marine part of the first e-navigation testbed “Hermitage” created in Russia, the equipment was installed on a functioning VTS. VTS Saint Petersburg, operated by FSUE Rosmorport, provides services to ships in the eastern part of the Gulf of Finland. In addition to the usual VTS services, STM functions are performed by the operator at a separate Transas workplace consisting of two parts. The route exchange is carried out with the help of a planning station, a monitoring station is used for the traffic control.

Most often, operators interacted with STM vessels heading to the ports of St. Petersburg and Ust-Luga. It was noted that STM VTS SOPs reduce the time of information exchange compared to the usual one, and also reduce the likelihood of errors during interaction, however, it is preferable to exchange routes and monitor traffic at the same station.

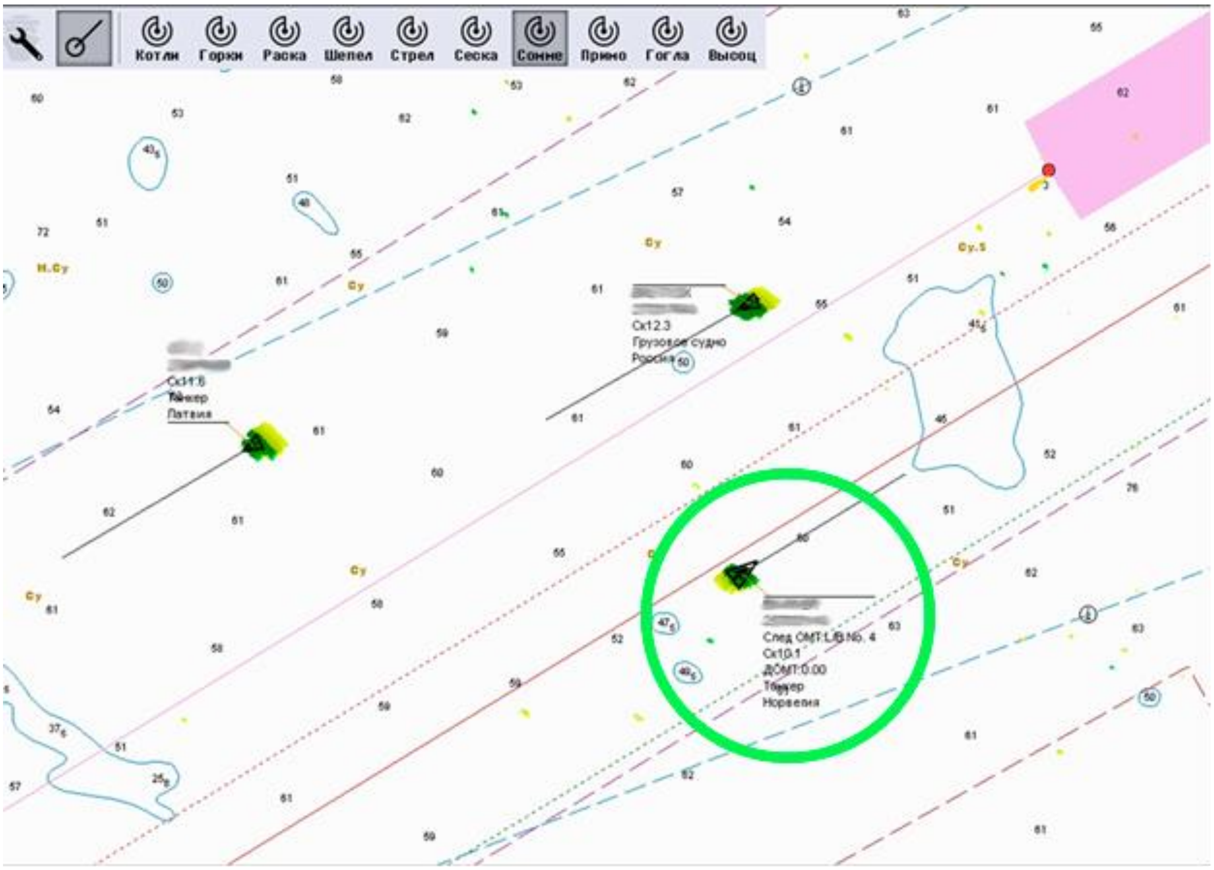


Figure 5. Route of an STM vessel proceeding in TSS

The services of STM VTS SOP’s in VTS Saint Petersburg are:

Route Crosscheck: Manual

Route Proposals: Yes

Route Corridor Deviations: Yes, automated

Predicted Rendezvous: No

Close Quarter Situations: No

6.3. The Norwegian Coastal Administration

The Norwegian Coastal Administration chose to implement the test to the VTS centre that previously participated in a similar test in the STM project. In the STM BALT SAFE project, new functions have been included, where ships and VTS would jointly test this through information exchange.

A VTS operator with prior knowledge and experience with the STM equipment previously tested at Kvitsøy VTS performed the test.

Kongsberg Norcontrol (KNC)'s VTS monitoring system "C-Scope" is used by all VTS’s in Norway. In order to carry out the STM BALT SAFE tests, KNC has further developed the STM equipment used during the STM Validation tests. This is still installed at Kvitsøy VTS as an additional system.

The services of STM VTS SOP’s in Kvitsøy VTS are:

Route Crosscheck: Manual

Route Proposals: Yes

Route Corridor Deviations: Yes, in Karmsundet, manual

Predicted Rendezvous: No

Close Quarter Situations: Yes

Figure 6. C-Scope system at Kvitsøy, visualizing the NCA ship routes

6.4. Vessel Traffic Services Sweden

In Sweden a procurement of a new VTS system were being done during the course of the STM BALT SAFE project. STM BALT SAFE specific requirements were included in the procurement documentation. Unfortunately, SMA withdrew from the contract with the assigned vendor due to information security issues which resulted in that no STM-tool were installed in the Swedish VTS system during the project time.

6.5. Vessel Traffic Services Estonia

New functionalities were installed in the Estonian Transport Administration's Vessel Traffic Management System (VTS/GOFREP) by SAAB late 2021. The upgrade brings a number of new features, the most notable being the STM module that allows end-to-end planning of vessel voyages. Other new features are improved traffic display software for the working positions, new route management functionality, integration of AIS route exchange and some technical improvements such as further virtualization of the software. The Estonian Transport Administration is a long-time customer of Saab, with the first order placed almost two decades ago.

7. Simulator exercises

One of the many areas in which STM can be applied is VTS. The opportunity to have approaching vessels´ voyage plans, their intentions, displayed in the VTS system well in advance brings great possibilities to strengthen the VTS´s capacity.

The new possibilities during this project have been described, and structured, in "Operational and Technical Use Cases of STM Compatible VTS Tools" and in Annex 1 STM VTS SOPs. In this document it is also described how the new STM VTS features are recommended to be merged into daily work and ordinary, regular national VTS SOPs. The process of how to train VTS operators in the practical use of STM functionality in VTS operations is further elaborated in the Annex 2: VTS Training.

It was evident at an early stage in the project, that not enough of real live vessels would be equipped with STM functionality to expect that a critical mass would appear in one VTS area at the same time. There simply would not be enough vessels in this projects time to test the VTS STM SOPs in a real live VTS area. Also, real hazard situations tend to grow on related VTS areas way too rarely to be able to collect enough structured data to make any kind of conclusions, in projects time. It was therefore decided that the STM VTS SOPs as specified in the STM VTS SOPs document were to be tested and evaluated in simulator trials.

7.1. Prerequisites for simulator trials

To conduct VTS simulator trials a few prerequisites must naturally be fulfilled. There must be a simulator with suitable staff and instructors. This simulator must be fully STM compatible meaning that it holds the ability to send and receive routes between simulator vessels and the simulator VTS. There must be VTS operators/test personnel, and they must be qualified and familiar with both the VTS area, the VTS System in general and with the new STM features. People observing and collecting data are also required.

In normal cases this is a quite complex task to arrange. During a worldwide pandemic it is not an impossible task, but it is very, very hard due to both travelling restrictions and the necessity to keep people apart, keeping a proper distance. The risk of having the disease spread in vital positions such as VTSes also made the whole simulations enterprise extremely hard to pull through.

7.2. The SMA simulator in Gothenburg

The Swedish Maritime Administration (SMA) has its own simulator in Gothenburg. The simulator holds four full mission bridges and two VTS stations. To be able to use this simulator in an STM VTS context it was necessary to supplement the two VTS stations and the four ECDISes of the bridges with STM compatible software. It was also deemed necessary to purchase four standalone units holding an ECDIS each. In that way eight STM compatible vessels could be presented in one simulator exercise or four vessels could be presented at the same time in two separate exercises (i.e., one per VTS station.) Since SMA´s simulator is of Wärtsilä make (former Transas) all additional equipment was procured from Wärtsilä.

7.3. The simulator staff

The same organization form that SMA previously has used when delivering VTS training was used during the simulations. The main responsible for the simulations were a former VTS Training Officer and a Simulator Instructor and maritime pilot, both of them employed by SMA. Extra staff was also brought in to send and receive routes from the vessels in the simulations. Technical support was provided by SMA´s simulator staff and remotely by Wärtsilä.

7.4. The test persons, the VTS operators

The previously mentioned STM VTS SOPs were written in the spring of 2021 by a group of VTS experts from Finland, Russia, Estonia, Norway, and Sweden. The original idea was to test the STM VTS SOPs in groups consisting of active VTS Operators from each country. Naturally the COVID situation made this extremely hard. Two of the participating countries, Russia, and Finland, had an absolute stop for VTS operators to travel. So did Norway but those restrictions were lightened up just before the second simulator runs (5th October to 7th October, the first runs were held 14th to 16th of September. Estonia could also contribute with VTS operators in the latter period. Swedish VTS operators were available at all times and an alternative would have been to run the simulations with only Swedish VTS operators. This solution was however not deemed to be in line with the purpose of the STM BALT SAFE project. The project is a cooperation between nations in the Baltic Sea region and it was therefore important to let all (possible) participating nations' VTS organizations to see the results of our efforts.

All in all, 16 unique test persons participated in the test trials. Four of them were Finnish, three Estonian, six Swedish and three Norwegian. In the table below each test person is noted with nationality and present position in respectively VTS organization. As can be read out of the table, nine of the participants are in active service as VTS operators or VTS supervisors whilst the other seven have connection to VTS and some knowledge of VTS, but they are not certified VTS operators in active service.

For a full analysis of simulations please study work package 6 report BS_ WP6.2.2 Validation of WP4. week 1 is 14th to 16th of September 2021 and week 2 is 5th to 7th of October 2021. Details of participants can be found in the next page table.

Test person's Number	Nationality	Position	Week
1	Finnish	VTS Consultant, STM, Fintraffic	
2	Finnish	VTS Development, responsible, Fintraffic.	
3	Finnish	Development Manager, ICT Services, Fintraffic	
4	Finnish	Consultant, Solita	
5	Estonian	VTS Operator/Supervisor	
6	Estonian	VTS Operator/Supervisor	
7	Estonian	VTS Manager	
8	Swedish	VTS Operator	
9	Swedish	VTS Operator	
10	Swedish	VTS Operator	
11	Swedish	VTS Operator	
12	Swedish	R&I Coordinator	
13	Swedish	R&I Coordinator	
14	Norwegian	VTS Operator	
15	Norwegian	VTS Operator	
16	Norwegian	VTS Operator	

7.5. The VTS area

The VTS area that was to be used during the simulations had to fulfil some criteria to be feasible. The VTS area had to be geographically small and compact. Otherwise, it would not have been possible for unaccustomed VTS operators to get familiar enough with the VTS area to act as VTS operators in the simulations. Yet the VTS area had to be complex enough to draw interesting scenarios in it. It was also deemed feasible if the Simulator Instructor who were to design the simulation scenarios were familiar with the area and that the particular area had been used before in the simulator. Therefore, it was decided that the Gothenburg VTS Area was to be used during the simulations.

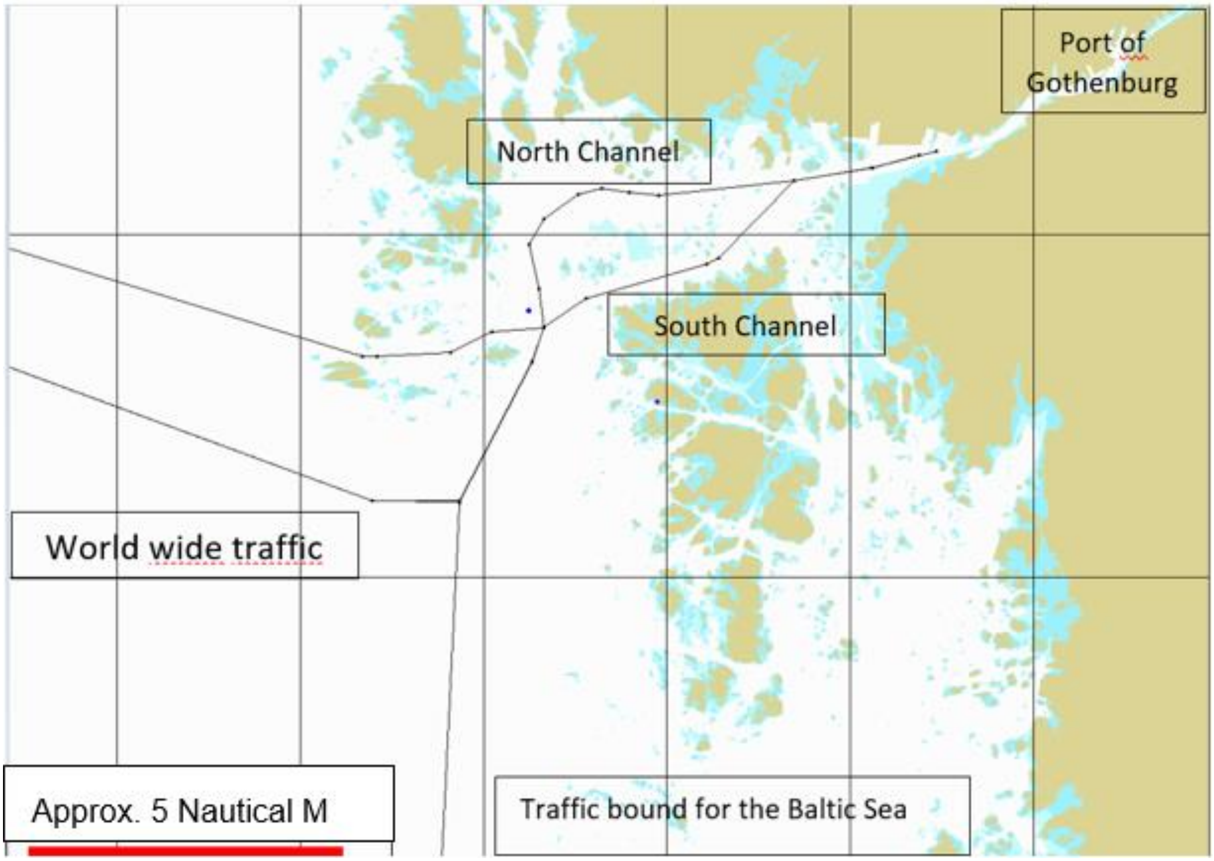


Figure 7. The VTS Area of Gothenburg

7.6. The VTS System used during the simulations

The SMA simulator in Gothenburg is of Wärtsilä make (former Transas). The HMI (Human Machine Interface) used in the VTSes were previously manufactured by Kongsberg since Swedish VTSes use Kongsberg systems. Unfortunately, the Kongsberg system used in the SMA simulator does not hold STM functionality. Nor does the bridges´ ECDISes (the vessels) in the simulator hold STM functionality. Upgrading of the equipment in the SMA simulator was consequently necessary.

The first that had to be done was to swap the original Kongsberg NorControl 5060 system with a Wärtsilä VTS system. The Wärtsilä STM VTS concept comprises of two systems, Navi-Harbour which is a traditional VTS system equipped with STM functionality and Navi-Port which more aims to facilitate JIT through the use of STM. Since both systems are highly important in a VTS using STM, both systems were purchased and installed.

Figure 8. The three screens of the VTS System NaviHarbour. These screens are used for monitoring of the Vessels.

It was also necessary to upgrade the ECDISes on the bridges of the simulator with STM capability. Since each of the four bridges only can represent one vessel at the time thus limiting the number of STM compatible vessels to four, it was deemed necessary to purchase four additional standalone-units (Wärtsilä ECDISes) each of them also able to present one STM equipped vessel each in the simulations.

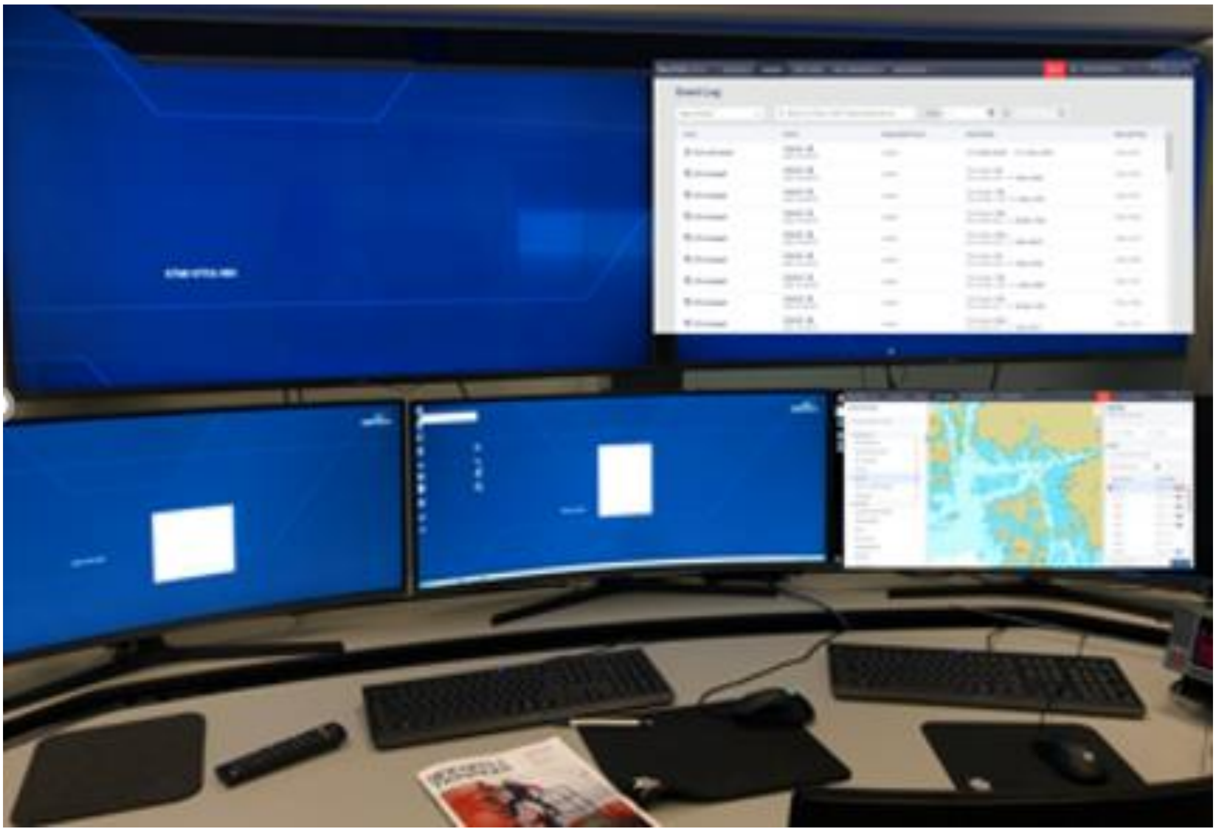


Figure 9. The two screens to the right were used for NaviPort which the part of the VTS system that is used for planning of routes and Route Proposals

Figure 10. Standalone ECDISes. Each of these standalone ECDISes represented a vessel in the simulations

7.7. The simulations

All in all, 16 simulator scenarios were prepared each of them approximately 30 minutes long except for one that was 60 minutes allowing time for a watch shift in the VTS. Since two simulator runs could be carried out in two separate simulations at the same time it was possible to have 32 unique runs per week. Two weeks of simulations would therefore have brought 64 runs to evaluate. Due to technical problems, not all simulations could be run fully, but it is fair to say that more than 60 simulator runs were successful. Counting man hours spent would therefore approximate to 16 x 2 = 32 (simulations per week), 32 x 2 = 64 (simulator runs in total over two weeks), 64 x 2 = 128 (two test persons in each run), 128 x 0.5 = 64 (each run is 30 minutes long) and finally approximately 4 runs had to be deducted due to technical problems. Thus, about 60 man-hours were spent in testing the STM VTS tools.

The simulations were arranged in such way, that the first half of them aimed to familiarize the test persons with the Gothenburg VTS area and traffic image, the VTS system in general and with the STM functionalities in special. The latter half of the simulations were of a more applied character. The VTS operators, the test persons, were given enough information about the traffic situation in the upcoming simulation and then they were instructed to do their very best to do their job as they would have done in their ordinary job. The VTS operators were also advised that the simulator scenarios would be quite busy and that they had to keep their spirits up even if they failed. A lot of different situations were to be tested during the runs; the time had to be used as efficient as possible.

7.8. Evaluation of the simulator trials

Two things, two perspectives, were to be evaluated in the simulations. The first one was the human factor side of bringing in STM to a VTS context. How tricky was it to learn the new features? How much extra workload/stress did they bring? Or did they ease the workload? The second perspective were of a more operational perspective. Were dangerous situations discovered at an earlier stage with the new STM tools? Did the information sharing of routes enhance safety?

The task to carry out data collection and evaluation of the simulations were given to RISE (Research Institute Sweden). Their findings can be found in their respective work package 6 deliverable

8. Reflections and conclusions

Project yielded lots of data that is to be screened to find the essential points that are usable in further development of route sharing capabilities and platform economy. Many observations were made in the course of the project which are reflected in this chapter against prevailing industry standards, current systems, current operative measures in vessel traffic services & shipboard activities. The current regulative state of the vessel traffic services, and adjoining affairs is also reflected.

8.1. Highly interactive

All relevant progress was made in workshops where level of participation was high, and the various point of views could be raised and managed. Documentation and online meetings only recorded the work made in workshops. Especially the need to understand the differences in the different VTSs required a lot of explanation and whiteboarding.

Here the virtual working environment, mandated by travel restrictions, fell short in providing sufficient means to said interaction. For future projects this is important to realize that on-site interacting is still required for success full innovation to happen.

8.2. Reflections on the work package 4 work

Participating coastal states had quite similar reflections on the work of STM BALT SAFE. What is common that further development of route sharing capabilities will happen, in national or international stages.

The STM BALT SAFE project was meant to be a follow-up and an implementation project to previous projects like MONALISA, MONALISA 2.0 and STM Validation. An absolute prerequisite for doing this in a VTS context was that both the vessels and the VTSes would be STM compatible. The VTSes had to have a VTS system with STM functionality and the vessels had to have ECDISes with the corresponding functionality. Having all this technical equipment procured, delivered, installed and this to such an amount that the impact of the innovations would be visible in real life daily operations was not easy in the period of COVID 19. VTSes in Finland, Russia, Estonia, and Norway were equipped with STM compatible VTS systems and the vessels did share their voyage plans with the VTSes. Technically it worked but to see the true effect of bringing in STM to VTS there were too few STM vessels present at the same time in any VTS Area.

To try to get any understanding of how STM would affect daily VTS work simulator tests were held. Trained VTS operators from Finland, Estonia, Norway, and Sweden were invited to test the STM functions under such as realistic forms as possible.

The STM system´s foundation is sharing information digitally and interoperable. In the case of VTS the information to be shared is the voyage plans, the intentions, of the vessels. Having this opportunity to scrutinize all vessels` intentions in advance would give the VTS enhanced capability to foresee potentially dangerous situations in traffic image of the VTS area.

The experiences from the live VTSes and the simulations are fairly aligned. STM has a clear potential and most likely it will facilitate the capability of the VTS to enhance efficiency, safety, and environmental sustainability in maritime transportation. There are still obstacles to tackle both technically and operational and there are issues that need to be addressed but in general the introduction of STM in to VTS was regarded as positive. The conclusion of this must be that further developing and application of STM in VTS is required.

In Russia, the development and application of the STM concept will continue in the following national projects. It is also planned to apply the concept within the framework of the upcoming autonomous navigation project.

Estonian Transport Administration (former Maritime Administration) also sees route and digital information exchange as a huge step towards ensuring safety. In addition, it will form a base for development of autonomous vessels management. Together with renewal of technics there is need for training of VTS personnel and also development of relevant and standardized procedures.

Norwegian Coastal Administration found many challenges in the work concerning work package 4. Challenges were similar to those faced in STM Validation. The installation of STM compatible equipment onboard test vessels was delayed so STM BALT SAFE testing could not be carried out, despite the extension of the project due to the pandemic. It was a similar experience with the STM validation tests. At that time, only a few of the vessels that used the VTS area had received test equipment on board by the end of the project period, despite the fact that the project period had been extended.

For STM Balt Safe and similar projects in the future, the installation of test equipment onboard ships should start at a much earlier stage. Manufacturers must have equipment completed and approved earlier in the project so the evaluation of the project can be carried out with all the necessary components in place in order for it to be operationally tested as a future standardized product.

The Norwegian Coastal Administration see the potential of STM BALT SAFE project with the exchange of information and digital services. The project is only in the start-up phase and it needs to be further developed, harmonized and the users to be involved. As a project we have come a few steps on our journey and need to work further with the concept and therefore it is recommended that this continues into a new project.

Fintraffic VTS is also continuing the development of route sharing activities and maritime connectivity by participating in global harmonization work governed by Maritime Connectivity Consortium. Further planned project will mostly handle the timely arrivals of vessels but sharing of monitored route might be one actor in providing accurate arrival forecasts.

8.3. Methodologies

The methodologies chosen for documenting the STM BALT SAFE work is not natural for VTS operators as they seldom have any training in the framework chosen to document projects. Using methodologies from the enterprise architecture and modelling domain can inhibit innovation as the functional user do not understand these techniques. This led to difficulties when trying to document work as it too often is removed from the operational context, when trying to fulfil the projects methodological requirements. It should be noted that this is not specific to this project, but for most projects.

Problem is that when capturing requirements and developing models, users start to think about implementation details and try to fulfil technical designs too early and most conceptual modelling techniques accentuate this behaviour. Using more innovation, like service design, driven methods might lead to more innovation and discussion between functional and technical people.

8.4. Technological assumptions

The functional domain has its own technological assumptions (e.g., radar, VHF, ais) which impose restrictions on how things are done today. This has two implications on creating (and innovating) new services:

- The VTS operator (incl. management) tend to think around the current technical limitations not considering the possibilities provided by new technology.

- As the “system” (namely regulation around VTS and ship equipment) is globally regulated the technological advances do not occur in an instant. This requires a lot of parallel planning, which inhibits (or slows down) out-of-the-box thinking.

Moving forward this suggests that this needs to be considered in further projects. Every project should ask if it is geared toward changing the current production (e.g., the real life) or if it is providing input to standardization. For example, this work package tried to do both; influence standardization of VTS and to provide new tools for use in the Baltic Sea. This applies also to the development of IT-support tools; are they for demonstration or production purposes. Sometimes a good demonstration, instead of talking about functionality, might change the general opinion about new tools.

Letting the technical people just build a demonstrator and then argue around the pros and cons on this demo, can be one way to drive innovation.

8.5. Perceived complex system

The described system has multiple interdependent components, which to a nontechnical person, seems like one system and therefore is quite difficult to understand and enhance.

The VTS uses one system, a ship uses multiple systems (backbridge and ECDIS), and authorities use their own. Remembering that these are systems developed by different companies is easy to forget and these systems currently are not interacting (that is what we have been trying to define)

In projects a common ground between stakeholders (functional and technical) needs to be established early in projects of this nature in order to find common ground before trying to create new functionality. Sometimes this requires teaching each other first and respecting each other's strengths and shortcomings.

8.6. Expectations from non-participating partners

The intricate complexity of projects of this magnitude makes the project dependent on companies and products that are not part of the project, which makes the project dependent on parties that are not committed to the project goals. These dependencies should be identified and managed early in the planning stage of projects.

STM BALT SAFE is good example of a procurement intensive project where in relatively short time there was supposed to have new capabilities developed, procured and in operational use. The systems that were to be developed are highly standardized and/or dealing with national security and safety such as preparedness.

8.7. Technological reflections

Several technological reflections need to be considered when implementing such capabilities as presented in this project. The ecosystem that we are working with has severe shortcoming that, at this present stage, have proved to provide hindrances to development and actual operational use.

The fundamental of platform economy, which is what these capabilities described in this project generally are part of, is the connectivity to internet. However, ship is not always online and considering the general status of ships trading worldwide it still is not common to have reliable satellite connections. Situation is improving though as satellite connections are becoming more affordable. In general, lack of connectivity means that cloud services or other services via internet are always not available and this must be least taken into account when developing new services. Ship being offline also prevents certain data distribution from the ship to other ships and shore stations, where outdated information might cause some false conclusion on ships actions etc. The receiving end should have a way of figuring out if the data is outdated.

The IMO has recognized the threat of cyber-attacks in the marine industry and will require ship operators to consider cyber risk management as a part of their safety management system. STM-concept has had a lot of effort on the subject of information security and identity management amongst other factors but for the ship operators or ship crews these efforts might come secondary as the primary concern is still the WIIFM (What's in it for me?) often addressed in change management.

The STM is one, although the most advanced, way to utilize the RTZ-standard and the possibilities in route-exchange. Still, the compatible ships and VTS centres are low in number, the service catalogue is paid to even see the services registered and there are no options for it, at least not easily chosen onboard. These issues might to be resolved in relatively near future, but it is good to recognize that the RTZ-capability is becoming more common on any ships due to IEC 61174 (Operational and performance requirements, methods of testing and required test results of ECDIS). It is far-sighted to keep all possible means open to send and especially receive and display routes in RTZ, apart from what kind of equipped sources they come.

9. Recommendations

9.1. Standardization

There are lots of standards governing the navigational equipment such as aforementioned IEC 61174 that considers the operational and performance standards of ECDIS. The regulations dealing with navigational equipment are not to be taken lightly, compared to relatively loose standards & regulations governing the vessel traffic monitoring systems. What is however missing is standardization of the procedures dealing with route sharing and for example the presentation of different routes and data on screens in VTS or onboard.

Common procedures for sending and receiving routes need to be compiled eg. we need to answer the question why one should share their route. For the project to advance further from testing phase these motives need to be clear, input without any reaction or value will not carry far. It should be clear to all parties what will be done with these routes. Providing reaction to routes creates trust between different actors and standard will evolve themselves. Before the aforesaid can be accomplished there are other issues to be resolved such as the requirements of the routes, with or without schedule, is the route monitored or not and so on. STM BALT SAFE work package 6 has meritoriously studied the problems in certifications & standardizations in their deliverable BS_WP6.3 Product Certification Schemes, Operational Data Analysis and Remote Testing.

9.2. Cloud-based services

Cloud-based services are transforming the way we work. We can store data, run applications, stream videos, manage email, or carry out many other activities on the servers. With an internet connection, we do not need to run the apps or store the data on our own devices or manage our own servers. Cloud platforms are fantastic when it comes to flexibility and scalability, up-time, simplicity, and off-site backups. On the other hand, they face ongoing challenges with privacy, security, and authentication.

Improving internet access onboard ships brings mariners closer to utilizing cloud-based maritime services in their work. We still have a long way ahead of us when it comes to relying on cloud-based services in maritime domain, especially for any critical function. In this context where we are bringing new capabilities to navigational equipment there should be careful consideration when it comes to implementing new functions to shipboard equipment that are governed by performance standards set by IMO and IEC for example. Things that need consideration are whether it is viable to have the shipboard equipment perform tasks such as meeting point calculations, or should it just receive information that is output from tasks performed somewhere else. This needs to be examined case by case basis taking account the available internet connection and the amount of data to be transferred, the complexity of the task in hand and current regulations considering the shipboard equipment.

9.3. Expanding ecosystem

Previous chapter stated that cloud-based services are inevitably the future also in maritime domain. IALA guideline G1161 *Evaluation of Platforms for the provision of Maritime Services in the context of E-navigation* describes several legacy platforms that are used to deliver information. What is common between these several platforms is that they are not interoperable at all and they are from times when this so-called platform economy was not yet widely known.

It is nowadays recognized that standardization is the key to functioning and expanding ecosystem. Advantages include using the same procedures for authentication, authorization, encryption, discoverability as defined in S-100 and the overall service management such as registration. Harmonization and interoperability between different platforms and maritime services are goals to be pursued.

Considering the aforesaid facts, the development must be guided to direction where there shall be many interoperable service platforms with no centralized governance. Devices, whether shipboard equipment or other should have the option to utilize several different decentralized platforms.

9.4. MCP

The services defined by MCP are a fundamental building block for a global maritime infrastructure that support a disparate party of the maritime community. These services have been a valuable as a part of the STM effort.

When talking about MCP it is important make a clear distinction between the two central building blocks: namely 1) certificates and 2) service registry. The certificates provide the trust needed by parties to be able to communicate with each other, without having any previous agreement (like a Chinese ship entering the Baltic for the first time).

The service registry provides information where services can be found. These services can be mandated by authorities and provided by commercial entities. For example, a ship new to a specific area can query the local reporting obligations such as SOUNDREP and GOFREP as well as using a commercial service provided by a company for example a fuel optimizing service for a specific route.

9.4.1. Globally federated

A centrally managed MCP is neither practical nor technically viable, due to its scale. This has been recognized in the MCP charter and its early works. However, this is still work in progress.

Building a network of federated MCP nodes either as country specific or area specific where different countries based on proximity such as in vicinity of the Baltic Sea could share the infrastructure. Logical clustering could be based on traffic e.g., where trade routes follow patterns like feeding Baltic from northern European hubs.

It seems logical that this underlying trust needs to be based on international agreements, like IMO.

9.4.2. Role of flag state and authorities

The ship and its staff are certified by the flags state of said ship. This implies that the ship registers and authority certifying staff are the logical entity to provide the required trust in the federated network for ships, crew, owners, and agents. This is no different than the current situation except we currently use paper-based certificates.

Note that a shipowner can in this network delegate authorizations to agents and such.

The authorities should register their (see “Costal state service” below) services in the authoritative service registry for their area responsibility, be that navigational or administrative.

9.4.3. Commercial interests

The commercial interest is twofold. Firstly, the various systems being used in the maritime community needs to support authentication and service discovery through MCP. Vendors need to build this as basic functionality be that onshore, backbridge, ECDIS or VTS systems. Wide adaptation requires that these should be open with very low barriers to join eg. free to implement and basic use.

Secondly commercial entities should be able to register their commercial services in the MCP. Registering a commercial service could. The commercial entity could charge the user for services rendered.

9.4.4. MCP conclusion

The idea is sound, but the future of MCP is dependent on finding the balance between commercial interest and the trust provided by flag states. The underlying federation of mandatory services and trust is difficult to build on commercial interests alone. The underlying funding needs to be public, for the core MCP infrastructure. In the long run it can be made self-financing through the commercial services, while still providing the needs of authorities free of charge. Optionally flag states can cover their costs via mandatory fees for certificates.

9.5. Message broadcasting

Moving forward STM should consider using broadcasting or some other means of sending same message to multiple receivers.

This functionality closely resembles the “overhearing effect” that the VHF channels provide to ships in the same area.

The operational aspects should be analysed and the need to broadcast everything should be considered carefully before implementation. It is not evident that everything should be automatically broadcasted to everyone in the area.

All and all, the task to reduce communications over VHF by implementing STM-messaging functions, turned out to be way too challenging to solve in the project's frames. Although VHF seems very simple and old technique, it has a bunch of features that are hard to outdo easily; it is well-known by all, cheap and comprehensive. Listening to VHF you are aware of what happens around in your location.

On the other hand, the quality in VHF broadcasts is often low, there is nowhere to re-listen the message again if you miss it, the range is very limited, channels are very limited, anyone can claim to be anyone, there are no very good means to restrict the receivers and there are no means to filter the broadcasts one receives.

With today's technique, when we all carry a dozen of messaging applications for different situations in our smartphones, it is very hard to believe that the VHF really is the best possible communication method available in maritime context.

Due to the complexity and relevance of the subject, it should be studied at least in an own future work package, if not a whole project.

9.6. Create portfolio of Costal state service

The monolithic VIS portfolio of services was originally written to represent a ship. It has during various projects been used to describe land-based information services. This has led to services which implement only a subset of the VIS specification and they have become hard to understand as they are described only as instance documents to the VIS specification.

One of the challenges is that every costal state is slightly different in terms of legislation and separation of concerns. Another challenge is that the systems are very different when it comes to supporting the ships. e.g., in one VTS there is only one system for everything and in another centre, there can be multiple systems supporting different aspects of Costal services.

Creating a portfolio of standalone service specifications for shore-based services should be considered. This would give each costal state and its administrative functions the freedom to choose which agency (and which system) provides specific services. By registering each service as a standalone in an MCP service registry it would be easier to document, find and implement said services.

The IALA draft document GUIDELINE 1089 PROVISION OF VESSEL TRAFFIC SERVICES (VTS) could be a good starting point to start identifying costal state services, with focus on VTS. These services should be implemented using specifications extending the IHO S-100 framework. for example, S-127 and IALA S-212.

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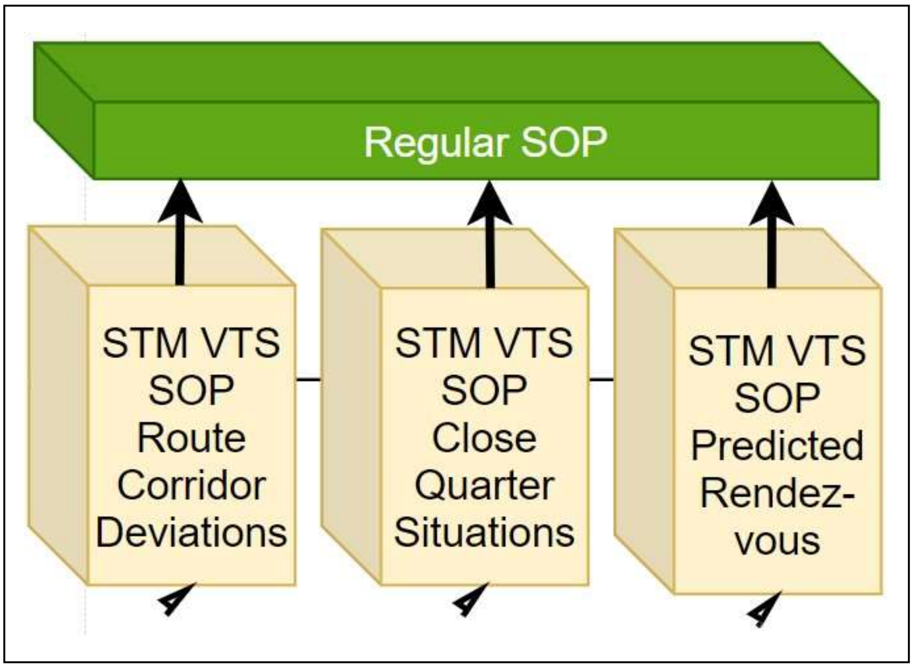

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Table of contents

1 INTRODUCTION

The purpose, aim and scope of VTS (Vessel Traffic Services) has remained the same since the beginning in the late 1940s. Efficiency, Safety and Protection of the Environment is to be enhanced in maritime shipping by surveillance of ship traffic from ashore and providing advisory information to the ships´ Officers and pilots.

To be able to do this a few requisites must be fulfilled. There must be a VTS Centre, there must be a VTS Area and there must be VTS Operators. The VTS Centre must hold a VTS System for monitoring of large sea areas and the VTS System must have proper sensors e.g. radar, AIS (Automatic Identification System), CCTV (Closed-Circuit Television), weather measuring stations etc.

Over the years VTS Systems and sensors have been developed and improved. Originally the VTS System comprised of a shore-based radar set and means for radio communication. The radar image would later on be presented in an ENC (Electronic Navigational Chart) and the radar was also equipped with ARPA (Automatic Radar Plotting Aid) which made it possible for the VTS Operator to predict the upcoming movements of the Vessels in the VTS Area without manual calculations. The introduction of the AIS (Automatic Identification System) in the 1990´s made it possible for the VTS Operator not only to discover upcoming potentially dangerous situations but also to see the names and call signs of the vessels that were involved in the situations. AIS also increased situational awareness, both on the ships side and on the shore side, since it depicted the vessels and their movements much more clear then what was the case with only radar.

On the Vessels´ side the development of technology was similar. Instead of using paper charts and visual fixations of lighthouses etc. to determine position and where to steer, the ECDIS (Electronic Chart Display and Information System) came into common use. The onboard ECDIS and the modern VTS System, both presenting an image of the traffic situation in an Electronic Chart, are each other’s equivalents. They differ a bit, but basically, they are each other’s match.

When the ECDIS and the modern VTS system came into common use the prerequisites for Data Exchange and Information Sharing was fulfilled. Several EU co-financed Projects as MonaLisa, MonaLisa 2.0 and STM (Sea Traffic Management) Validation started to explore the possibilities to strengthen Efficiency, Safety and Environmental Protection by means of the sharper Situation Awareness made possible through Data Exchange and Information Sharing.

2 PURPOSE AND INTENDED READERSHIP

The purpose of the present work is to point out how the new forms of STM information sharing can be brought in to daily VTS work. To provide a clear and traceable structure each one of the five new STM features is introduced in its own STM VTS SOP. The overarching STM VTS SOP Interdependence has been drawn up to explain the relations between the five STM VTS SOPs. This work also aims to give guidance in how to merge the STM VTS SOPs in to already existing national regular VTS SOPs.

The present work aims to provide VTS Supervisors, VTS Instructors, VTS Managers and VTS Authorities in general with guidance on how Data Exchange and Information Sharing by means of STM functionality can be utilized in a VTS context. The aim is not to present complete step by step instructions on how to carry out the processes but a higher-level overview. A more detailed work instruction to be used in daily operations must be done locally, in cooperation with the respective VTS System manufacturer and approved by the VTS Authority.

Nor does this work aim to establish a rigid set of rules to follow for anyone planning to purchase a STM compatible VTS system. It should rather be regarded as a flexible example of how to insert STM VTS SOPs into an already existing structure of national regular SOPs.

3 DEFINITIONS AND CLARIFICATIONS

3.1 Different formats for routes

A concept that needs to be clear in this work is the route. Basically, a route is a route regardless of it is presentation method or format. It will always be a route connecting two places with intercepting lines and waypoints. But in this context, it is particularly necessary to be able to distinguish between four types of *expressing* a route.

1. **The basic route**, just any route. It describes the way from point A to point B, in any other format than RTZ, including a line drawn on a paper chart and files from ECDIS in proprietary file formats. Assumed to be originated from the Vessel or its representative.
2. **The RTZ route** is a route expressed in the Route plan exchange format - RTZ, independent of which RTZ version used. This Route Plan Exchange Format is based on standardizing a single route plan (IEC 61174 v.4 Annex S.1). The latest schema files can be retrieved from http://cirm.org/rtz/index.html. When writing, available versions was the original 1.0 and Publicly Available Specification (PAS) 1.2, which incorporates version 1.1 that was developed, implemented and tested by participants in the STM project.
3. As a generic idea, the RTZ has a need to ensure that there is a possibility to keep extensions from different manufacturers in single file (IEC 61174 v.4 Annex S.4.1). **The STM Route** is written in RTZ version 1.1 with STM extension as defined at https://www.seatrafficmanagement.info/developers-forum/schemas/ in section "RTZ FORMAT + STM EXTENTION" and can be shared by STM compatible Vessels and VTSes.
4. **The simulated route** is not originated from the vessels navigation system. The vessel is attached to this route by the VTS Operator. The route may origin from a VHF call from the Vessel, a descriptive email, or it can be retrieved from a Route Library based on the experiential assumptions how certain vessels travel in certain areas, AIS track history etc. The simulated routes are used to enable the VTS Operator to surveil that the Vessel follows its expected route even without the Vessel´s precise digital route plan.

3.2 Definitions and clarifications in general

Automatic Identification System – Radio modem that automatically exchanges static (identity) and dynamic (navigation) data between ships.

Cross-Track Distance – The distance that a ship can deviate from its monitored route line before having alert. Defined in RTZ. See also VTS-defined XTD.

ECDIS - Electronic Chart Display and Information System. In this on board computer information from AIS, radar and possibly other sensors are gathered and displayed in an Electronic Chart. The ECDIS is today´s main aid to navigation. The same computer is usually used for sending and receiving Voyage Plans. It is not necessarily done in the same process as where the navigation calculations are carried out but in the same computer. A route received from the VTS can easily be used in the ECDIS process.

Fairway Library – Database containing pre-made routes e.g. routes used by pilots.

Information Service (INS) – An information service is a service to ensure that essential information becomes available in time for onboard navigational decision-making. See IALA VTS Manual for exact definition.

Monitoring - In conjunction with VTS the word monitoring is equivalent to surveilling. On board the meaning of “monitoring” may also indicate the route that the Vessel is following for the moment. This is the route that “has been taken in to monitoring” in the Vessels ECDIS.

Navigational Assistance Service (NAS) – Navigational Assistance Service is a service to assist onboard navigational decision-making and to monitor its effects. See IALA VTS Manual for exact definition.

RTZ – Route plan exchange format. Route plan exchange is used in conjunction with ECDIS to IEC 61174 (RTZ version 1.0) and IEC PAS XXXXX (RTZ version 1.2). The route plan exchange format is based on standardizing a route plan. A route plan consists of waypoints where each waypoint contains information related to the leg from the previous waypoint. The route exchange format is a file – RTZ – containing an XML coded version of the route plan. RTZ XML schemas are defined by CIRM listed at

http://www.cirm.org/rtz/index.html

Schedule - The estimated timing of a voyage, i.e. ETA/ETD of waypoints, speed on legs, etc.

Sea Traffic Management – A concept based on data Exchange and Information Sharing. The bearing beam is the idea of that if all actors´ (in this work ships´) intentions are communicated it will promote Efficiency, Safety and Environmental Protection in maritime shipping.

Ship Reporting System – SRS aims to keep a vigilant eye on the sea traffic. In cases of rendering help, the systems enable to give pieces of information about navigational hazards, medical advice, directing the closest ship towards the vessel in peril, and defining the area of searching SRS may be voluntary or obligatory.

Standard Operational Procedure – The documentation governing the VTS service. It defines everything pertaining the management, development and operations of a VTS.

STM Balt Safe – An EU co-financed project in which the present work has been written. The STM Balt Safe Project is a follow up project following MonaLisa, MonaLisa 2.0 and STM Validation Project aiming to implement findings from previous projects.

STM Compliance implies that ships are equipped with STM compatible bridge systems or VTS with STM compatible VTS systems.

Traffic Organization Service – A Traffic Organization Service is a service to prevent the development of dangerous maritime traffic situations and to provide for the safe and efficient movement of vessel traffic within the VTS area. See IALA VTS Manual for exact definition

Vessel – When the word Vessel is mentioned in this work it usually refers to a ship or Vessel navigating, or planning to navigate, in the VTS Area. The word Vessel also refers to the ship´s captain and crew. E.g. if it reads in the text that “the Vessel shares its Voyage Plan with the VTS” it means that the Captain or someone authorized by the Captain sends the Voyage Plan to the VTS by means of the Vessel´s ECDIS.

Vessel Traffic Services - VTS – are shore-side systems which range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to extensive management of traffic within a port or waterway.

Voyage Plan – A representation of the planned way to get from point A to point B, consisting of a list of waypoints (geometry) and information associated with the legs between waypoints, plus a Schedule, describing the planned time axis of a ships voyage.

VTS Area – Area in territorial waters in which VTS is provided to the merchant fleet.

VTS Authority – The national authority responsible for delivering Vessel Traffic Services.

VTS-defined XTD – XTD (Cross Track Distance) that is defined by the VTSO. The XTD is relative to the route line. The opposite is when the XTD is defined by the Vessel´s captain.

VTS Instructor – Person involved in training of VTS Operators and/or Supervisors.

VTS Operator – The Watch keeping person in the VTS. In general terms there are two different ways of recruiting VTS Operators. Either you employ ships officers and give them a fairly short VTS Operators training often about one or two months or you employ persons with little or no seagoing experience and train them for a longer period perhaps about a year. The main task of the VTS Operator is to monitor sea traffic and to prevent maritime accidents by giving Vessels Information, Advice etc.

VTS Supervisor - VTS Centres surveilling large VTS Areas or Ports often divide their Areas into different Sectors having one VTS Operator responsible for each Sector. A VTS Supervisor is the leader for a shift of VTS Operators.

VTS System - In the context of this work VTS System refers to the system used by the VTS Operator when surveilling sea traffic. In this work it is also assumed that this system is STM compatible i.e. it holds the possibility to share Voyage Plans with the Vessels in the RTZ format.

Waypoint - A position marking the intersection between two legs in a Voyage Plan.

4 ABBREVIATIONS AND ACRONYMS

AIS - Automatic Identification System

ARPA - Automatic Radar Plotting Aid

CIRM – Comité International Radio-Maritime

CPA – Closest Point of Approach

CQS – Close Quarter Situation

ECDIS - Electronic Chart Display and Information System

GOFREP - Gulf of Finland Reporting scheme (supported by the VTS's in the Gulf of Finland)

IALA - International Association of Lighthouse Authorities and Aids to Navigation

INS - Information Service

NAS - Navigational Assistance Service

OOW – Officer on Watch

REGSOP - Regular Standard Operational Procedure

REGSOP MIX - Regular Standard Operational Procedure Mix. (A STM VTS SOP mixed in to REGSOP.)

RTZ - Route Plan Exchange Format

SOP - Standard Operational Procedure

SRS – Ship Reporting System

STM - Sea Traffic Management

STM VTS SOP – SOPs developed in the STM Balt Safe Project to be fitted in to REGSOPs.

TCPA – Time to Closest Point of Approach

TOS - Traffic Organization Service

TSS – Traffic Separation Scheme

VHF – Very High Frequency, radio frequency range. Common way of communicating ship to VTS.

VTS – Vessel Traffic Services

VTSO - Vessel Traffic Service Operator

XTD – Cross-Track Distance

5 STANDARD OPERATIONAL PROCEDURES

To both describe and explain a process and to provide a user of a process with step by step instructions on how to conduct the process, SOPs (Standard Operational Procedures) are often formed. The overall aim of a Standard is to promote efficiency, uniformity and quality output. Reducing miscommunication between, or within, processes is also within the scope when forming SOPs.

5.1 Standard Operational Procedures in VTS

When forming Standard Operational Procedures for VTS, IALA gives guidance in G 1141 OPERATIONAL PROCEDURES FOR VESSEL TRAFFIC SERVICES and in RO127 (V 127) - VTS OPERATIONS. In general IALA distinguishes between internal (e.g. staffing, managing, equipment etc.) and external procedures (e.g. participating Vessels, allied services such as Pilots etc.) A distinction is also made between routine and emergency procedures. The STM VTS SOPs (below) are meant to be add-ons to be inserted where applicable.

5.2 STM VTS SOPs

In all we bring in five new processes based on the concept of information sharing to the VTS context. Each process is described in its own Flow Chart (see sections 6.3 to 6.7) and the processes are named STM VTS SOP followed by a name describing what is in the particular process e.g. Route Crosscheck.

6 THE STM VTS SOPs DEPICTED IN FLOW CHARTS

The five STM VTS SOPs describe and explain the processes of Route Crosscheck, Route Proposals, Route Corridor Deviations, Close Quarter Situations and Predicted Rendezvous. STM VTS SOP INTERDEPENDENCE is presented to indicate where, when and by whom each of the five is to be utilized during a Vessel´s sea voyage.

6.1 How to read the Flow Charts

All of the Flow Charts should be read from left to right to catch the timely flow. Looking at the Flow Charts from top to bottom will indicate who is doing what in the processes. Basically there are three “doers” the Vessel´s Officers, the VTS Operator and the VTS System.

Whatever action is done, is described within boxes in the charts. Should the box be framed with a solid black line, it indicates that the action is to be taken by the VTS Operator. Any solid black line leading to an “action box” is something that the VTS Operator must pay attention to, and the same goes for a solid black line leaving the “action box”. The dashed framed boxes and lines indicate that this is information exchange, or processing, between “machines”.

In several places in the STM VTS SOPs the black solid line will end in a green box with white text reading “REGULAR SOP”. This indicates that the VTSO now must deal with the situation e.g. a Close Quarter Situation in accordance with the regular SOPs of his or her VTS.

6.2 STM VTS SOP INTERDEPENDENCE

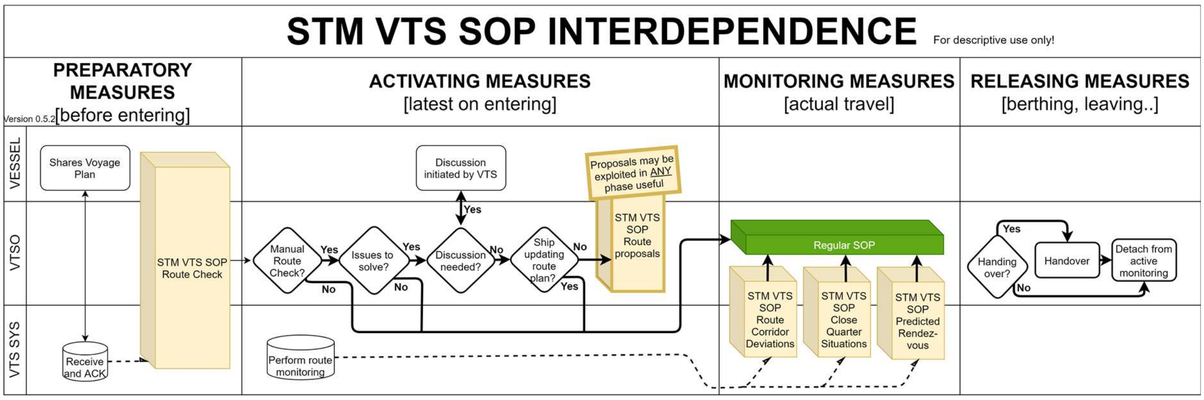


Figure 1 STM VTS SOP INTERDEPENDENCE

INTERDEPENDENCE has four different timely phases, Preparatory Measures, Activating Measures, Monitoring Measures and Releasing Measures. The phases follow the sea voyage of a vessel in the sequence of pre-entering, entering, monitoring (when the vessel is navigating through the area) and leaving the VTS area. It should be noted that INTERDEPENDENCE can describe either an inbound or an outbound Vessel´s voyage. Preparatory measures can be made outside the VTS area or at berth or anchorage within the VTS Area. Activating Measures can be carried out when the Vessel is about to enter the VTS area from sea or when it is about to leave a berth or an anchorage within the VTS Area.

6.3 STM VTS SOP Route Crosscheck

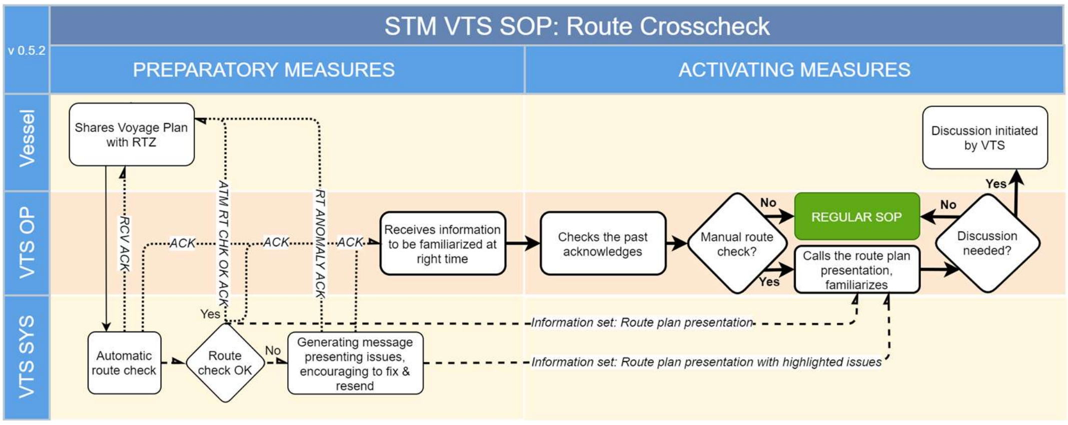


Figure 2 STM VTS SOP Route Crosscheck

To have any kind of Data Exchange and Information Sharing there must be at least two computers and something to share between them. In our case the two computers are the ECDIS of the Vessel and the VTS System of the VTS. What is to be shared is the Voyage Plan of the Vessel. If this is not done the rest of the processes (6.4 – 6.7) falls.

The Vessel must first make an active choice to share their Voyage Plan with the VTS. Having received the Voyage Plan the VTS System will automatically perform a Route Crosscheck. What criteria are to be checked may vary, but at least the safety check should assure that the Vessel´s route does not conflict with depth of navigable water, other geographical constraints, sailing free heights under bridges, off shore installations and that it does not cross any prohibited areas.

The second part of the route cross check is carried out manually by the VTS Operator, usually done shortly before the Vessel starts navigating in the VTS Area. The manual route check carried out by the VTS Operator is made to ensure that no temporary obstacles affects the safe passage of the Vessel, i.e. works in progress in the fairway, fairways blocked by deep draft vessels, ice etc. (For further explanation of Manual Route Crosscheck see ANNEX A).

6.4 STM VTS SOP Route Proposals

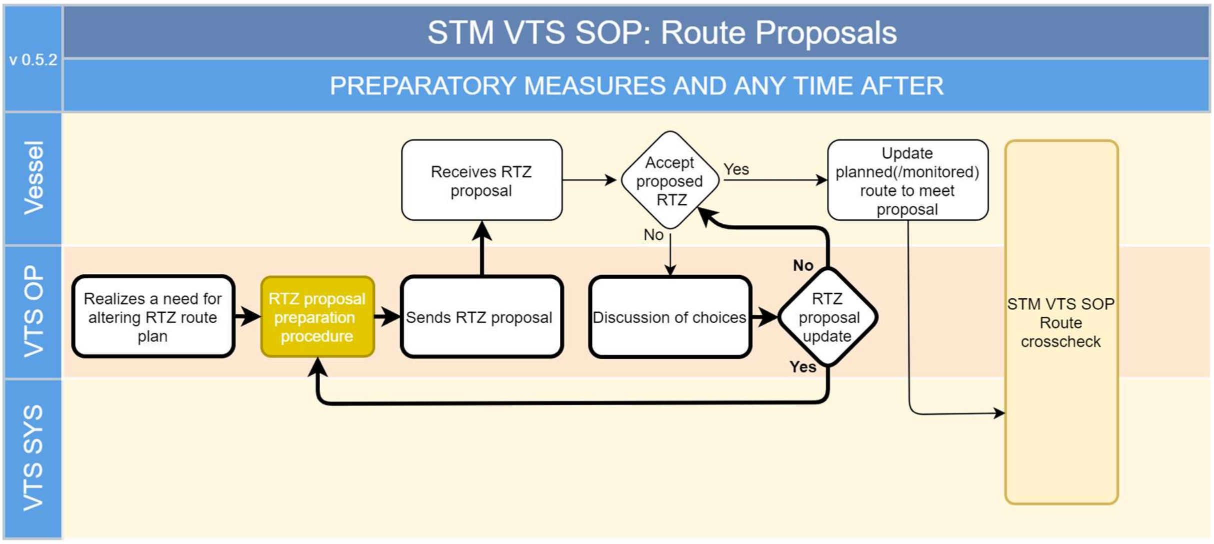


Figure 3 STM VTS SOP Route proposals

If deemed necessary the VTS Operator can send a route proposal to the Vessel for the Ship´s Officers to review in their ECDIS. (How this proposed route is prepared is explained in ANNEX B RTZ Route Proposal Preparation Procedure. This Annex corresponds to the brown action box with white text in the picture above.)

If the Vessel agrees with the proposed route the process proceeds with the previously described STM VTS SOP Route Crosscheck. If there are no other inaccuracies discovered the Vessel can take the route in to monitoring and start navigating through the VTS Area. If the Vessel does not agree with the proposed route, they must present a solution of their own. In the end the Captain of the Vessel is always responsible for the safe navigation of his or hers ship.

6.5 STM VTS SOP Route Corridor Deviations

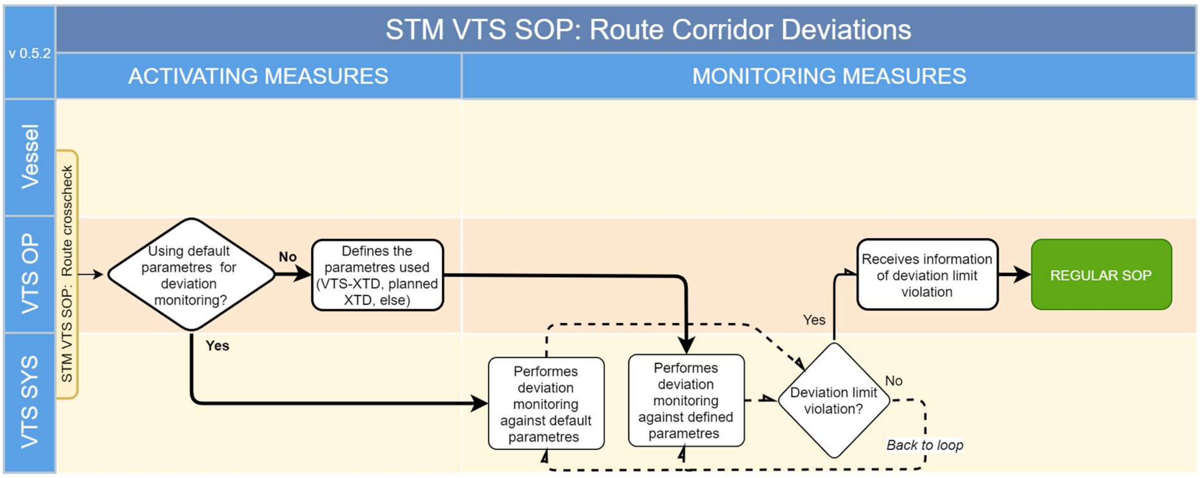


Figure 4 STM VTS SOP Route Corridor Deviations

When a route has been crosschecked and the Vessel starts to monitor it the VTS System will automatically surveil if the Vessel follows its route. Should the Vessel deviate from the route and exceed the preset Route Corridor limits the VTS Operator will be alerted.

It should be noted that the XTD (Cross Track Distance), i.e. the width of the corridor, is initially set in the Voyage Plan by the Vessel. If the VTS Operator deems the XTD inappropriate it is possible for the VTS Operator to change the values. (See the action box with the text “Defines the parameters used (VTS-XTD, planned XTD, else)”.

Should the VTSO be alerted of a Vessel leaving its intended route he or she must act in accordance with REGULAR SOPs.

6.6 STM VTS SOP Close Quarter Situations

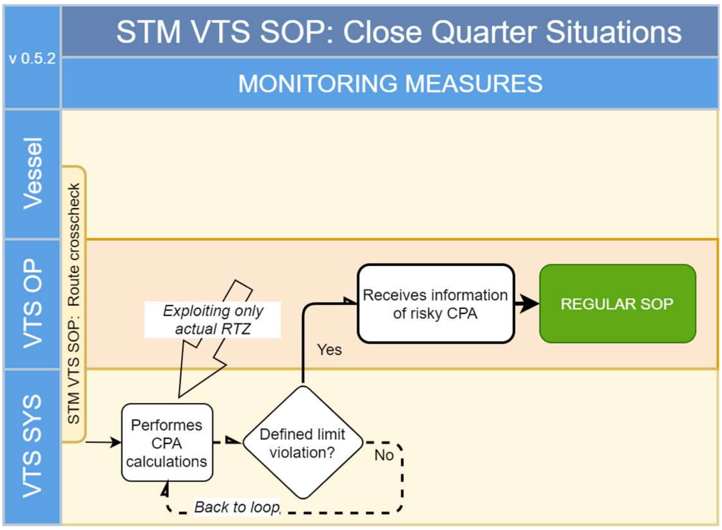


Figure 5 STM VTS SOP Close Quarter Situations

When two or more STM compatible Vessels are navigating in the VTS Area it is possible to calculate their CPA (Closest Point of Approach) based on the Voyage Plans that they have submitted. In opposite of when only the Vessels´ present course and speed can be exploited as base for CPA calculations this enables foreseeing of dangerous situations much further in advance.

The transparent arrow with the text “Exploiting only actual RTZ” indicates that the VTS System only takes Voyage Plans that have been shared between the Vessels and the VTS in account. The STM VTS SOP Close Quarter Situations is likely to be feasible to use in fairly open waters. In the next section we will deal with meetings in narrow waters.

Again, if the VTS Operator is notified by the VTS System of a possibly dangerous upcoming situation he or she must act in accordance with REGULAR SOP.

6.7 STM VTS SOP Predicted Rendezvous

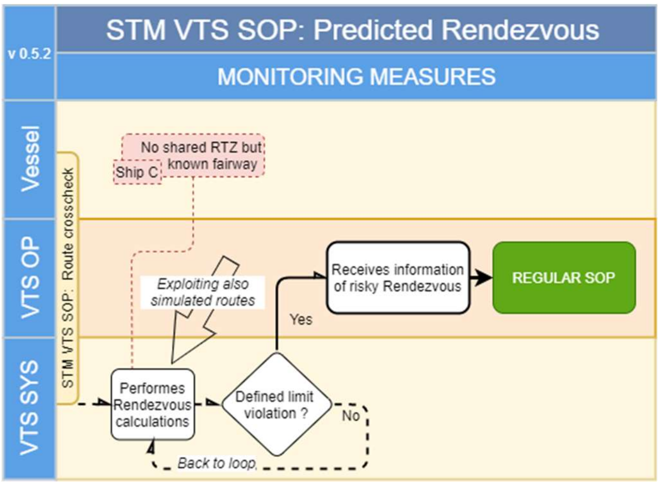


Figure 6 STM VTS SOP Predicted Rendezvous

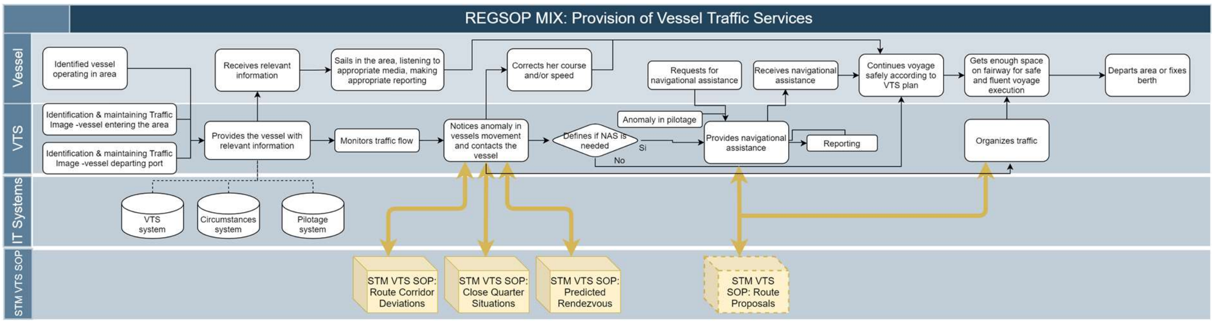
The purpose of Predicted Rendezvous is to detect meetings between Vessels in areas that are deemed unappropriate for meetings. Should the VTS System spot an upcoming meeting in such a place it will warn the VTSO who is to follow REGULAR SOPs.

6.8 How to insert the STM VTS SOPs into Regular SOPs

Nothing in the STM VTS SOPs presented here is meant to replace any ordinary, robust VTS work that has stood the test of time. What is brought here is meant to supplement everyday VTS work with the possibilities to work proactive that Data Exchange and Information Sharing enables. The STM VTS SOPs have been produced with the aim to be easy to insert in to an already existing set of SOPs. They have also been designed to be fairly easy to adjust if they do not match the process of one particular VTS System manufacturer or VTS Authority´s working methods. The reason for this sought flexibility is to make the STM VTS SOPs feasible for all types of VTSes, regardless of type of service rendered or VTS System used. The Flow Chart below depicts a fictitious REGULAR SOP over the process of provision of Vessel Traffic Services. In the third box from left on the VTS layer it reads “Monitors Traffic Flow”. In the next box it reads “Notices anomaly in vessels movement and contacts the Vessel”. As visualized by the light brown arrows “STM VTS SOP Route Corridor Deviations, STM VTS SOP Close Quarter Situations and STM VTS SOP Rendezvous Predictions” have been added as support to this box. Looking further to the right the “STM VTS SOP Route Proposals” has been added to provide an extra tool when delivering NAS (Navigational Assistance Service) or TOS (Traffic Organization Service). Should the VTS System not hold the Route Proposals functionality or if the applicable VTS Authority for some reason do not want to make use of this feature, it can easily be excluded.

Figure 7 REGSOP MIX Provision of Vessel Traffic Services

Below you will find another fictitious example of an already existing SOP. This one concerns Vessels navigating in the Gulf of Finland reporting area. Since navigating in this area is done in large open waters that are regulated by TSS (Traffic Separation Scheme) the fictitious VTS Authority has decided that the proper STM VTS SOPs to use here are “STM VTS SOP Route Corridor Deviations” and “STM VTS SOP Close Quarter Situations”.



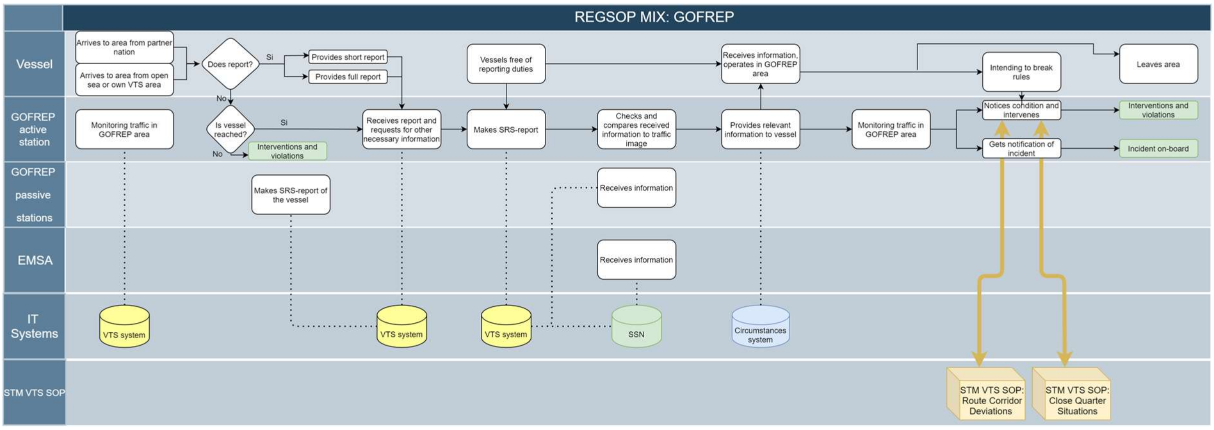


Figure 8 REGSOP MIX Gofrep

ANNEX A MANUAL ROUTE CROSSCHECK

The purpose of the manual route check is to ensure that nothing has occurred at the last minute before the Vessel starts its voyage through the VTS Area. Even though the Vessel´s intended route has been checked automatically both by the VTS System and the ECDIS, it is possible that something has emerged, such as a Search and Rescue Operation, dredging in the fairways, adverse weather conditions etc. that might jeopardize the safe passage of the Vessel. It can also be the case, that the automatically pre-checked and intended route for some reason is not attached to the Vessel or that the route, however pre-checked and found safe does not take the Vessel to the predetermined berth due to e.g. changes in plans at the terminal. What is to be included in the Manual Route is up to the VTS Operator´s experience and depending on local conditions. Most likely the Manual Route Check should include:

- Is the Vessel attached to the proper Route in the VTS System?
- Will this route take the Vessel to the intended destination (usually a berth but could be an anchorage, Rendezvous point for bunkering, pilot boarding position etc.)?
- Is the berth available?
- Does the Vessel intend to follow a Route usually used by vessels of its type?
- Following (by eye) the Vessels Route, are there any hindrances in the fairway?

ANNEX B RTZ ROUTE PROPOSAL PREPARATION PROCEDURE

The actual sending of a route proposal to a Vessel is not very complicated. What to send, how to choose the route that is to be sent might be trickier. Basically there are three alternatives to choose from:

1. If the Vessel has submitted a route only planned to the Pilot boarding position or if the Vessel has not shared any route at all it might be feasible for the VTS Operator to send a pre-made route fetched from a suitable Fairway Library.
2. Should the Vessel have done a flawless planning of their voyage but some last minute change is necessary to make, e.g. go to another boarding position, anchorage etc. then the VTS Operator can make the adjustments in the Vessel´s route and send it back to the Vessel.
3. A third way to choose a route to send to a Vessel for the VTS Operator is to fabricate one of his or hers own. This might be feasible if a Vessel is to shift between two anchorages, go to an unusual position for hull cleaning or make any other movement that does not happen very often.

Regardless of what route is sent to the Vessel the STM VTS SOP Route Crosscheck is to be followed before the Vessel takes a new route in to monitoring. All other safety measures on board the Vessel e.g. safety check of the route in the Vessels ECDIS must be carried out as well. In the end the Captain is always responsible for the safe navigation of his or hers ship.

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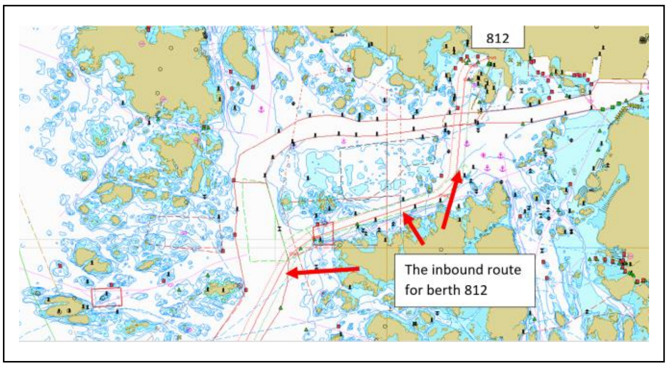

Document No: BS_WP4.3 APPENDIX B

Title: STM VTS SOPs Adaptation Training

Date: 29.11.2021

Interreg Baltic Sea Region
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EUROPEAN REGIONAL DEVELOPMENT FUND

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INTERREG PROJECT NO: R103

1. CONTENTS

DEFINITIONS AND CLARIFICATIONS

Automatic Identification System – Radio modem that automatically exchanges static (identity) and dynamic (navigation) data between ships.

Cross-Track Distance – The distance that a ship can deviate from its monitored route line before having alert. Defined in RTZ. See also VTS-defined XTD.

ECDIS - Electronic Chart Display and Information System. In this on board computer information from AIS, radar and possibly other sensors are gathered and displayed in an Electronic Chart. The ECDIS is today´s main aid to navigation. The same computer is usually used for sending and receiving Voyage Plans. It is not necessarily done in the same process as where the navigation calculations are carried out but in the same computer. A route received from the VTS can easily be used in the ECDIS process.

Fairway Library – Database containing pre-made routes e.g. routes used by pilots.

Information Service (INS) – An information service is a service to ensure that essential information becomes available in time for onboard navigational decision-making. See IALA VTS Manual for exact definition.

Monitoring - In conjunction with VTS the word monitoring is equivalent to surveilling. On board the meaning of “monitoring” may also indicate the route that the Vessel is following for the moment. This is the route that “has been taken in to monitoring” in the Vessels ECDIS.

Navigational Assistance Service (NAS) – Navigational Assistance Service is a service to assist onboard navigational decision-making and to monitor its effects. See IALA VTS Manual for exact definition.

RTZ – Route plan exchange format. Route plan exchange is used in conjunction with ECDIS to IEC 61174 (RTZ version 1.0) and IEC PAS XXXXX (RTZ version 1.2). The route plan exchange format is based on standardizing a route plan. A route plan consists of waypoints where each waypoint contains information related to the leg from the previous waypoint. The route exchange format is a file – RTZ – containing an XML coded version of the route plan. RTZ XML schemas are defined by CIRM listed at

http://www.cirm.org/rtz/index.html

Schedule - The estimated timing of a voyage, i.e. ETA/ETD of waypoints, speed on legs, etc.

Sea Traffic Management – A concept based on data Exchange and Information Sharing. The bearing beam is the idea of that if all actors´ (in this work ships´) intentions are communicated it will promote Efficiency, Safety and Environmental Protection in maritime shipping.

Ship Reporting System – SRS aims to keep a vigilant eye on the sea traffic. In cases of rendering help, the systems enable to give pieces of information about navigational hazards, medical advice, directing the closest ship towards the vessel in peril, and defining the area of searching SRS may be voluntary or obligatory.

Standard Operational Procedure – The documentation governing the VTS service. It defines everything pertaining the management, development and operations of a VTS.

STM Balt Safe – An EU co-financed project in which the present work has been written. The STM Balt Safe Project is a follow up project following MonaLisa, MonaLisa 2.0 and STM Validation Project aiming to implement findings from previous projects.

STM Compliance implies that ships are equipped with STM compatible bridge systems or VTS with STM compatible VTS systems.

Traffic Organization Service – A Traffic Organization Service is a service to prevent the development of dangerous maritime traffic situations and to provide for the safe and efficient movement of vessel traffic within the VTS area. See IALA VTS Manual for exact definition

Vessel – When the word Vessel is mentioned in this work it usually refers to a ship or Vessel navigating, or planning to navigate, in the VTS Area. The word Vessel also refers to the ship´s captain and crew. E.g. if it reads in the text that "the Vessel shares its Voyage Plan with the VTS" it means that the Captain or someone authorized by the Captain sends the Voyage Plan to the VTS by means of the Vessel´s ECDIS.

Vessel Traffic Services - VTS – are shore-side systems which range from the provision of simple information messages to ships, such as position of other traffic or meteorological hazard warnings, to extensive management of traffic within a port or waterway.

Voyage Plan – A representation of the planned way to get from point A to point B, consisting of a list of waypoints (geometry) and information associated with the legs between waypoints, plus a Schedule, describing the planned time axis of a ships voyage.

VTS Area – Area in territorial waters in which VTS is provided to the merchant fleet.

VTS Authority – The national authority responsible for delivering Vessel Traffic Services.

VTS-defined XTD – XTD (Cross Track Distance) that is defined by the VTSO. The XTD is relative to the route line. The opposite is when the XTD is defined by the Vessel´s captain.

VTS Instructor – Person involved in training of VTS Operators and/or Supervisors.

VTS Operator – The Watch keeping person in the VTS. In general terms there are two different ways of recruiting VTS Operators. Either you employ ships officers and give them a fairly short VTS Operators training often about one or two months or you employ persons with little or no seagoing experience and train them for a longer period perhaps about a year. The main task of the VTS Operator is to monitor sea traffic and to prevent maritime accidents by giving Vessels Information, Advice etc.

VTS Supervisor - VTS Centres surveilling large VTS Areas or Ports often divide their Areas into different Sectors having one VTS Operator responsible for each Sector. A VTS Supervisor is the leader for a shift of VTS Operators.

VTS System - In the context of this work VTS System refers to the system used by the VTS Operator when surveilling sea traffic. In this work it is also assumed that this system is STM compatible i.e. it holds the possibility to share Voyage Plans with the Vessels in the RTZ format.

Waypoint - A position marking the intersection between two legs in a Voyage Plan.

ABBREVIATIONS AND ACRONYMS

AIS - Automatic Identification System

ARPA - Automatic Radar Plotting Aid

CIRM – Comité International Radio-Maritime

CPA – Closest Point of Approach

CQS – Close Quarter Situation

ECDIS - Electronic Chart Display and Information System

GOFREP - Gulf of Finland Reporting scheme (supported by the VTS's in the Gulf of Finland)

IALA - International Association of Lighthouse Authorities and Aids to Navigation

INS - Information Service

NAS - Navigational Assistance Service

OOW – Officer on Watch

REGSOP - Regular Standard Operational Procedure

REGSOP MIX - Regular Standard Operational Procedure Mix. (A STM VTS SOP mixed in to REGSOP.)

RTZ - Route Plan Exchange Format

SOP - Standard Operational Procedure

SRS – Ship Reporting System

STM - Sea Traffic Management

STM VTS SOP – SOPs developed in the STM Balt Safe Project to be fitted in to REGSOPs.

TCPA – Time to Closest Point of Approach

TOS - Traffic Organization Service

TSS – Traffic Separation Scheme

VHF – Very High Frequency, radio frequency range. Common way of communicating ship to VTS.

VTS – Vessel Traffic Services

VTSO - Vessel Traffic Service Operator

XTD – Cross-Track Distance

2. INTRODUCTION

Kommentoinut [KM1]: Following text is more like purpose than introduction?

Kommentoinut [JA2R1]: True. Have fixed a new introduction part.

STM Balt Safe is a follow up project to MonaLisa, MonaLisa 2.0 and STM Validation with the ambition to implement findings made previously in the mentioned projects. To implement something new and fairly technical complex presupposes that quite a few prerequisites are fulfilled. One is that the equipment to be used is in place and working properly another one is that staff is available that knows how to operate the new equipment. This Annex deals with the latter part i.e., how to train VTS Operators both in how to, when to and perhaps when not to make use of STM in a VTS context.

2.1 Purpose and intended readership

The present Annex has two purposes. Partly it has been written to supplement chapter 7. Simulator Exercises of document “BS_WP4.3 Report of the Testbed for STM tools in VTS centres, the idea is to give the reader the opportunity to go deeper into the details of the simulations and of what STM is expected to be like in real live VTS Operations. Partly this Annex has been written to support any VTS Training Organization should they want to form a training program for VTS Operators in the use of STM functionality.

3. GUIDING PRINCIPLES FOR THIS DOCUMENT

Since this document has the ambition to give guidance when forming VTS Training it has been written to comply with *IALA Model Course V 103 -5 The Revalidation Process for VTS Qualification and Certification.* Chapter 2 “Adaptation Training” has in particular been taken into account since this is the chapter giving guidance about how to introduce changes in daily VTS work. The IALA document states that:

“A process of Adaptation Training will be implemented whenever significant changes are expected or have been made, concerning equipment, regulations, operational procedures, the VTS environment or any other matter which is relevant to the performance of the VTSO.”

This document focuses on the technical (how to perform) and the operational (when and for what purpose) aspects of the STM VTS functions. Although the possible risks and downsides with new technology always must be stressed and scrutinized the final decision of starting using STM, and to what extent, must lie with the Competent Authority and the VTS Authority Nationally. Legal aspects, to what extent the STM tools should be used and what back up measures that must be used as well is up to each responsible Competent Authority and VTS Authority to decide.

The scope of this document is to show what is possible to do and how to train people to do this.

Chapter 4. Five STM VTS SOPs/features introduction intends to form a theory background for training given with the purpose to introduce VTS Operators in the use of STM in a VTS context. Chapter 5, Forming STM Adaptation Training when introducing STM to daily VTS work is intended to be a more practical guidance when planning simulator training in STM VTS SOPs.

It should be emphasized already at this stage that the suggested training plan accounted for in this document should be assessed and if necessary, adjusted by each VTS Authority before the training is started. Should a VTS Authority deem it not feasible to use e.g., “STM VTS SOP 2 Route Proposals” this part can be left out. Should it on the other hand be the case that the VTS Authority would like to add contents that is not included in this document like text messages, sending Navigational Warnings etc. this can be done as well. The important thing is that the syllabus is assessed in advance and found relevant and comprehensive.

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Kommentoinut [KM5R3]: Changed to ‘this document’

Kommentoinut [KM6R3]:

Kommentoinut [KM7]: This is chaptering I can follow! Yes!

Kommentoinut [JA8R7]: OK, now I see. When I previously have referred to some chapter e.g. “Chapter 9” I have referred to something outside this Annex. E.g. I have written a chapter previously about the simulations in general and I would like to refer to that chapter. But since the final report is not finished yet this has to be done in the last minute work with the complete version of the report.

4. FIVE STM VTS SOPS/FEATURES INTRODUCTION

The outline of this document follows the flow presented in *D4.3 Annex A: STM VTS SOPs*. The mentioned document shall be carefully studied before commencing any training since this document describes the functionality of the new STM features and puts them in to their context and flow.

In short five new features are brought in to VTS operations in the STM Balt Safe Project:

1. Route Crosscheck
2. Route Proposals
3. Route Corridor Deviations
4. Close Quarter Situations
5. Predicted Rendezvous

The foundation for all these five features is the Voyage Plan, which is formed of the route and the schedule that the Vessel has submitted to the VTS. The Voyage Plan states the intentions of the Vessels "at this particular time we will be here, heading this way, making this speed, our next turning point will be here and we will reach Pilot boarding ground, berth, anchorage etc. at XX:XX hours." It is important to realize that this information is shared by the Vessels in whole. It is not an oral description stating the main points of the planned journey, but a full description of the intended voyage and that this description can be displayed digitally in the VTS system, on the VTS Operators´ screens.

Figure 1. An example of a Route sent digitally from a Vessel to the VTS displayed and compared with the standard oral description that would have been used in this area

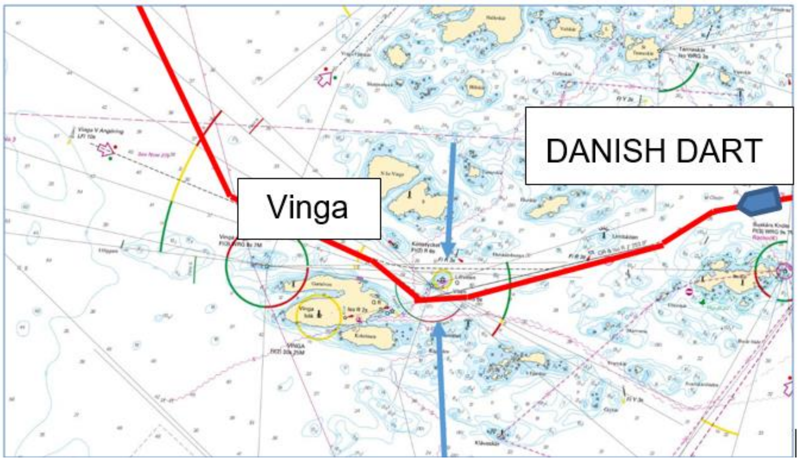

Figure 1. The phrase to describe the Vessel´s route here orally would most likely have been stated on VHF as: "VTS Gothenburg DANISH DART, we go out North of Vinga, then we go to the Northwest." Comparing this sentence to the red route digitally submitted by the Vessel indicates that no information is given orally about whether the Vessel intends to go North or South of Viten Lighthouse (marked with blue arrows.) Nor is it obvious from the oral message when the DANISH DART will go to Northwest. The red line, the route line, clearly indicates that DANISH DART will turn to starboard as soon as they have cleared Vinga Island.

4.1 STM VTS SOP 1 Route Crosscheck

The process starts with that the Vessel, already when starting their Voyage, shares their monitored route and schedule with the VTS. Most likely the VTS will be notified of the approaching Vessel´s intentions in this way hours or even days before the Vessel enters the VTS area. (The Vessel can choose to share their Voyage plan with all sorts of stakeholders at the same time such as pilots, port authorities, terminals, agents, tugboat companies etc. but in this document, we focus on VTS.)

Having received the Vessel´s voyage plan the VTS´s first task is to crosscheck the Vessel´s route before it enters the VTS Area. This route crosscheck is to be done both automatically and manually.

4.1.1 Automatic Route Crosscheck

As is the case with the ECDIS, the Vessels´ primary aid for navigation, the idea is that the VTS System (the VTS system is the equivalent to the ECDIS but used in the VTS) will hold an automated Route Crosscheck function. The goal of the automated Route

Crosscheck is to make sure that the planned route of the Vessel meets some five or six criteria. First the Vessel´s planned route must be sketched where there is navigable water for the Vessel, i.e., the water depth has to be sufficient and the route must be possible to navigate. There must be no obstacles as e.g., low bridges, too small locks, narrow passages etc. The planned route must not cross any restricted areas such as windmill farms, military practice areas, areas restricted due to sensitive environment etc. Should the Vessel´s Voyage Plan break any of the above-mentioned constraints the automatic Route Crosscheck should alert the VTS Operator.

Figure 2. A screenshot from the VTS System NaviHarbour. The three-masted barque Gorch Fock intends to sail through the archipelago.

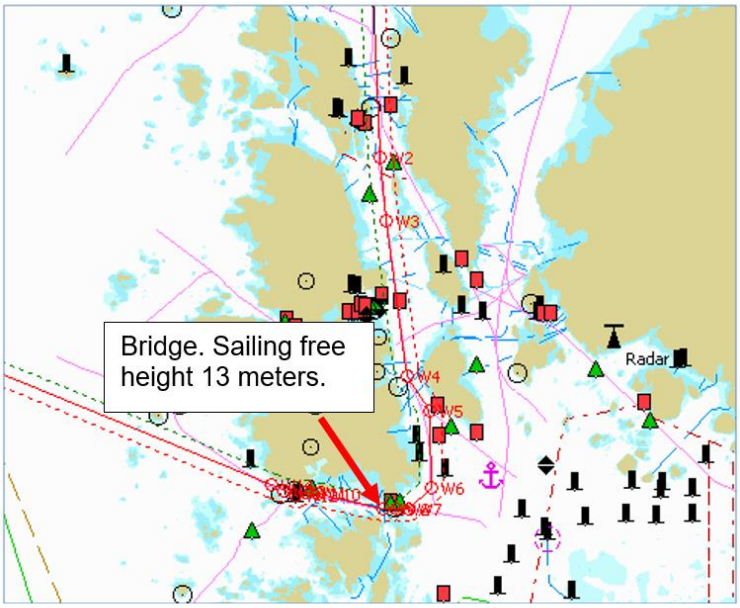

Figure 2. The route in the picture has been submitted by a three-mast barque with an air draught of more than 40 meters. The Automatic Route Crosscheck should indicate to the VTS Operator that someone is presently planning to do something that can´t be done and the VTS Operator must take action.

However, when the STM Balt Safe VTS simulations were held during the fall of 2021 no automated Route Crosscheck functionality were available in the VTS System used. Thus, this part could not be simulated or tested.

4.1.2 Manual Route Crosscheck

Regardless of whether the VTS system holds the possibility to perform an automated Route Crosscheck or not a Manual Route Crosscheck is to be carried out. The Manual Route Crosscheck is a fairly brief process and also very similar to what is common practice in VTS work. The difference is that the VTS Operator now can follow the Vessels´ intended route visually. The VTS Operator must search the Vessel´s way for any kind of hindrances.

Figure 3. Manual Route Crosscheck of Sandy Hook´s route inbound for Berth 812. Again the screenshot comes from the Wärtsilä VTS System NaviHarbour.

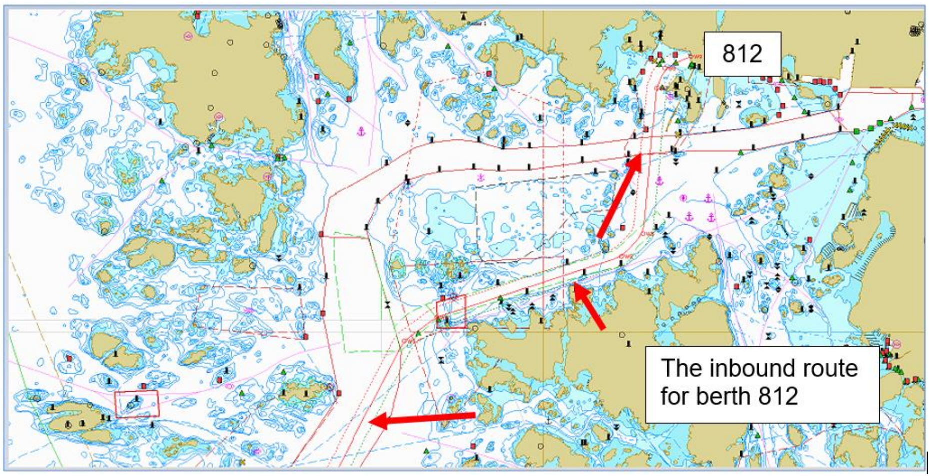

Figure 3. In the Chart above the inbound route of the Sandy Hook is displayed with a thin red line. The route corridor is marked with a thin dotted line, red on port side and green on starboard side. The Manual Route Crosscheck consists of a visual check along the route performed by the VTS Operator. The VTS Operator is to scan the route and check it for obstacles and hindrances that the Automated Route Crosscheck cannot be expected to warn about. Examples of such obstacles are usually of a more temporary art, it could be the case that the weather forecast is predicting higher wind speed than what is allowed when berthing at 812. It could also be the case that sensitive work with lighthouses is in progress in the South Channel (see the red arrows) and that Vessels are recommended to choose the North Channel on this particular day.

What is relevant, what is to be included, in the Manual Route Crosscheck must be assessed by the national or local VTS Authorities. It depends on the characteristic of each VTS area and of local conditions. Information about icebergs may be highly relevant when navigating the Northeast Passage but irrelevant in the Mediterranean Sea. Below some generic points to check that should fit in to most VTS Areas have been listed.

Table 1.Suggested points to be included in the Manual Route Crosscheck

Item	To be checked	Additional explanation

1. Entering point of the VTS area and the destination of the Vessel	Does the Voyage Plan submitted by the Vessel match other known details with their port call? Have they submitted a route that will take them to the proper destination? (In our example to berth 812.) Is the berth available at the Vessel´s ETA?	In Coastal VTS like Dover Strait, Gibraltar or Sound this is most likely applicable to a less extent then in a VTS port or River Service. A vessel inbound for a berth will usually have more points that needs to be checked than a transiting Vessel.
2. The intended route	Is this a route usually used by Vessels of the imminent type? (In our example Sandy Hook is a small bulk carrier and the submitted route is a perfectly common route for such a ship. Nothing peculiar in this case.)	If the route submitted by the Vessel is possible to navigate or not is to be checked by the Automated Route Crosscheck. In the Manual Route Check the VTS Operator is to overview the route to see if it in hers or his opinion is “reasonable”? (A couple of examples of this will be given in a figure below.)*
3. Pilotage	Is this Vessel obliged to take Pilot? In that case, has the Vessel´s route a waypoint at the proper Pilot boarding position? Does the Vessel´s schedule match the time for when the Pilot has been ordered?	Again, in heavily trafficked straits where most Vessels only are transiting this point may not be relevant. But in a more confined area where the Pilot is to be picked up (or later dropped) close to the entrance of a port this may be a very important matter.
4. Temporary obstacles in the fairway	Is there anything in particular going on in the fairway at this time that could affect the Vessel´s voyage? Is there e.g. work in progress demanding swell free passage from passing	The basic idea here is to cover what the Automated Route Crosscheck cannot cover. Any information that is hard for the Vessel to assimilate should be relayed by the VTS. By following the Vessel´s

	Vessels? Is there a Search and Rescue operation going on? Has there been sightings of floating obstacles (containers, timber, fishing gear etc.) reported?	route that has been submitted in advance it should be easy for the VTS Operator to assess what information is relevant to the Vessel.
5. Weather conditions	Are there any restrictions in force along the submitted route, berth, anchorage, pilot boarding position etc.? Are there regulations stating that the Vessel must be securely moored not later than sunset etc.?	Reading this table may give the impression that the sole responsibility of the Vessel´s port call lies with the VTS. That is of course not the case. But since it is the case that the VTS most likely is the institution with the best overview of the traffic situation in the area it is important to discuss what kind of information the VTS should relay and to what stakeholders.

Table 1. The Manual Route Cross Check. What is to be included in the Manual Route Crosscheck must be decided locally depending on the particular VTS´s tasks and forms of cooperation with other stakeholders. It is perhaps not a very bold assumption to make that a natural flow for a VTS Operator when a Vessel enters the VTS Area is to first look at the Vessel (who is coming), then to look at the Vessel´s destination (where are they going) and finally to check the Vessel´s presumed route (what does the way there look like). The Manual Route Crosscheck is done with pretty much the same flow but hopefully it will be done with even more accuracy since the VTS Operator can see the route in the VTS System and have access to the Vessel´s schedule.

Figure 4. An example of how the Manual Route Crosscheck may differ from the Automated Route Crosscheck. (This time the route is displayed in Navi Port, the route planning part of the Wärtsilä system.)

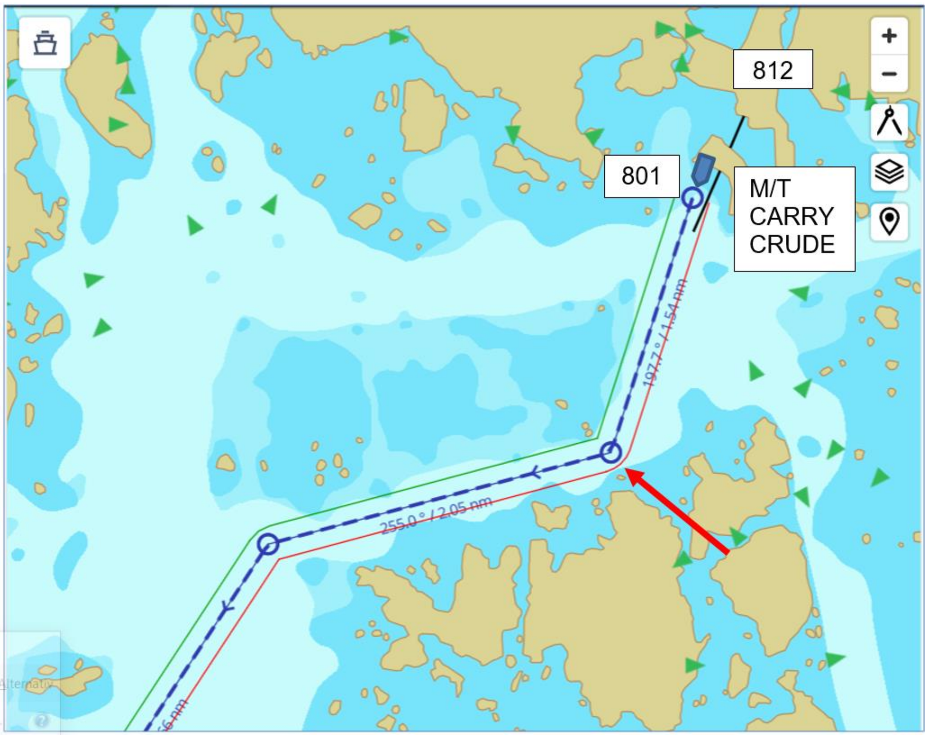

Figure 4. Manual Route Crosscheck of an unloaded crude carrier´s route out from 801 (close to 812 used in a previous example). The Automatic Route Crosscheck feature would most likely not make any remarks, there is water and room enough and no constrains are broken. Still, this plan might pose a problem. The VTS Operator will note that the turn marked with the arrow is steep for a Vessel of this type. It will most likely have to use the full width of the fairway. The VTS Operator should either redirect the Vessel to the North Channel (normal practice for Vessels of this type) or pay extra attention to the traffic situation at the time when the crude carrier is expected to pass through the turn.

4.2 STM VTS SOP 2 Route Proposals

Should the VTS Operator find it necessary to redirect a vessel this can be done digitally. Of course the VTS Systems differ a bit between them but basically there are three ways of making a route proposal. The first way is that the VTS Operator edits the original route and sends it back to the Vessel. Another alternative is that the VTS Operator sketches a new route and sends it to the Vessel. The third way is that the VTSO retrieves route from a route library or database and forwards it to the Vessel. The route sent to the Vessel is a proposal and it is up to the Vessel´s Captain to accept or reject it. Should the Captain accept the he or she must safety check it before starting to monitor it.

Figure 5. A Route Proposal sent to M/T CARRY CRUDE

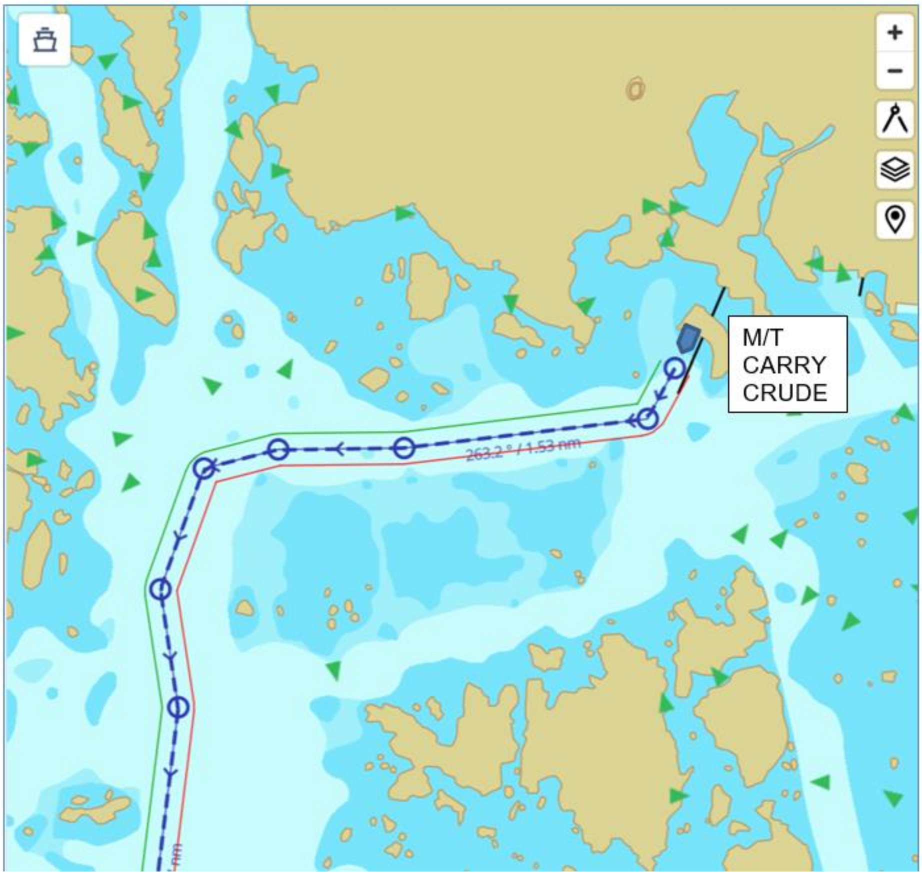

Figure 5. Having assessed the expected traffic situation in the vicinity of the critical turn the VTS Operator concludes that the planned route of the M/T CARRY CRUDE causes unnecessary risks. The Operator therefore decides to advise M/T CARRY CRUDE to choose the North Channel out. The VTS Operator moves the essential waypoints from the South Channel to the North Channel and sends the suggestion to M/T CARRY CRUDE.

It should be noted that the operation above is technically easy to perform. However this process must not be taken lightly. Advising a Vessel to choose another route or fairway is in itself nothing dramatic. Doing this orally over VHF is one thing and most likely it would have sounded something like this: “CARRY CRUDE, VTS Gothenburg calling: Advice: Due to the traffic situation choose the North Channel out!” After that the Vessel would have had to make a new planning out through the North Channel themselves.

If the VTS on the other hand digitally sends a complete route, possible to display in the Vessel´s ECDIS, then VTS is not only advising the Vessel to choose another Channel the VTS is also pointing out how to navigate this Channel. The Vessel must safety check the suggested route that came from the VTS but even if the route passes the Vessel´s safety check it may still not be the best possible route under the circumstances on this particular day with this particular Vessel. This is something that must be considered by the VTS Authority and the Competent Authority and it must be stressed to the Captains and crews of the Vessels that the full responsibility of the navigation of their Vessel always lies with them.

4.3 STM VTS SOP 3 Route Corridor Deviations

Having reached this far in the chain of the STM VTS SOPs a little change of perspective has to be done. So far we have been in a preparing phase, planning for the Vessel´s safe voyage through the VTS Area. In the following it is assumed that the Vessel has entered the VTS Area and is navigating through it.

In accordance with sections 3.1 and 3.2 the Vessel now has a route that is taken in to monitoring and this is the plan they intend to follow. The foremost task of the VTS is now to provide the Vessel with information regarding the traffic situation, weather etc. and to intervene with further information, questions, warnings or advice to the Vessel if deemed necessary. One example of when such an intervention could be necessary is when a Vessel deviates from its route (see example below).

Figure 6. An example of Route Corridor Deviation

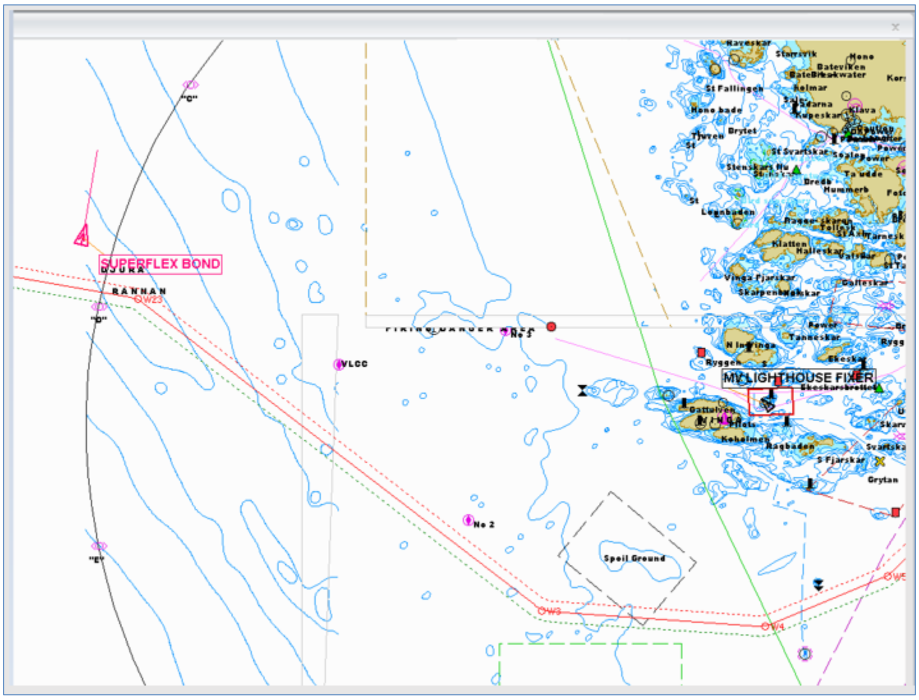

Figure 6. In this picture it is clear that SUPERFLEX BOND has deviated from its route. There is no imminent danger, the water depth is sufficient, the Vessel is far away from land and shoals and there are no other Vessels in the vicinity. But still, SUPERFLEX BOND is not following its route and the VTS Operator is alerted by the VTS System. What action the VTS Operator is to take is to be explained in the particular VTS´s SOPs, but a natural first step to take would probably be to ask the Vessel about its actions.

A vessel leaving its planned and safety checked route can of course be a very dangerous situation should it happen in a narrow passage and if the Route Corridor Deviation is caused by the Vessel failing to turn. In many other situations e.g. the situation in figure 5 there is no immediate danger. The important thing is that the VTS Operator´s attention is drawn to the fact that something is no longer going as planned.

4.4 STM VTS SOP 4 Close Quarter Situation

The knowledge of where each Vessel will be and at what time it will be there (should everything go as planned) gives the VTS Operator very good possibilities to anticipate congested traffic situations and possible Close Quarter Situations. Ever since radar made its breakthrough after the Second World War the prime method of predicting

Close Quarter Situations has been “dead reckoning”. i.e. the positions of the targets at a certain time lay the foundation for Closest Point of Approach calculations. The plotted positions will form a line and by following this line, assuming that the target will keep moving with the same course and speed, a prediction can be made of where the plotted Vessel will be in a near future. The downside with this method is the assumption made that Vessels will keep moving with the same course and speed “for ever”. This makes this method rather useless in confined waters since the Vessels naturally must follow the turns of the fairways thus making it harder to foresee their upcoming positions at certain times. To anticipate congested situations the VTS operator must use his or hers experience to estimate how the traffic situations will develop and thereby when and where the Vessels will come close to each other.

Most modern VTS Systems hold the possibility to create its own routes or channels and to attach the Vessels (the Vessels´ symbols as depicted in the VTS System´s screens) to these channels. When the predictions of the Vessels´ movements are being done the Vessels´ symbols will move along the navigation channels or routes created by the VTS Operator (or perhaps more likely by the System Administrator responsible for the VTS System.) In this way the prediction will be more accurate but it is still based on what the VTS Operator assumes about the Vessel´s route.

What is introduced by STM in conjunction with Close Quarter Situations (and in all other STM VTS SOPs) is that the basis for the prediction of the upcoming traffic situations is information that origins from the Vessels.

Figure 7. STM VTS SOP 3 Close Quarter Situations

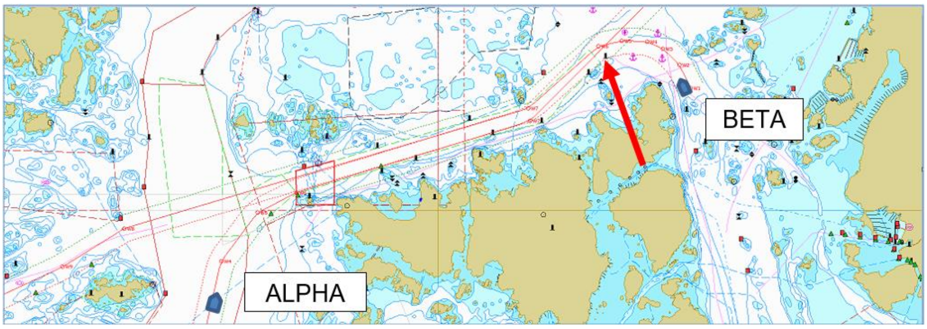

Figure 7. In the picture above the Vessel BETA is heaving up her anchor and intends to enter the fairway. ALPHA is inbound using the same fairway. Should the Voyage Plans (route and schedule) indicate that ALPHA and BETA will be at the position pointed out with the arrow at the same time then there will be a Close Quarter Situation.

A lot of things could rightfully be argued when looking at the situation in figure 7. First it is not sure that the schedules of ALPHA and BETA will be kept to the minute. Second, should Vessel ALPHA be of such size that it only can be navigated safely in the fairway then Vessel BETA is not allowed to enter the fairway should they become a hindrance to ALPHA. Third the Vessel BETA should (at least in this VTS Area) announce their intentions on the VTS VHF channel and both the ALPHA and the VTS should pay attention to this announcement. And so on and so forth.

Actually, all of these objections are irrelevant to the VTS Operator. What is relevant is that in this particular part of the VTS Area at this particular time a Close Quarter Situation may occur. Attention must be payed to this and if necessary proper actions must be taken.

4.5 STM VTS SOP 5 Predicted Rendezvous

The fifth of the STM VTS SOPs is Predicted Rendezvous and at a first look it may look very similar to Close Quarter Situations. Practically there is a difference though. Close Quarter Situations deals with Vessels that are risking a collision i.e., two (or more) Vessel’s risking being at the same position at the same time. This must of course be avoided regardless of where it will happen in the VTS Area.

STM VTS SOP 5 Predicted Rendezvous rather deals with planning of where Vessels will meet than avoiding collisions. Most likely these two aims go hand in hand but there is a difference. STM VTS SOP 5 presupposes that there are predefined areas in which meetings between Vessels must be avoided. What the Predicted Rendezvous feature does is to point out to the VTS Operator where the meetings will take place. Should the system indicate that a meeting will take place in a forbidden area then the VTS Operator must act.

Figure 8. STM VTS SOP 5 Predicted Rendezvous

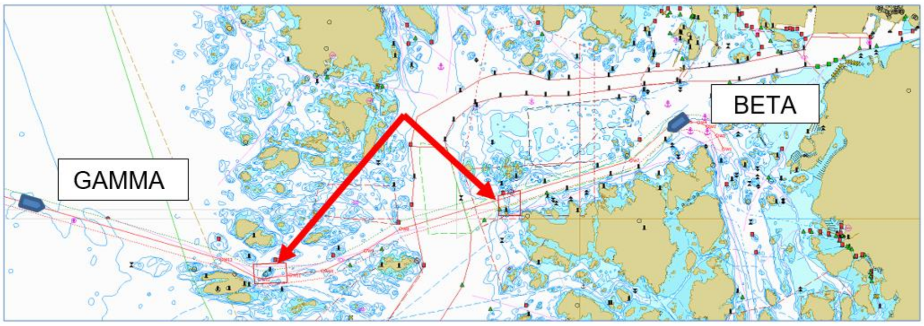

Figure 8. The two red rectangles mark areas where it is forbidden for Vessels to meet. Just looking at the picture will easily give the impression that GAMMA and BETA will not meet in either of the red squares. Should it however be the case that GAMMA is travelling with 19 knots while BETA is making no more than 11 knots then it is trickier to foresee where they will meet. Just like in the example in figure 7 the VTS Operator will get a premonition of a not wanted situation by the VTS system based on input from the involved Vessels.

In the document “STM VTS SOPs” frequent references are made to “REGSOP” (acronym meaning Regular Standard Operating Procedures). The situation depicted in Figure 8. could well serve as an example of this. What the STM feature brings is a prediction of where two Vessels will meet based on the Vessels´ Voyage plans. Should it be indicated that the two Vessels actually will meet in an area where meetings are prohibited then the STM VTS SOPs gives no further guidance. The VTS Operator must act in accordance with REGSOP (i.e. the Standard operating Procedures of the particular VTS), should REGSOP state that it is always the outbound Vessel that must wait then the VTS Operator must instruct the Vessel BETA to wait. This is out of the scope of this document.

5. FORMING STM ADAPTATION TRAINING WHEN INTRODUCING STM TO DAILY VTS WORK

The following section is based on experiences made during the STM VTS simulations held in the fall of 2021. After the three days of simulations the participants were asked to fill in a questionnaire aiming at training of VTS Operators. The test persons the first week were asked six questions and the second week seven questions were asked. In total 16 questionnaires were collected. This section is also based on opinions given by members of the group of VTS experts that were involved in the writing of the STM VTS SOPs.

5.1 General prerequisites to be met when delivering STM VTS training

Planning VTS Training is likely to be easier to carry out if a framework regarding the practical details of the training programme is set first. In the chapter "Simulator exercises" of document *BS_WP4.3 Report of the Testbed for STM tools for VTS centres* it is discussed and explained how it was decided how the STM VTS simulations were to be carried out e.g., what VTS Area that was to be used, number of test participants, simulator staff etc. In the following the same discussion will be carried out, but now also taking the test participants views into account. There is also a little bit of a change in scope in that that when the STM Balt Safe VTS simulations were carried out the main thing was to test new technology. In the following the focus is rather on teaching and training.

The first question (was not asked in the questionnaires) should probably be if it is necessary to carry out this training in a simulator. The answer to that is yes. Naturally everything can be explained orally and by using PowerPoint presentations but if it is possible to arrange simulator training it is to be preferred.

5.1.1 The duration of the Adaptation Course

First it should be noted that the simulations in STM Balt Safe lasted for three days a period. The question "Did you on the third day feel fairly comfortable with the 5 STM features and the VTS Gothenburg area?" was answered by all 16 participants and only two of them gave a negative answer with a grade lower than "average". (It should be mentioned that those two persons did not participate all three days and that their nautical background was poor.) Thus 14 of the test persons rated their knowledge of STM VTS to be fair or good after three days of training. Consequently, more than three days of training is most likely not required. In eight of the questionnaires the question "How many days do you think that this training should last (given that it was in your own VTS Area and with your own VTS System)?". The answers to this question were a little bit more diverting but it is fair to say that the average answer was two days.

A bit depending on how many participants that are to be trained at the same time, one full day or two a shorter days (based on what is deemed most feasible taken travelling arrangements in to account etc.) should be enough.

5.1.2 The simulator that is to be used and the simulator staff

The simulator that is to be used could basically be any VTS simulator, but it must hold an additional STM module, meaning that it must be possible to exchange routes in the RTZ 1.1 format between the Vessels and the VTS. What should be considered is that the Vessel side of the simulations is more resource-intensive than in VTS simulations in general. The Vessels are to share their Voyage Plans with the VTS during the simulations and they are to receive Route Proposals. The process of this on the ships´ side must be done by designated persons. Depending on how many VTS-station-workplaces that are available in the simulator facilities used, this task can be done by an Instructor or course participants (VTS Operators) that are surplus during the simulator exercises i.e., waiting for their next turn in the VTS simulator.

Under all circumstances the need of extra staff compared with carrying out ordinary (without STM) VTS simulations must be considered.

5.1.3 The VTS Area to be used in the training sessions

Both in discussions when preparing the simulations and in the evaluation questionnaires it was obvious that if the course participants would have been able to choose they would, of course, prefer to have used their own VTS Area, the VTS Areas that they are familiar with. However, many of the participants stated that this question was of less importance. Any VTS area would do nicely for training purposes.

Not to waste any unnecessary time it is advised that a VTS Area is chosen that is complex enough to in a realistic way hold all traffic situations that are necessary to test the five STM VTS SOPs but otherwise as small as possible. In this way as little as possible time is wasted with familiarizing with the VTS Area before starting training the VTS features.

5.1.4 Documentation of the Adaptation Course

In every sense it is deemed important that all relevant IALA Recommendations, Guidelines and Model Courses are considered. This is to ensure that all relevant aspects of the STM VTS SOPs are covered and that the training is done in a transparent way. Should a Competent Authority or other authorized stakeholder want to review the training it is necessary that it is documented and that this is done in a clear and structured way. The documentation also serves as a guide for the Instructors/Organization delivering the training.

5.1.4.1 The schedule

Figure 9. Example of a schedule for a two days training course

STM VTS Adaptation Training Schedule

Time	First day	Second day
0900 - 1000		Sim 5. Route Corridor Deviations, CQS and Predicted Rendezvous
1000 - 1015		Coffee
1015 - 1100		Sim 6. Route Corridor Deviations, CQS and Predicted Rendezvous
1100 - 1215	Introduction	Sim 7. Applied STM VTS Simulations
1215 -1300	Lunch	Lunch
1300 - 1400	Sim 1. Introduction Simulator, "clicking session"	Sim 8. Applied STM VTS Simulations
1400 - 1500	Sim 2. Introduction Simulator, "clicking session"	Sim 9. Applied STM VTS Simulations
1500 - 1515	Coffee	Coffee
1515 - 1600	Sim 3. Route Crosscheck & Route Proposals	Examination and Assessment
1600 - 1700	Sim 4. Route Crosscheck & Route Proposals	Time at disposal (e.g. time to be used for further training if required.)

Figure 9. The schedule above is based on the assumption that the trainees will travel on the first day and that the training can start after lunch. The reason for giving each simulation two times (the same theme that is) is that it is assumed that half of the participants will be doing "VTS duty" whilst the other part of the group will assist the Instructors with being the "Vessels´ side." In this way all participants will have the

opportunity to go through all necessary STM VTS SOPs from both the VTS and the Vessel side. How many VTS Operators that can be trained at each course depends on how many VTS Stations that are available in the simulator. In our case (Gothenburg) two VTS stations can be used at the same time with two VTS Operators in each. Thus training eight VTS Operators per course is feasible.

5.1.4.2 The training course´s syllabus and aim

The aim of the training course and what is expected in terms of learning from the trainees must be clearly stated in a document made available to the organizer of the training. This explanation of the purpose with the training may actually vary a bit on who is delivering the course (e.g. a VTS Authority or a Training Institute) but most likely it should at least contain the following points:

- The training delivered is Adaptation Training (see *IALA Model Course V 103 – 5 The revalidation process for VTS Qualification Certification*) and the reason for giving the training is the emergent of new technique.
- It should also be made clear if the training is given to be a general educating and overviewing or if the trainees are supposed to start using STM in a VTS context in a near future. In the latter case the training should be tailor made and clearly stress what features the VTS Operator is to use and what precautionary measures must be taken.
- The role of the VTS in an upcoming STM cluster should be clarified, is the VTS operator supposed only to understand the functions of his or hers own VTS System and to be able to respond on other stakeholders actions? Or is the VTS expected to be one of the STM drivers being able to support e.g. Vessels navigating the VTS Area with information regarding STM and STM Services? In that case this Adaptation Training´s ambition must be set higher.
- The document “The training course´s Syllabus and aim” should also include a list of what the training course contains in terms of presentations, simulations, forms of examinations and assessment of the trainees etc. The purpose of each item on this list should be clearly stated.
- The risks of bringing in new technology, how to mitigate these risks and what actions that must be taken to secure redundancy with old proven technical aids must be specially emphasized.

5.1.4.3 Theory presentations and simulation documents

As stated above it is important that the training is well structured, documented and transparent. The above-mentioned document “The Training course´s syllabus and aim” should be complemented with further documentation explaining all elements of the training more in detail. To ascertain this each part of the course should be accounted for in a document stating the content as well as the aim with the learning objective. Of course, such documentation can be done in many ways but most likely it will have to comprise of three phases at least: Preparation of the simulator exercises or presentations, carrying through of the training moment and one concluding part to summarize, debrief and assess.

Figure 10. An example of how a simulator session could be structured and documented

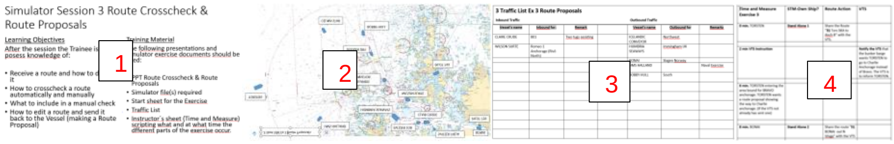

Figure 10. Both to prepare and later on recapture and assess it is necessary to keep order and document the simulator exercises. The documentation suggested here (four documents) consists of:

1. Overall description of the simulation. In this document an overall aim of the exercise is given, and necessary preparations are listed.

2. A map/chart indicating the traffic situation when the exercise starts. This document is both used as a checklist for the simulator Instructor and also as a method of quick getting all persons involved in the simulation to understand what the situation is like when the simulation starts.

3. A Traffic List to be used when the exercise starts to give the VTS Operator a proper watch handover. Here in- and outbound traffic is accounted for and if anything special is going on (e.g. hampered Vessels, work in progress etc.) it is noted here.

4. One script to be used by the Instructors. Here all upcoming events in the exercise are listed minute by minute. In this document the Instructor also can make notes about the trainee's progress which can be used at the debriefing or as a basis for assessment.

5.1.5 Assessment of the trainee

To make sure that the trainee has acquired enough skill and knowledge in using the new technology it is necessary to assess the trainee. This can be done in different ways and what is most feasible much depends on the circumstances that the course was given under. Let us say that only one or two VTS Operators were trained during one day and at all times getting the full attention of the Instructor then an assessment can comprise of the Instructor´s opinion. Should it on the other hand be the case that 8 – 10 Operators are trained at the same time it will be much harder for the Instructor to have the same overview of the students. Most likely it would be more feasible to let the students take one individual theory test and one practical test thus proving that their new skills are sufficient.

5.1.6 Preparatory Training

Before the students arrive at the Training Centre it is desirable that they have some prior knowledge of the subject that they are going to train. To supply the students with some preparatory knowledge it is advised to send some learning material in advance. It is not necessary to urge the student to study everything in detail but if the student posses an overview knowledge of how to operate STM functions in VTS and the purpose of this it is a good start.

A prepared package of learning material like this containing e.g. presentations, images of route sharing examples could also be used for introduction of STM in VTS in other contexts.

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