MONALISA 2.0 – Activity 1.2

Concept of operation and standard operating procedures for Sea Traffic Management Services

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![Co-financed by the European Union](image)

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### Review

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1 Introduction

1.1 Scope and purpose

This document outlines a concept of operation (CONOP) for part of Flow Management and Dynamic Voyage Management, which are part of the Sea Traffic Management (STM) concept as defined in Activity 2 Target Concept. This report focuses on those operational services applicable for sub-activity 1.2 “STM SOP and HMI”, sub-activity 1.4. “Simulator Testing” and 1.5 “Deep Sea Shore Based Assistance”.

This document has the following aims:

• Description of services that will be tested in the European Maritime Simulator Network (EMSN)

• Identification of functions, facilitating the STM operational services, that will be implemented in the MONALISA (M)-ECDIS and in the Shore Based Service Center

• Establishment of high level Standard Operating Procedures (SOP) for those services

• Development of Human Machine Interface (HMI) for the above identified functions.

This version of the document constitutes the final D1.2.1 deliverable.

1.2 Background

The STM concept has been introduced by the MONALISA 2.0 project. An overview description of STM can be found in the document “Sea Traffic Management – a Holistic View” (STM, 2015). Within STM, four enabling strategic concepts have been identified as crucial for reaching the target values. These are:

• Port Collaborative Decision Making (Port CDM), in which the process for arrivals and departures is made more efficient through information sharing, common situational awareness and improved processes

• Strategic Voyage Management (SVM), which deals with route planning, route exchange and route optimisation before the voyage has started

• Dynamic Voyage Management (DVM) which deals with route planning, route exchange and route optimisation whilst the ship is on its way

• Flow Management (FM), which includes services that will support both land organisations and ships in optimising overall traffic flow through areas of dense traffic and areas with particular navigational challenges.
These are all enabled by:  

- Information sharing by **Sea System Wide Information Management (SeaSWIM)**, which has the intention of being a common framework for information sharing and service distribution for maritime activities.

This document focuses on the definition and operational services included in the Flow Management concept.

For sub-activity 1.2 and 1.5, DVM and FM are the most relevant concepts and from which operational services are selected for implementation, testing and evaluation. Hence, this document also provides a mapping between Activity 1 and Activity 2. FM focuses on the whole traffic flow, while DVM looks at individual voyages, but using information from FM when optimising the specific routes.

### 1.3 Method

The operational analysis is inspired by the Unified Profile for DoDAF/MODAF (UPDM) that provides industry standard UML/SysML representation of DoDAF/MODAF architecture artefacts. One of the outputs from the operational analysis concerns information needs. Another output is the information exchange requirements between ship and shore during navigation assistance. A high-level task analysis gives the basis for operational procedures, which thereafter are further tested and developed using advanced ship simulators. High level results of the operational analysis and operating procedures are reported in this document.

### 1.4 Structure of the document

This document is organised as follows:

- **Chapter 1** is an introduction that states scope and purpose of the document, lists abbreviations and definitions.
- **Chapter 2** summarises the strategic enabling concepts and operational services applicable for Activity 1.
- **Chapter 3** gives an operational analysis of the concepts introduced in chapter 2.
- **Chapter 4** gives a first set of high level SOP for the ship navigation and shore-based service centre.
- **Chapter 5** gives a first set of HMI guidelines and examples on implementation.
### 1.5 Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AIS</td>
<td>Automatic Identification System</td>
</tr>
<tr>
<td>ATC</td>
<td>Air Traffic Control</td>
</tr>
<tr>
<td>ATM</td>
<td>Air Traffic Management</td>
</tr>
<tr>
<td>CDM</td>
<td>Collaborative Decision Making</td>
</tr>
<tr>
<td>COLREG</td>
<td>International Regulation for Preventing Collisions at Sea</td>
</tr>
<tr>
<td>D</td>
<td>Delivery</td>
</tr>
<tr>
<td>DVM</td>
<td>Dynamic Voyage Management</td>
</tr>
<tr>
<td>ECDIS</td>
<td>Electronic Chart Display and Information System</td>
</tr>
<tr>
<td>ENC</td>
<td>Electronic Nautical Charts</td>
</tr>
<tr>
<td>EMSN</td>
<td>European Maritime Simulator Network</td>
</tr>
<tr>
<td>ETA</td>
<td>Estimated Time of Arrival</td>
</tr>
<tr>
<td>ETD</td>
<td>Estimated Time of Departure</td>
</tr>
<tr>
<td>FIR</td>
<td>Flight Information Region</td>
</tr>
<tr>
<td>FM</td>
<td>Flow Management</td>
</tr>
<tr>
<td>FPT</td>
<td>Flow Point</td>
</tr>
<tr>
<td>FSA</td>
<td>Formal Safety Assessment</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>KPA</td>
<td>Key Performance Area</td>
</tr>
<tr>
<td>KPO</td>
<td>Key Performance Objective</td>
</tr>
<tr>
<td>LRIT</td>
<td>Long Range Identification and Tracking</td>
</tr>
<tr>
<td>M-ECDIS</td>
<td>MONALISA-ECDIS</td>
</tr>
<tr>
<td>MRCC</td>
<td>Maritime Rescue Coordination Center</td>
</tr>
<tr>
<td>MSI</td>
<td>Maritime Safety Information</td>
</tr>
<tr>
<td>MSP</td>
<td>Maritime Service Portfolio</td>
</tr>
<tr>
<td>MSP</td>
<td>Maritime Special Planning</td>
</tr>
<tr>
<td>NCA</td>
<td>National Competence Authority</td>
</tr>
<tr>
<td>NM</td>
<td>Nautical Mile</td>
</tr>
<tr>
<td>NtM</td>
<td>Notice to Mariners</td>
</tr>
<tr>
<td>OOW</td>
<td>Officer on Watch</td>
</tr>
<tr>
<td>RNP</td>
<td>Required Navigational Performance</td>
</tr>
<tr>
<td>SAR</td>
<td>Search and Rescue</td>
</tr>
<tr>
<td>SRS</td>
<td>Ship Reporting System</td>
</tr>
<tr>
<td>STM</td>
<td>Sea Traffic Management</td>
</tr>
<tr>
<td>STCW</td>
<td>International Convention on Standards of Training, Certification and Watchkeeping</td>
</tr>
<tr>
<td>SVM</td>
<td>Strategic Voyage Management</td>
</tr>
<tr>
<td>SWIM</td>
<td>System Wide Information Management</td>
</tr>
<tr>
<td>TBD</td>
<td>To Be Determined</td>
</tr>
<tr>
<td>TSS</td>
<td>Traffic Separation Schemes</td>
</tr>
<tr>
<td>UCD</td>
<td>User Center Design</td>
</tr>
</tbody>
</table>
### 1.6 Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waypoint</td>
<td>Reference point on the route</td>
</tr>
<tr>
<td>Flowpoint</td>
<td>Key waypoint for which ETA is used in Traffic Coordination</td>
</tr>
<tr>
<td>Route</td>
<td>The intended horizontal direction of travel with respect to the earth. The route is described in IEC 61174 by route information, route geometry and route schedule</td>
</tr>
<tr>
<td>Route plan</td>
<td>Detail plan of the geometrical route together with route schedule.</td>
</tr>
<tr>
<td>Voyage plan</td>
<td>Route plan together with additional voyage information regarding crew, cargo, environmental and legal aspects.</td>
</tr>
<tr>
<td>Route exchange (ship-to-ship)</td>
<td>Next couple of WPT along the ships planned route are broadcast by means of AIS to vessels in line of site</td>
</tr>
<tr>
<td>Intended routes</td>
<td>A route that has reached status TBD</td>
</tr>
<tr>
<td>Suggested route</td>
<td>A proposed change to the agreed geometrical route</td>
</tr>
<tr>
<td>Suggested schedule</td>
<td>A proposed change to the agreed route schedule</td>
</tr>
<tr>
<td><strong>Type of geographical area</strong></td>
<td><strong>Definition</strong></td>
</tr>
<tr>
<td>Area of operation</td>
<td>A geographical area where a certain service can be provided</td>
</tr>
<tr>
<td>Critical area</td>
<td>An high risk geographical area where ship traffic is allowed, but increase safety measures are taken as stringent safety margins</td>
</tr>
<tr>
<td>Static No Go Area</td>
<td>A static (over time and in space) geographical area where ship traffic is restricted or partially restricted for ship traffic</td>
</tr>
<tr>
<td>Dynamic No Go Area</td>
<td>A dynamic (in time and space) geographical area restricted or partially restricted for ships traffic</td>
</tr>
<tr>
<td>VTS area</td>
<td>A geographical area where VTS is conducted to all or some specific vessels</td>
</tr>
</tbody>
</table>
| Port area                           | A geographical area where Port Control is conducted to all or
SRS area
Ship reporting system (SRS) area (IMO defined)

SAR area
Search and rescue areas, in each of which the countries concerned have delimited search and rescue regions for which they are responsible.

NAVAREA/METAREA
Geographic areas in which various governments are responsible for navigation and weather warnings

### 1.7 Documents


2 Strategic enabling concepts

This section describes the strategic enabling concepts FM and DVM, which are defined in Activity 2 and for which operational services are detailed and tested in Activity 1. But first, the overall STM concept is described.

2.1 Background

The introduction of STM puts a focus on enabling safe, sustainable, and efficient sea transports. STM is a response to the need to increase efficiency in operations within and between ports. The concept takes a holistic approach to services putting the berth-to-berth voyage in focus and uses that as a core element for process optimisation, actors and stakeholder interaction and information sharing. An enhanced sharing of information ship-to-ship, ship-to-shore, and shore-to-shore is also an important enabler for increased safety during sea transports. The improved safety is based through an enhanced situational awareness and right information at the right time. Shore-based organisations can contribute considerably by adding valuable information and advice based on:

- An enhanced traffic image which can be used to detect potential collisions, groundings and traffic congestions alerting vessels
- Updated regional information and effective way of informing ships about potential hazards.

All this is enabled by allowing information owners to share real-time information to preferred recipients as well as allowing information users to access necessary, real-time based data streams for their purpose.

The scope of STM includes private, mandatory, and public service opportunities along the voyage, berth-to-berth. Further, STM relates to existing practices and initiatives within e-navigation, e-maritime, and the collaborative port. As outlined above, the STM concept is defined by its operational services, which involves already existing processes and services and in some cases new defined services by:

- Enhancing existing services
- Proposing and validating new innovative services.

Four enabling strategic concepts have been identified in STM as crucial for reaching the target values. These are:
- **Port Collaborative Decision Making (Port CDM)**, in which the process for arrivals and departures is made more efficient through information sharing, common situational awareness and improved processes;

- **Strategic Voyage Management (SVM)**, which deals with route planning, route exchange and route optimisation before the voyage has started;

- **Dynamic Voyage Management (DVM)** which deals with route planning, route exchange and route optimisation whilst the ship is on its way;

- **Flow Management (FM)**, which includes services that will support both land organisations and ships in optimising overall traffic flow through areas of dense traffic and areas particular navigational challenges.

These are all enabled by:

- Information sharing by **Sea System Wide Information Management (SeaSWIM)**, which has the intention of being a common framework for information sharing and service distribution for maritime activities.

### 2.2 Flow Management

FM focuses on optimising the overall maritime traffic flow within a specific geographical region. The knowledge of all or nearly all ship’s route plans and schedules within a geographical region gives rise to the possibility of coordinating the traffic by the use of:

- **Dynamic No-Go-Areas**, representing areas that should be avoided during certain time periods or by certain ships, due to environmental or navigational aspects. This will be accounted for already in the voyage planning phase.

- **Dynamic separation**, which can be performed in two ways:
  - Lateral dynamic separation, which may be used to separate in/out-bound but also in overtaking situations; and
  - Longitudinal dynamic separation, i.e. when overtaking is not safe or practical, separating traffic in the longitude plane. This can be performed already in the voyage-planning phase.

- **Temporal separation**, representing a time window for the ship in order to reach an optimised ETA in port, also considering areas with traffic congestions. This can be accounted for in the voyage planning process and will be a continually updated.

FM services are provided by authorities or commercial service providers appointed by the National Competent Authority (NCA), and could for instance be:
• Port Control
• Vessel Traffic Service (VTS)
• Other shore-based service provider.

The two first organisations already exist today, while the last one may be introduced by the STM concept. FM services are provided within a specific defined geographical area. Below there is a summary of the FM services:

• **Establish a regional traffic image and route plan database**, which continuously updates the real time traffic and stores the ship's intended routes and schedules

• **Enhanced shore-based monitoring in critical areas**, which uses the known intended routes and schedules to monitor ship traffic in specific areas, which could be environmental sensitive, or have high traffic density or be navigationally challenging

• **Area management**, which collects, manages and distributes maritime information, and manages dynamic no-go-areas

• **Flow optimisation**, which optimises the overall traffic flow within congested areas

• **Traffic Pattern Analysis**, which use statistical information in order to optimises future traffic flow in congested areas.

Note that the SeaSWIM concept guarantees a seamless transition of information along the ship's route.

### 2.3 Dynamic Voyage Management

The DVM concept provides improved situational awareness through enhanced traffic information by route exchange ship-to-ship, ship-to-shore and opens up new possibilities for assistance of vessels en-route. The optimisation creates the prerequisite for “just-in-time” operations arriving and departing from ports. Below the above listed operational services are further described.

If a ship's route plan and schedule are exchanged and made available for different actors and stakeholders this would open up for new possible services:
• **Single reporting**, the objective is to perform ship reporting once, which is then distributed to all stakeholders along the route. Ship information is transmitted together with route information

• **Route cross-checking**, which checks the planned route with respect to regional information

• **Route optimisation**, which optimises the route with respect to environmental, port, regional and traffic parameters and constraints

• **Deep sea shore based assistance or shore based navigation assistance**, which gives navigational support outside the VTS area. This is discussed further in SA 1.5.

• **Routes exchange** ship to ship, which increases the situational awareness in traffic situations.
2.4 Interaction between FM and DVM

The FM relation to DVM is depicted in figure 1 and figure 2, below. In the DVM operational service Route Cross-Checking, the route plan is validated with respect to the current situation in a specific geographical area along the route. Route Cross-Checking uses the Area Management along the route.

![Diagram showing interaction between FM and DVM](image)

**Figure 1: Relationship between DVM: Route Cross-Checking and FM: Area Management.**

In the DVM service Route Optimisation, the route plan is initially optimised with respect to:

- Weather routing service, weather, current, ice conditions along the route for the time span of the voyage
- Area Management, regional conditions for the geographical areas along the route;
- Flow Optimisation, in congested regions along the route
- Port status in the port of call.

Several of the above parameters are changing at different time scales and the route optimisation process needs to be constantly performed during the voyage updating the route and schedule.
The Strategic planning turns into a dynamic voyage plan when the voyage order is issued and delivered on board. A voyage plan can in any given moment be updated by a new Strategic Voyage Plan (SVP), depending on altered prerequisites from owner or charterer. The dynamic voyage plan turns into a tactical condition when enhanced situational awareness is required on the conning place on board.

A dynamic voyage plan is the strategic voyage plan in iterative condition, sharing information in real time; updating voyage plans between involved parties in order to improve the safety, efficiency, environmental performance and situational awareness on board.

The relationship between components; strategic planning, dynamic operation and tactical action in the total STM concept is visualised in figure below;
Figure 3  Relationship between strategic planning, dynamic operation and tactical action in the total STM concept.
3 Operational analysis

This section performs an operational analysis of the FM and DVM services defined in chapter 2, in order to identify operational parameters, information needs and functions.

3.1 Operational aspects of route exchange

The FM and DVM operate in two main modes of operation:

**Ship-to-shore mode, Shore-to-ship:**
Exchange of route information in order to:

- Enhanced traffic monitoring for improved navigation safety
- Enhanced traffic surveillance for improved security
- Navigation assistance
- route optimisation for efficient shipping and low environmental impact, and
- ashore coordination of ice navigation by dynamic ice routes changes to participating ships. (This application is not discussed in this document.)
- ashore coordination of SAR and pollution response operations by providing search path as route changes to participating ships. This application is not treated in this document.

**Ship-to-ship mode:**
Exchange of route information between ships within the horizon, or AIS line of sight, in order to:

- Enhance the onboard situational awareness by combining Radar/ARPA/AIS/Visual observations of other nearby ships. Note that the route information is considered as traffic information and used in the strategic navigation and not used for tactical anti-collision; and
- On scene coordination of SAR and oil response operations by providing search path as route changes to participating ships. This is not covered in this report.

3.1.1 Operational picture

An operational picture of the route exchange concept is depicted in the figure 4 below, identifying system actors and stakeholders.
Based on the operational picture, the following operational nodes can be identified:

- **Actors**, which are part of the system. Each actor is in fact a complete system operated by one or several operators.
- **Users**, working outside the system, but are directly using the system's data.
- **Stakeholders**, which are working outside the system, which are benefiting from the system.

The following actors are identified as part of this service:

- **Shore-based operator**, this is the operator delivering shore-based services. If the area of operation is located within a Vessel Traffic Service (VTS) area, then the service is performed by a VTS operator.

- **STM compliant ships**, having the relevant STM equipment and procedures implemented on board, so it can make full use of the STM concept. In practice meaning the functionality of exchanging a segment of its route and schedule plan with the shore-based operator.

- **STM non-compliant ships**, a ship(s) that is/are not participating in the STM process or does not have the relevant STM compliant equipment. Following vessels can be of this category:
- Other merchant ships
- Fishing vessel
- Leisure ships
- Governmental ships.

The main operational element in the concept, representing the main information transfer, is represented by the ship’s route, and dynamic restricted areas:

- **Ship’s route.** This is geospatial information in the form of waypoint (WPT) coordinates, courses and distances representing legs between the WPTs, Wheel Over Position (WOP) or Wheel Over Line (WOL) and turning radius, and safety margin, and temporal information in the form of WPT ETAs. A WPT represent a change in the ship status e.g. course or speed alterations, manning status or reporting point. The safety margins represent a safety corridor around the track. The dimensions are defined by: safety depth, cross track distance (XTD) error, and air draught.

![Figure 5: Definitions of route elements. WPT, leg and, XTD.](image)

- ![Figure 6: Definitions of route elements used in a turn.](image)
• **Dynamic restricted areas/No-go-areas.** This is geographical information in the form of geographical coordinates, and temporal information defining the time for which the area is restricted, together with text information regarding e.g. type of restriction, which vessels does it apply for etc.

The services route cross checking, optimised route, area management, and flow optimisation refers to areas or zones around the ship:

• Ship safety box, and
• Temporal and spatial separation.

The ship’s **safety box** refers to the safety parameters defined in the voyage plan process:

• Safety depth
• XTD
• Air draught.

The safety box is also entered into the ECDIS and bridge systems. The route is internally checked and validated according to the normal ECDIS functions.

Within the project a **common route exchange format** supporting all processes in the STM concept is developed. It will be used:

• On board for safe navigation (ECDIS etc.)
• On board for route-, schedule- and speed optimisation
• By service provider for route optimisation services
• Ashore for different services, and
• Ashore by other stake holders who have interest in the vessels route and schedule Vetting, Ships-operator, Port Authorities etc.

The route format will:

• Be open and aligned with international standards
• Allow easy customization so that project goals can be achieved
• Allow easy and safe exchange of routes between ship and shore.
The information can be divided in three groups:

- General Route Information and vessel static data
- Route geometry and waypoint data
- Schedule and environmental data.

3.1.2 Operational phases and areas

The world’s oceans and coastal waters are divided into SAR and NAVAREA/METAREA regions. The SeaSWIM concept guarantees the seamless transition of information along the ship’s route and through the different geographical regions. All the FM services are acting regionally within specific regions. During the voyage different services have different importance. During ocean passages, the ship traffic is of very low density and the primary objective is to optimise the routes with respect to shortest passage in combination with environmental conditions as ocean currents, weather system, sea state and ice conditions.

The FM optimisation service is manly relevant in coastal regions and more specific; restricted waters, fairways, port and canal entrants. Hence, FM mainly affects fairway and coastal navigation but also port departure and arrival. FM and DVM acts on all operational phases for a voyage, as defined in figure 7 below.

![Figure 7](image-url)

Figure 7: Definition of planning and execution phases used in the project.

The FM services are working with input local and regional inputs that are constantly changing in time:

- Traffic situation
- Safety of navigation (MSI)
- Environment conditions.
This means that the FM services are more focuses on the execution phase and near-time planning. This is reflected in the table below.

<table>
<thead>
<tr>
<th>Phase</th>
<th>FM service/DVM service</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning</td>
<td>Area Management</td>
<td>Mainly in the area of departure</td>
</tr>
<tr>
<td></td>
<td>Flow optimisation</td>
<td>Mainly in the area of departure</td>
</tr>
<tr>
<td></td>
<td>Route cross-checking</td>
<td>Along the whole voyage</td>
</tr>
<tr>
<td></td>
<td>Route optimisation</td>
<td>Along the whole voyage</td>
</tr>
<tr>
<td>Execution</td>
<td>Traffic image</td>
<td>Constantly updated in the upcoming and current SIRs</td>
</tr>
<tr>
<td></td>
<td>Route database</td>
<td>Mainly in the current and upcoming</td>
</tr>
<tr>
<td></td>
<td>Area Management</td>
<td>Outside the VTS area</td>
</tr>
<tr>
<td></td>
<td>Flow optimisation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Route optimisation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Deep sea shorebased assistance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Route exchange</td>
<td>Route exchange between ships</td>
</tr>
<tr>
<td>Evaluation</td>
<td>Capacity planning</td>
<td>Mainly in areas with high traffic density</td>
</tr>
</tbody>
</table>

Table 1: FM services wrt to different operational phases of the voyage.

### 3.1.3 Operational processes

Each actor is performing a number of operational processes. These processes are listed in the figure 8.

**Figure 8:** Identification of operational processes for the involved actors. At this level, there is no difference between ships participating in the system or ships not participating in the system.
The information flow between the actors are identified in figure 9.

The FM and DVM need to interact with ships not participating in the system. This means that the main medium for communication is voice. The different communication paths are defined in the table 2 below.

<table>
<thead>
<tr>
<th>Path</th>
<th>Actor - output</th>
<th>Actor - input</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Participating ship</td>
<td>Shore-based service provider</td>
<td>Route information</td>
</tr>
<tr>
<td>1</td>
<td>Shore-based service provider</td>
<td>Participating ship</td>
<td>Updated Route information</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Restricted areas</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Voice communication</td>
</tr>
<tr>
<td>2</td>
<td>Participating ship</td>
<td>Participating ship</td>
<td>Part of the route</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Voice communication</td>
</tr>
</tbody>
</table>

Figure 9: Identification of information flow between the involved actors.
Table 2: Identification of information flow between the involved actors. Note that information to/from not participating ships is as today – voice communication.

A flow diagram of the route exchange process is captured in figure 10 below.

Figure 10: Flow diagram of the route exchange process.
3.2 Analysis of operational services

3.2.1 Route exchange ship-to-ship

Operational context
Introducing route exchange ship-to-ship, will give the intentions of other ships. The route exchange will solely introduce a new tool that helps the Officer of the Watch (OOW) to plan ahead, foresee possible dangerous situations and reduce route detours due to traffic conditions. Hence, the objective with route exchange is to enhance the situational awareness by providing a ship surrounding ship’s routes and displaying them on the ECDIS.

Nothing in the current “navigational process” will be changed, the master is still responsible and COLREGs are always in force. The route exchange should be used to avoid close quarter situations. The Route Exchange Service is implemented by exchanging or a few WPT ahead. The route segment is sent using AIS-ASM. Support for this is already implemented in the AIS-ASM standard but very few onboard ECDIS support this today. However, also Turn Radius should be implemented as part of next revision of the standard as there is large difference in route geometry if vessel use 0,5 M compare 1,5 M radius.

Operational parameters
Based on the above contextual description the bases of the operational analysis may be laid down, identifying the operational parameters, see table 3 below.

<table>
<thead>
<tr>
<th>Operational parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational environment</td>
<td>The service can be used in all types of weather conditions</td>
</tr>
<tr>
<td>Operational geographical area</td>
<td>All geographical areas Coverage is within AIS line of sight, typically 30 M</td>
</tr>
<tr>
<td>Operational nodes</td>
<td>STM compliant ship using the service</td>
</tr>
<tr>
<td></td>
<td>STM compliant ship which is not using the service</td>
</tr>
<tr>
<td></td>
<td>Non STM compliant ships/vessels</td>
</tr>
<tr>
<td>Operational element</td>
<td>Exchanged information – few WPT ahead of the intended route and the leg between them together with turn radius</td>
</tr>
<tr>
<td></td>
<td>Exchange routes (send and receive route segments) ship to ship via AIS (message 8 SN.1/Circ.2892 June 2010) and display them on ECDIS</td>
</tr>
<tr>
<td>Actors</td>
<td>Ship’s master for the STM ship using the service</td>
</tr>
<tr>
<td></td>
<td>Ship’s OOW for the STM ship using the service</td>
</tr>
<tr>
<td></td>
<td>Shore based service operator</td>
</tr>
<tr>
<td>VTS operator</td>
<td>Stakeholders</td>
</tr>
<tr>
<td>----------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Ship's master for the STM ship not using the service</td>
<td>Coastal State NCA</td>
</tr>
<tr>
<td>Ship's OOW for the STM ship not using the service</td>
<td></td>
</tr>
<tr>
<td>Ship's master for the STM non-compliant ship/vessel</td>
<td></td>
</tr>
<tr>
<td>Ship's OOW for the STM non-compliant ship/vessel</td>
<td></td>
</tr>
</tbody>
</table>

Table 3: Operational parameters identified based on the operational description.

**Analysis**

Based on the operational context and operational parameters listed in the previous paragraph Route exchange is divided into four distinct functions:

1. Voyage is loaded for monitoring and a choice is made to allow other vessels to see route segments.
2. Ship changes a WPT or ETA. New route should be sent.
3. Other ship acquire own ship’s route and displays it on the M-ECDIS display.
4. The handshaking process should be automatic. It should be possible to show/not show the ship’s exchanged route.

The route exchange is used in order to increase the situational awareness and in strategic decision making to avoid, if possible, ending up in a risk of collision or a close quarter situations. It is important to note that COLREG always applies when vessels are in a risk of collision and route exchange should not be used in those situations. In confined waters, archipelago and other areas where there is limited space for manoeuvre outside the recommended fairway or TSS, speed adjustments is the best and many cases the only way to prevent close situations. The anti-collision function can be divided into two modes of operation that are run in parallel:

- Tactical navigation mode; and
- Look ahead mode or strategic mode
Figure 11 Illustration of the two modes Tactical navigation and Look ahead, which constitutes the anti-collision function.

**Tactical navigation mode:**
In this mode, the ship has the intended route displayed on its navigational displays. It monitors its voyage and schedule according to normal operating procedures with the addition of procedures for the ship-to-shore communication. The OOW monitors all surrounding vessels based on visual-, Radar-, and AIS-observations. If a risk of collision is detected, the involved vessels should follow COLREG.

**Look ahead:**
In this mode the OOW looks ahead along the ships route to detect any potential dangers or reasons for route change. In this mode, strategic navigation, it is still possible to make small course alterations and in that way avoid ending up in a risk of collision situation. It is in this mode the OOW can use the route exchange service in order to increase the situational awareness.
3.2.2 Enhanced shore-based monitoring

**Operational description**

The objective of this service is to perform enhanced shore based monitoring within a defined area in order to increase the safety of navigation. Enhanced monitoring will be supported by adding route information and a more detailed service than present VTS can be provided. Shore centres will be able to detect if the planned schedule is not kept or if a ship deviates from the intended route. Thus shore centres can monitor that ships are following their planned route and also foresee possible dangerous situations and suggest route modifications (geographic and/or speed) due to traffic or other impeding conditions.

The shore centres should exchange routes with the ships, send and receive routes/route segments, ship to shore and display them on the VTS/STM shore centre system. The shore centre operators will be supported by anomaly detection tools to be taken into operation in the project.

**Operational parameters**
Based on the above contextual description the bases of the operational analysis may be laid down, identifying the operational parameters, see table 4 below.

<table>
<thead>
<tr>
<th>Operational parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational environment</td>
<td>The service can be used in all type of weather conditions</td>
</tr>
<tr>
<td>Operational geographical area</td>
<td>VTS area. An critical area within a nation's territorial waters or Exclusive Economic Zone (EEZ)</td>
</tr>
<tr>
<td></td>
<td>Examples of criteria for critical sea areas are:</td>
</tr>
<tr>
<td></td>
<td>Restricted areas with high traffic density</td>
</tr>
<tr>
<td></td>
<td>Environmentally sensitive sea areas, and Oil, gas, wind or wave energy installation arrays.</td>
</tr>
<tr>
<td>Operational nodes</td>
<td>Shore based service provider</td>
</tr>
<tr>
<td></td>
<td>VTS</td>
</tr>
<tr>
<td></td>
<td>STM compliant ship using the service</td>
</tr>
<tr>
<td></td>
<td>STM compliant ship which is not using the service</td>
</tr>
<tr>
<td></td>
<td>Non STM compliant ships/vessels</td>
</tr>
<tr>
<td>Operational element</td>
<td>Exchanged information – segment of intended route, all WPT through the area of operation</td>
</tr>
<tr>
<td></td>
<td>Route suggestion</td>
</tr>
<tr>
<td></td>
<td>ETA suggestion</td>
</tr>
<tr>
<td>Actors</td>
<td>Ship’s master for the STM ship using the service</td>
</tr>
<tr>
<td></td>
<td>Ship's OOW for the STM ship using the service</td>
</tr>
<tr>
<td></td>
<td>Shore based service operator</td>
</tr>
<tr>
<td></td>
<td>VTS operator</td>
</tr>
<tr>
<td></td>
<td>Ship’s master for the STM ship not using the service</td>
</tr>
<tr>
<td></td>
<td>Ship’s OOW for the STM ship not using the service</td>
</tr>
<tr>
<td></td>
<td>Ship’s master for the STM non-compliant ship/vessel</td>
</tr>
<tr>
<td></td>
<td>Ship’s OOW for the STM non-compliant ship/vessel</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Coastal State NCA</td>
</tr>
<tr>
<td></td>
<td>Port</td>
</tr>
<tr>
<td></td>
<td>Ship owner</td>
</tr>
</tbody>
</table>

Table 4: Operational parameters identified based on the operational description.

**Analysis**
This service is provided by an authority or commercial service provider approved by a NCA.

The intention of this service is to operate in coastal regions within a critical sea area. This is a geographical area located within or outside a VTS area. However, the area is defined within a nation’s territorial waters or Exclusive Economic Zone (EEZ). Examples of criteria for critical sea areas are:
- Restricted areas with high traffic density
- Environmentally sensitive sea areas
- Oil, gas, wind or wave energy installation arrays.

Another type of critical sea area is denoted a dynamic No Go Area, with the criteria that it is only valid during a certain period of time or only valid for certain types of ships during a certain period of time. This type of critical sea area can also utilise enhanced shore-based monitoring.

During the monitoring phase, the OOW continuously monitors the ship’s track with respect to the intended track, navigational hazards, and other traffic. In more restricted waters or were the traffic is congested increased manning could be a measure to cope with the increased workload. Deviations from the intended route will be detected by constantly comparing the route database with the traffic image and necessary measures could be taken. Both the monitoring and the surveillance functions could use different types of automatic rule based anomaly detection functions. Hence, the system would automatically detect if a ship is leaving its intended track or if a non-participating ship is manoeuvring according to “strange patterns”. In order to identify “strange patterns” statistical analysis could be used to identify “normal traffic patterns”.

There are some conditions that have to be fulfilled in order to be able to provide the services:

- The existing traffic image consisting of AIS targets; and
- Voice and text communication are supported.

Today, real-time traffic images are established within VTS and port areas. In EU coastal waters, a near-time traffic image is established by regional AIS networks. Still, in most cases a real-time traffic image need to be established. All SOLAS vessels are equipped with AIS class-A stations. Other vessels can be equipped with AIS-B stations on voluntary basis; hence all vessels are not shown as AIS targets.

The service can be divided into three distinct operational phases:

**Phase 1: Planning**

This phase starts when the ship receives a Voyage Order from the shipping company. The detailed route planning is performed according the ship’s normal navigation policy and procedures. It is decided by the master or shipping company’s navigation policy if Enhanced Monitoring service will be used and for which leg.

Further, one more possible input to the route planning process within the critical area could be a ship risk index. Hence, for each ship using the service a risk calculation is performed by the master based on:

- Ship’s cargo, dangerous cargo
• Master’s experience
• Bridge crew experience
• Expected weather and oceanographic conditions
• Ship’s manoeuvring characteristics
• Port Control status.

The total risk value is also considering the geographical area with respect to:
• Navigation hazards
• Traffic density
• Environmental sensitive areas
• MSP
• Offshore activities
• Operations conducted in the area
• Current and tidal water conditions.

When the ship is leaving port, the service provider receives ship-reporting information via the Single Reporting Service and planned route segment.

Phase 2: Outside the area
Before entering the critical area, the intended route is made available and at the same time traffic coordination is performed affecting mainly the ship’s schedule.

Phase 3: Within the area
The service is executed:
• Route monitoring on board
• Route monitoring ashore, and
• Detection of deviation.
The different operational phases are illustrated in Figure 4 below.

![Figure 12: Illustration of the service operational phases put into an operational context.](image)

### 3.2.3 Area management

**Operational context**

Introducing Maritime Spatial Planning (MSP) tool into the maritime domain will give a more graphic overview on areas where ships are not allowed to pass due to e.g. whale nursery areas, military exercises or SAR operations. The areas should be attached with a date attribute so that they disappear when they are obsolete.

**Operational parameters**

Based on the above contextual description the bases of the operational analysis may be laid down, identifying the operational parameters, see table 5 below.

<table>
<thead>
<tr>
<th>Operational parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational environment</td>
<td>All conditions</td>
</tr>
<tr>
<td>Operational geographical area</td>
<td>All sea areas, divided into METAREAS/NAVAREAS</td>
</tr>
</tbody>
</table>
| Operational nodes                  | Shore based service provider  
|                                     | VTS                                                                         |
|                                     | STM compliant ship using the service |
Table 5: Operational parameters identified based on the operational description.

Analysis
The exchange of route information and dynamic geo-locations, open up new possibilities for area management. A geographical area, which is considered to be a sensitive during specific periods of times, can dynamically be classified as a restricted area or no-go-area. This type of eras will be considered already during the planning phase, when using route optimisation or Route Validation. This area will also be visible on-board, presented to the OOW by the normal ECDIS system. MSI and other safety related information are geo-spatial information and can also be presented by the ECDIS. This has been investigated in the EU-INTEREG project ACCSEAS. Area Management will manage all this geo-spatial information and issue and handle dynamic No-Go areas. One application of this service is Management of Maritime Spatial Planning (MSP).

The service can be divided into two functions:
1. Area to be avoided should be visible on an ECDIS or other STM display
2. Area should be “erased” automatically when obsolete

Further, this service is to establish a Single Page for updated navigational information and especially maritime safety information. Shore based organisations continually updates information about safety within their respectively areas of responsibility. The information can be divided into:

- Legal and environmental requirements;
- Nautical information;
- Notices to Mariners;
- Dynamic no-go-areas;
- MSI warnings;
- Weather information; and
• Oceanographic information.

3.2.4 Flow optimisation

Operational context
A shore-based operator is performing flow optimisation through advice to the ships within a defined sea area using an enhanced traffic image, consisting of AIS targets and with the planned routes for the STM compliant ships. As a part of the route schedule, the operator has access to the ship’s ETA to some key waypoint, denoted flowpoint (FPT). Based on the above information, the operator is continually assessing the overall maritime traffic situation within his sector of responsibility. If a developing traffic situation is identified, the operator can recommend a new ETA for the FPT in order to resolve the situation at an early stage. In case of a MSI receipt, e.g. a fairway or traffic lane is closed; the operator can use both re-scheduling and suggested route/s, which is a proposed new route segment. In the case of a port approach the approach could be synchronised with the port call.

The objective of this operational service is to, if needed, perform traffic flow optimisation in restricted geographical areas with high traffic density in order to increase both the safety of navigation and the efficiency of ship traffic. If the traffic flow keeps defined safety margins, no interference from shore is needed.

Operational parameters
Based on the above contextual description the bases of the operational analysis may be laid down, identifying the operational parameters, see table 6 below.

<table>
<thead>
<tr>
<th>Operational parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational environment</td>
<td>The service can be used in all type of weather conditions</td>
</tr>
<tr>
<td>Operational geographical area</td>
<td>Coastal regions within a specific critical sea area. Within a VTS area or within a nation’s territorial waters or EEZ. Examples of criteria for these geographical sea areas are: Restricted areas with high traffic density Port entrances with high traffic density Fairways with high traffic density, and Canals or inland waterways with high traffic density.</td>
</tr>
<tr>
<td>Operational nodes</td>
<td>Shore based service provider VTS STM compliant ship using the service STM compliant ship which is not using the service Non STM compliant ships/vessels</td>
</tr>
</tbody>
</table>
| Operational element | Exchanged information – segment of intended route, all WPT through the area of operation  
|                     | Route suggestion  
|                     | ETA suggestion  
| **Actors**          | Ship's master for the STM ship using the service  
|                     | Ship's OOW for the STM ship using the service  
|                     | Shore based service operator  
|                     | VTS operator  
|                     | Ship's master for the STM ship not using the service  
|                     | Ship's OOW for the STM ship not using the service  
|                     | Ship's master for the STM non-compliant ship/vessel  
|                     | Ship's OOW for the STM non-compliant ship/vessel  
| **Stakeholders**    | Coastal State NCA  
|                     | Port  
|                     | Ship owner  

Table 6: Operational parameters identified based on the operational description.

**Analysis**

In theory, the Route optimisation service could also include traffic in congested waters and port entrances as a parameter in the overall optimisation of the voyage. However, in practice this would require that all ships are using this service and follow its plan. Flow optimisation may also work as an independent service in specific geographical areas and optimising the traffic in near real-time.

Flow optimisation could separate inbound traffic from outbound traffic resolving unnecessary traffic congestions. Also a time slot separation between ships close to the departing port could be included. During the execution of the voyage, the continuous route optimisation can include traffic coordination in nearby congested areas using time slots.

The time slot or ETA window can visuals the ETA margin in order to maintain an optimal speed and arrive in port at the predicted ETA. However, the practical implementation will be ETA driven and using key WPT at strategic positions along the route, here denoted Flowpoint (FPT), will be part of the route plan.

The overall objectives of this service are:

- Ship to arrive at final destination in due time as efficient as possible
- Provide information to interested parties about planned and predicted time of arrival to final destination or other point of interest
- Increase safety and prevent delays through a good flow in narrow channels where traffic density is high.
The two first objectives are all about sharing information where:

- Port needs to inform ship about any change in the planned time of arrival or prerequisites for to the final destination. Today, this is done by mail, fax or phone. In the future this should be done online as message to ship for direct access to the OOW.

- Ship to inform about the estimated time of arrival ETA. There are two ways available today; to obtain the information from vessels voyage plan or read this information from AIS. In the Strategic Scenario > 24h we can anticipate that vessel might update schedule as part of voyage plan or post the information as part of none report. In the shorter time scenario tactical <24 hours there are no other means than information obtained from AIS that contains two fields Destination and Time of arrival. This is a manual input made by OOW when voyage is started. In most cases not updated in case of change of ETA often it is seen that ships sailing with destination and ETA for previous port. This could be automated in the following way if ECDIS has AIS MKD functionality:
  - Destination - should be taken from ECDIS route. Default will be last WP but it should be possible to choose any other as example a WPT located at Pilot buoy.
  - ETA - should be taken from Schedule and be updated online by ECDIS.

The last objective can be solved in two ways either recommend vessels a change in route geometry or change of speed and ETA:

- **Change of route geometry**
  This is supported by the new route exchange format allowing shore centre to adjust ship’s route plan and send it as a recommendation or alternative create just an alternative segment that can be sent as a recommendation that ship can use as an alternative segment.

- Change of Speed and ETA

- Separating vessels in time when they pass a narrow channel or area with dense traffic is the best way to increase safety, efficiency and save the environment. This can be done by recommend new speed or ETA where the latest is the most efficient as it requires no online monitoring of vessel position and performance. By recommending ETA including an ETA window time slot will be allocated for each ship.
There are some conditions that have to be fulfilled in the area of operation in order to be able to provide the services:

• The existing traffic image consisting of AIS targets
• Enhanced monitoring service is active by utilising an enhanced traffic image
• Voice and text communication are supported.

In summary, an implementation of this service would require:

A. As part of sailing instructions for given area geographical points where it is needed to separate ships in time must be defined. Hereinafter we call them Flow points or Flow Line. During Voyage planning ship should plan a WPT where route pass flow point or cross flow line. Let us call this WPT FWP. A FWP must have a unique name that is defined in the sailing instructions allowing shore centre to sort and filter different ships routes by ETA to FWP.
B. Functions in shore centre to manage ships relations to each FWP in the given area and methods to easy recommend ships change in the PTA/ETA. Methods should be available for ship to confirm that recommendation will be followed.

C. Function on board to select the next FWP for monitoring of ship’s speed allowing the ship to arrive in due time. ETA Box as well as Indicator will be implemented in onboard ECDIS.

D. Methods to share ETA to next FWP to shore centre and other ships. Today, there are no standard messages available as part of AIS ASM.

3.2.5 Route cross-checking

Operational context
The intended voyage plan is sent to a shore based service provider for cross-checking. The purpose is to include updated regional area information that could affect ships voyage plan. The cross-checking can be done before the ship’s departure or before arrival at a certain geographical area. The cross-check can include, but is not limited to, UKC, air draught, no violation of no-go areas, MSI and compliance with mandatory routeing. No optimisation service as such is included in the route validation.

Operational parameters
Based on the above contextual description the basis of the operational analysis may be laid down, identifying the operational parameters, see table 7 below.

<table>
<thead>
<tr>
<th>Operational parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational environment</td>
<td>The service can be used in all type of weather conditions</td>
</tr>
<tr>
<td>Operational geographical area</td>
<td>Coastal regions</td>
</tr>
<tr>
<td>Operational nodes</td>
<td>Shore based service provider</td>
</tr>
<tr>
<td></td>
<td>VTS</td>
</tr>
<tr>
<td></td>
<td>STM compliant ship using the service</td>
</tr>
<tr>
<td>Operational element</td>
<td>Ship name</td>
</tr>
<tr>
<td></td>
<td>Call sign/UVID</td>
</tr>
<tr>
<td></td>
<td>POS, SOG, COG</td>
</tr>
<tr>
<td></td>
<td>Navigation state (restricted by draft, etc.)</td>
</tr>
<tr>
<td></td>
<td>Route (Waypoints/Schedule/ETAs, Destination)</td>
</tr>
<tr>
<td>Actors</td>
<td>Ship’s master for the STM ship using the service</td>
</tr>
<tr>
<td></td>
<td>Ship’s OOW for the STM ship using the service</td>
</tr>
<tr>
<td></td>
<td>Shore based service operator</td>
</tr>
<tr>
<td></td>
<td>VTS operator</td>
</tr>
<tr>
<td>Stakeholders</td>
<td>Coastal State NCA</td>
</tr>
</tbody>
</table>
Table 7: Operational parameters identified based on the operational description.

Analysis
Today, the planned route is checked and validated by the onboard ECDIS before activated in the system. This service could offer an additional safety check of the intended route before entering a specific geographical area based on the latest regional information. A request of using this service could be based on:

- Particular ships navigation policy under current conditions;
- Shipping company’s navigation policy;
- Ship’s crew lack experience of the area
- Cargo owner requirement; and
- Insurance requirements.

The specific route segment could be checked both prior to departure and prior to entry to the specific area.

The service can be divided into the following functions:

- Voyage is loaded for monitoring on board and a choice is made to allow shore centres to see route/route segments and that cross-checking is requested.
- Shore centre cross-checks route according to their available information. Sends verification or new suggested route back.
- If new suggestion ships decides if to use suggested route as monitored.

3.2.6 Route optimisation

Operational context
The route optimisation tools will be different in nature with a common purpose to provide more information for the navigator on board. The STM concept will provide the means to get the ships route optimised from different service providers. The service providers have different focus including best route regarding; the weather forecast, surface currents, fuel consumption, no-go areas regarding draft, areas with sensitive nature, conflicts with other ships routes etc.

This is a service that is conducted by commercial service providers.
Operational parameters
Based on the above contextual description the bases of the operational analysis may be laid down, identifying the operational parameters, see table 8 below.

<table>
<thead>
<tr>
<th>Operational parameter</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational environment</td>
<td>The service can be used in all type of weather conditions</td>
</tr>
<tr>
<td>Operational geographical area</td>
<td>All sea areas</td>
</tr>
</tbody>
</table>
| Operational nodes | Shore based service provider  
STM compliant ship using the service |
| Operational element | Ship information:  
Ships identification/UVID  
Route (Waypoints/Schedule/ETAs and Destination)  
Draught  
Fuel type  
Block coefficient  
Dimensions (Length, beam)  
Speed-to-power profile  
Max Sign Wave height  
Speed/Apparent wind direction speed reducing ratio  
XYZ…. (Additional fields anticipated to be needed…) |
| Actors | Ship’s master for the STM ship using the service  
Ship’s OOW for the STM ship using the service  
Shore based service operator  
VTS operator |
| Stakeholders | Shipping company  
MSP NCA |

**Table 8: Operational parameters identified based on the operational description.**

Analysis
When the time of departure is defined, the voyage plan should be evaluated with respect to the latest environmental data (wind, visibility, tide, current, sea state). This can be gathered by means off:

- Onboard weather routing tool, or
- In cooperation with a shore based weather routing service provider.

Hence, the master can use different shore based service providers in order to optimise the ship’s passage. In the optimisation process the ship’s performance characteristics are used together with current and future environmental conditions. Different
organisations and companies provide shore based routing services, but these services are not free. Some Charter Parties specify that ships should be routed by a shore-based organisation as a condition or in some cases it is a company policy. However, it should be noted that there is no intentions by the routing agency to take over the initiative and responsibility from the master; the master is still responsible for all decisions and the safe passage of the ship.

The routing service is used in order to optimise the voyage with respect to for example:

- Least time
- Least time with least damage
- Least damage
- Constant speed, and/or
- Fuel saving.

The above parameters are often specified together with criteria such as:

- Ice free route (i.e. no ice classification);
- Deep water routes; and/or
- Good weather route (passenger and cargo).

The table below describes the communication process between the ship and the service provider.

<table>
<thead>
<tr>
<th>Planning</th>
<th>Information sent from ship</th>
<th>Information sent from service provider</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preliminary route</td>
<td></td>
<td>Weather report</td>
</tr>
<tr>
<td></td>
<td>Ship characteristics</td>
<td>Updated route</td>
</tr>
<tr>
<td>Passage plan</td>
<td></td>
<td>Weather report</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Route advice</td>
</tr>
<tr>
<td>Execution stage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9 Communication paths for a weather routing service between ship and shore based service provider.
The STM Route Optimisation services are voluntary services provided by different private or public service providers with the intention to optimise the route regarding to more parameters than is provided today e.g. weather, ice conditions, MSI, MSP, distance, speed, traffic congestion and bathymetric conditions. The route optimisation is an iterative process and can be performed both pre-departure and continuously en-route as basis and conditions changes.

The following functions are identified:

1. The route is shared to a service provider for optimisation.
2. The service provider alters the route as to their calculations.
3. The optimised route is send back to the ship.
4. The Master/OOW decides upon changing route or not.

In conclusion some of these services are available today and optimisation is carried out on board as well as by service providers ashore. However the route exchange provides new and more effective possibilities for this optimisation.

### 3.2.7 Information needs

Based on the above operational description an information analysis has been performed for the actors:

- Ship’s Master/OOW; and
- Shore based operator.

This is summarised in table 10.

<table>
<thead>
<tr>
<th>Actor/Information</th>
<th>Source of information</th>
<th>Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shore based operator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic image</td>
<td>FM: based on AIS</td>
<td>Current targets within a specific geographical area: Target ID Target COG and SOG Target position</td>
</tr>
<tr>
<td>Route data base</td>
<td>DVM: based on exchanged route information</td>
<td>Current intended route planes and route schedule for all targets within a specific geographical area and targets that will approach the area</td>
</tr>
<tr>
<td>Safety</td>
<td>NCA</td>
<td>NTM, MSI and other safety information within area of operation</td>
</tr>
<tr>
<td>Environmental parameters within the SIR:</td>
<td>Wind</td>
<td>Current</td>
</tr>
</tbody>
</table>

### SBNAS ship’s route and schedule
- **DVM: Route Optimisation Service**
  - SBNAS made the original route segment.
  - Route optimisation service optimise the whole route

### Ship reporting information and additional ship information
- **DVM: Single Reporting Service**
  - Ship reporting information.
  - Ship’s particulars; and
  - Ship’s manoeuvring characteristics.

### New route and schedule
- **DVM/FM**
  - Suggested route plane
  - Suggested route schedule

### Voice and text communication
- **FM, DVM**
  - Several possible communication channels

### Master/OOW

| Nautical chart       | On-board system (M-ECDIS) | Nautical chart
|----------------------|---------------------------|-----------------
|                      | Intended route            | Intended route

| On-board traffic image | On-board system (M-ECDIS, Radar, AIS) | Radar and AIS targets
|------------------------|--------------------------------------|-----------------
|                        | DVM: Route exchange Service          | Other ship’s routes via ship-to-ship route exchange

| Planned route and schedule | DVM: Route optimisation service | Ships intended route and SBNAS route segment

<table>
<thead>
<tr>
<th>Navigation Plan</th>
<th>DVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>For each leg: Lighthouses, with characters and visual range</td>
<td></td>
</tr>
<tr>
<td>Aids-to-Navigation (AtN)</td>
<td></td>
</tr>
<tr>
<td>Dangers and distance to dangers</td>
<td></td>
</tr>
<tr>
<td>Position fixing method</td>
<td></td>
</tr>
<tr>
<td>WO fixing method</td>
<td></td>
</tr>
<tr>
<td>Turning radius</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>New route and schedule</th>
<th>DVM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested route plane</td>
<td></td>
</tr>
<tr>
<td>Suggested route schedule</td>
<td></td>
</tr>
</tbody>
</table>

| Voice and text communication | FM, DVM |

---

**Table 10: Information needs for the different actors.**
This section discusses roles and procedures. The STM concept is an interaction between ships and shore organisations and it is paramount to have clearly defined roles and operating procedures.

4.1 Actors and roles

Based on the of operating elements identified above, actors can be identified and their roles can be described. This has been performed in the table below.

<table>
<thead>
<tr>
<th>Operating element</th>
<th>Actors</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participating ship</td>
<td>Master</td>
<td>The Master has the overriding authority and responsibility to make decisions with respect to: Safety of life Safety of property at sea Preventing pollution of the marine environment Commercial considerations are never allowed to take precedence over the primary concerns of: Safety of life Safety of property at sea Preventing pollution of the marine environment The specific responsibility with respect to FM is: That the ship follows the intended route and if it makes a major deviation from the route, a route change message is sent to the appropriate shore-based centre Confirms area notifications and respects no-go-areas (normal responsibility)</td>
</tr>
<tr>
<td>Participating ship</td>
<td>OOW</td>
<td>The OOW are responsible for the safe navigation of the ship during his time period of duty. He should specifically avoid grounding and collision. The OOW should read and understand: Stand operating procedures Standing orders Night orders The specific responsibility with respect to FM is: That the ship follows the intended route and if makes a major deviation from the route, notify the Master, a route change message is send to the appropriate shore based centre Notify the Master if a new route suggestion is received from a shore based centre Confirms area notifications and respects no-go-areas (normal responsibility)</td>
</tr>
<tr>
<td>Participating ship/ Master</td>
<td></td>
<td>The Master has the overriding authority and</td>
</tr>
</tbody>
</table>
Not-participating ships | responsibility to make decisions with respect to:
| Safety of life
| Safety of property at sea
| Preventing pollution of the marine environment
| Commercial considerations are never allowed to take precedence over the primary concerns of:
| Safety of life
| Safety of property at sea
| Preventing pollution of the marine environment
| No specific responsibility towards FM

Participating ship/Not participating ships | OOW
---|---
The OOW are responsible for the safe navigation of the ship during his time period of duty. He should specifically avoid grounding and collision. The OOW should read and understand:
| Stand operating procedures
| Standing orders
| Night orders
| No specific responsibility towards FM

Shore based service centre | Authority
---|---
Responsible for the shore based centre establishment and the safe operation of the services:
| Establish traffic image and game plan
| Single reporting area
| Area management
| Traffic coordination
| Capacity planning

Shore based service centre | OOW
---|---
Responsible for the shore based centre establishment and the safe operation of the services:
| Establish traffic image
| Single reporting area
| Area management
| Traffic coordination

VTS | OOW
---|---
The VTS is responsible for its specified service: Information service, and/or Navigation assistance, and/or Traffic organisation.
VTS OOW can use FM data for decision support within its normal operational services.

Port control | OOW
---|---
The Port Control is responsible for its specified services and Port Control OOW can use FM data for decision support within its normal operational services.

MRCC | OOW
---|---
The MRCC is responsible for its specified services and Can use FM data for decision support and coordination within its normal operational services.

Ice management | OOW
---|---
The ice management is responsible for its specified services and can use FM data for decision support and coordination within its normal operational services.
4.2 SOP preparation, review and approval

The organisation should first have a procedure in place for determining what procedures or processes need to be documented. Those SOPs should then be written by individuals knowledgeable with the activity and the organisation's internal structure. These individuals are essentially subject-matter experts who actually perform the work or use the process. A team approach can be followed, especially for multi-tasked processes where the experiences of a number of individuals is critical, which also promotes “buy-in” from potential users of the SOP.

SOPs should be written with sufficient detail so that someone with limited experience with or knowledge of the procedure, but with a basic understanding, can successfully reproduce the procedure when unsupervised. The experience requirement for performing an activity should be noted in the section on personnel qualifications. For example, if a basic chemistry or biological course experience or additional training is required that requirement should be indicated.

Further, SOPs should be reviewed (that is, validated) by one or more individuals with appropriate training and experience with the process. It is especially helpful if draft SOPs are actually tested by individuals other than the original writer before the SOPs are finalized.

Note that in this chapter the SOP proposed are on a high level in order to indicate how the STM concept affect today procedures on-board and ashore. Hence, they have not followed the above quality process. Here, the following method has been used to derive high order procedures:

1) Start with the role and functions that the operator has to perform.
2) Establish a high-level task analysis.
3) Use existing processes in the VTS domain in order to propose STCC procedures.
4) Use existing bridge processes in order to adapt them to the STM concept.

But first is the navigation process updated in the view of the STM concept.

4.3 Navigation process

This first paragraph gives an overview of the voyage planning process followed by the route, with a view of the STM concept. A detailed process description is found in (Anwar,
2008). The nautical work aboard a ship follows the navigation process that consists of four main phases:

- Appraisal
- Planning
- Execution
- Monitoring

Routes are an essential part of these phases and the navigation process as whole. When looking at routes and exchange of route information all of these phases need to be addressed. The navigation officer is preparing the ship’s route plan under supervision of the Master. During the appraisal stage, the navigation officer is listing available information sources and collecting relevant information.

A ship’s voyage needs to be planned in advance and it is the Master’s responsibility that the plan is made and followed. The actual planning is often delegated to another bridge officer normally second officer, hereafter denoted the navigation officer (NO).

“The intended voyage shall be planned in advance, taking into consideration all pertinent information, and any course laid down shall be checked before the voyage commences.” (STCW, 1995). Further, a voyage plan should cover the complete voyage berth-to-berth and describe the most favourable route taking into account, predictable problems and hazards along the route.

### 4.4 Bridge standard operating procedures

It is important to note that the Bridge SOP should meet all requirements stated in international conventions and national laws. The assumption made here is that the DRP concept is a regional voluntary system that can be assigned before the departure from the port prior to the STCC area. Procedure steps beginning with STM means that this is a changed or new process that is introduced by the STM concept.

#### 4.4.1 Planning

As already stated [STCW, 1995]:

> The voyage need to be planned in advanced. The plan should also include pilotage and in port movements.
The following should be noted with respect to voyage planning (Anwar, 2008):

- Planning should be conducted by Navigating Officer under the Master supervision.
- The Master should approve the voyage before leaving the port.
- **STM**: The Master should approve the voyage received from Service Provider before activating it in the ship's navigation system.
- New destination would require a new voyage plan which should be created and approved before the ship proceeds on the new route.
- If the OOW cannot follow the plan, the Masters should be called. Changes should be documented and the bridge team should be informed.
- **STM**: The new route should be sent to shore based centre if applicable.

**STM**: route validation and optimisation services: The ECDIS voyage and departure time and ETA is transmitted to Service provider for validation and advice. Service provider checks the voyage plan with respect to:

- Navigation constrains
- Static and dynamic restricted areas
- Safety margins in critical areas
- Traffic constrains
- Environmental protection constrains
- Local weather and sea state
- Pilot/tug constrains
- Port constrains

**The following route exchanges are possible within the FM service:**

- Ship change request
- Shore based centre change request
- Ship contingency plan
- Shore based centre contingency plan
4.4.2 Monitoring

STM: enhanced monitoring services:

- Within a critical area shore-based operator/automatic is monitoring the progress according to the intended route
- Within a VTS area, the VTS operator is manually/automatic monitoring the progress according to the intended route
- In a pilotage fairway: the pilot together with the bridge team monitors/VTS operator the progress
- Shore based centre can transmit route change messages due to current Maritime Safety Information (MSI)

The role of the Master is:

The Master has the overriding authority and responsibility to make decisions with respect to:

- Safety of life
- Safety of property at sea
- Preventing pollution of the marine environment

Commercial considerations are never allowed to take precedence over the primary concerns of:

- Safety of life
- Safety of property at sea
- Preventing pollution of the marine environment

STM: the Master has the overall responsibility and do not have to follow the shore based centre advice. However, if the ship takes part in the DLR exchange the Masters intended route should be transmitted to shore based centre.

STM: The Master should set up rules when he should be notified:

- New route suggestion from shore based centre
- Any major deviations from the agreed route
The role of the OOW is:

The OOW are responsible for the safe navigation of the ship during his time period of duty. He should specifically avoid grounding and collision. The OOW should read and understand:

- Stand operating procedures
- Standing orders
- Night orders

Navigator/Lookout set-up:
The Navigator’s tasks are:

- Route monitoring
- Anti-grounding
- Anti-collision
- Lookout
- GMDSS lookout
- **STM**: Use Lookout as assistant when receiving a shore based centre route change
- **STM**: Call the Master when receiving a shore based centre route change. New route to be checked and agreed by the Master

**STM**: The OOW should understand the MONALISA route agreed with shore-based centre.

During the watch the OOW has limited possibilities to perform other duties as chart updates, voyage planning, **checking change route messages**. If any doubt, extra duties has to be postponed or extra lookout or officer or Master has to be called.

Handing over the watch is a critical period and should be postponed if:

- A manoeuvre is imminent
- **STM**: when a shore based centre route change message is received

The OOW should notify the Master immediately if:

- In any emergency or breakdown of equipment
• Restricted visibility
• Traffic condition which make concerns
• Difficulty to follow voyage plan and course
• Nearby Ship or person in distress
• Heavy weather, ice, etc.
• **STM**: reception of shore based centre change route message

The OOW should always cross-check all information if possible.
The OOW should use two or more different methods for position fixing and course monitoring
**STM**: the OOW should check that the agreed route is consistent with the activated ECDIS route.

### 4.5 Shore based centre operational procedures

These procedures are derived using the same principles used for VTS in [IALA, 2011].

First a general process:

**Watch handover**
The watch handover procedures should include information as:

- Present traffic situation
- Expected/developing traffic situation
- Incidents or on going operations (pollution, SAR)
- Weather and oceanographic conditions
- Resent and current MSI

**Planning phase**
Before a ship is departs it’s route is exchanged, and validated/optimised by a Service Provider. This is an automatic process. However the operator has to confirm and check each individual step.

- Confirming ship’s selection of service
- Confirming validated route
- Confirming optimised route

**Monitoring phase**
The shore-based centre’s second operational phase is monitoring and coordination of the ship traffic. A shore based centre traffic image is established including both participating and non-participating vessels. The image should clearly indicate each target which type of vessel it belongs to. If the area of operation is large, it is divided into sectors with one operator assign to each sector. All participating ships are treated as to follow enhanced monitoring services:

- **Ship entering critical area from open sea**
  Ship entering the area trigs an alert for the operator. Route and observed target is automatically correlated and confirmed. Ship entering the area should be activated by selecting the target. The ship is now assigned to a dedicated operator and any deviation from the route is automatically detected by the Anomaly Detector function in the system.

- **Ship entering critical Area from VTS area**
  The VTS operator handover the ship to the shore based centre and trigs an alert for the shore based operator. Route and observed target is automatically correlated and confirmed. Ship entering the area should be activated by selecting the target. The ship is now assigned to a dedicated operator and any deviation from the route is automatically detected by the Anomaly Detector function in the system.

- **Ship within a critical area**
  The ship is assigned by a dedicated operator and any deviation from the route, XTA or ETA, is automatically detected by the Anomaly Detector function in the system and the operator makes contact to the ship. Any unsolved closed quarter situation is detected by the Anomaly Detector function and the operator makes contact to the involved ships.

- **Ship at anchor**
  A ship at anchor is only monitored that it is not drifting out of its safety berth. An alert is automatically detected by the Anomaly Detector function in the system and the operators contact the ship.

- **Ship leaving critical area for open sea**
  A note is made and the ship is deleted from the active ships list.

- **Ship leaving critical area for VTS area**
  If a ship leaves the critical area and enters a VTS area the ship is handover to the VTS operator. The VTS operator has the ship’s route information and can assign that to the target. The ship does not need to call the VTS operator.

- **New MSI**
  One assigned operator is responsible for new MSI for the critical area. The MSI is transmitted according to normal channels but is also visualized on the onboard equipment.

- **Monitoring of non-participating ships**
  Ship that is not part of the system is monitored by means of Radar and AIS. Deviations from route cannot be detected. However, if a dangerous situation occurs the operator should make contact with the ship.
Emergency phase
Shore based centres could be a crucial part of a nations allied serves. Each shore-based centre should establish and train emergency procedures:

- **Ship accident**
  When observing a ship accident (collision, grounding, fire etc.) an alert should be sent to MRCC according to GMDSS. MRCC is now in command and can use the shore based centre traffic image and services.

- **Pollution**
  When observing a pollution incident an alert should be sent to the environmental authority. STCC can be used by that authority to coordinate a pollution response operation using its traffic image and services.

- **Ship not under command**
  When a vessel Not Under Command (NUC) is noted, emergency towing service should be notified and the ship's contingency plan should activated.

- **SAR**
  When observing a SAR alert MRCC should be notified according to GMDSS. MRCC is now in command and can use the shore based centre traffic image and services.

- **Medical emergency**
  MRCC should be informed. Shore based centre can help to establish contact to Radio Medical Services
5 STM human machine interface

The HMI design is relevant for the STM equipment on board ships and on the shore side, implementing the shore based service centres. This section discuss some HMI design principles and gives some design examples.

5.1 User-Center Design Process

The goal of a User-Centered Design (UCD) is to create systems that are strongly adapted to the intended final user. This requires a deep understanding of the conditions and needs of the user, and an integration of this knowledge into every stage of the design process, starting as early as possible. This process has been standardised in ISO 9241-210:2010 (Ergonomics of human-system interaction, Part 210: Human-centred design for interactive systems).

The central focus of UCD on understanding the user and integrating this understanding throughout the design of a computerised system was initially pushed in a context where the development of such systems were largely dictated by engineers and by the available technology. As technology develops limitations related to technology are becoming less and less important, and it is natural to look to the user and the working environment for requirements that are often more difficult to side step. Within modern Human-Computer Interaction this focus on the user and the User Experience (UX) is the norm and there are many descriptions about how to go about this in practice.

5.2 Basic HMI principles

It is important to realize that the requirements of an HMI design can vary greatly based on the kind of expected use. Primarily, basic principles suggest different developments depending on whether the end-user is expected to be an expert at working with the system or if it should be (easily) usable for a novice. Some designs require a significant investment in training or time to get familiar with the system but are more efficient to use when one has become an expert. Other designs may be much easier to use at first contact, but may lack or hide advanced features or esoteric shortcuts that an expert would like to have access to.

As UCD takes the current user and her situation as an explicit starting point it lends itself naturally to creating systems that are easily integrated into existing practice. This does not mean that a design needs to be easy to use for a novice in general, but it should be easy to use or easy to learn for a user within the target group, with the pre-existing experience and expertise expected from such a user. Thus, the typical starting point is a system that works as the user would expect based on their experience with current systems, with additional features and design modifications deliberately designed to be
easy to understand and learn for intended users. Whenever possible established interaction principles should be re-used and the introduction of new principles should be explicitly motivated.

In the present context, one implication of the reasoning above is that the design suggestions presented here should be relatively easy to integrate into the many diverse systems currently installed on ship bridges around the globe. In particular, we should note which suggestions are hard requirements and which suggestions provide more freedom to adapt to particular existing systems.

It is interesting to note that the intended users are not only professionals and experts in using specific systems, but also citizens in our developing and increasingly technological society. This does, for example, that increasing familiarity with touch interfaces made common through modern smart phones and tablets can be taken into consideration also when designing expert systems for professional environments, such as the bridge of a ship.

5.3 Usability testing

Different forms of usability testing are performed throughout the design process in order to shape and guide the final design. Initially, evaluations should be conducted on the usability of existing systems, as a step towards the understanding of the user in the working context. Any issues identified as this stage can be integrated into the initial design and contribute greatly to the final quality of the system.

Usability testing should also be used several times throughout an incremental design process, to evaluate the usability of increasingly developed prototypes and identify issues as early as possible. Such usability testing is tightly connected to the heavy use of prototyping in a UCD process. It is important to repeatedly create and update prototypes that can be used as an efficient way of getting critical feedback from the users. As the prototypes approach the finished product at the end of the project, the usability testing is expected to increasingly focus on the evaluation of implementation details.

5.4 Examples on HMI design

This paragraph gives some examples of HMI solutions applicable for the STM on-board equipment.

Basic colour coding
The basic colour coding of routes with different status: Dashed lines means “under negotiation”, full drawn green line means “agreed route”. Coloured backdrops are all transparent as to not hide underlying information. Yellow line means “pending”, red means “not recommended” and green dashed “suggested” route.
Send route to Service provider

When a ship has created, opened from a library or in any other way acquired a route which has been validated (checked for under keel clearance - UKC) using the ECDIS standard tool, it must be scheduled. That is adding an estimated time of departure (ETD) and arrival (ETA), or alternatively, any of the preceding attributes plus a speed. In the figure below is the design guideline for the Route Info and Route Details windows and their respective parameters.

**Figure 14:** The basic colour coding of routes with different status.

**Figure 15:** Send route to Service provider.
Shore based centre recommends a route

In the simplest case the new route suggested by the ship is found to be without conflicts by the shore based centre. The shore-based centre therefore acknowledges the request by sending an OK, shore-based centre “recommends” the route.

The final step is now left to the captain on the ship to acknowledge the route that now becomes an “agreed” route signified by a transparent green backdrop. The route can now be activated for monitoring and will stay “agreed” as long as the ship is on track and on schedule, or a new route or schedule is requested from the ship or from shore based centre.

Figure 16: Shore based centre recommends a route.
5.5 Simulations in the European Maritime Simulator Network (EMSN)

Several simulator centres around Europe have been and are interconnected in what is called the European Maritime Simulator Network (EMSN) that gives a unique possibility in creating scenarios with a large number of participating own ships.

The simulator runs were part of the Formal Safety Assessment (FSA) where the risks associated with implementing the STM concept were to be identified, analysed and evaluated in comparative studies from both a “metric perspective” i.e. reduction of probability of close quarter situations, and from a Human Factors perspective i.e. the usability of the system from the operators point of view.

The simulation exercises were built according to the following:

Phase 1:
- Identification of a suitable geographical area and its traffic for evaluating the STM concept.
- HAZID in identified area.
- Recording vessel traffic in identified area and finding a suitable real life scenario that can be used in the simulations.

Phase 2:
- Building the scenario representing the traffic identified in phase 1 (Base Line Runs B/L)
- Running the simulation exercise, with existing navigational tools with the objective of comparing real life situation (based on AIS information) with the simulation runs in order to evaluate any discrepancies between them.

Phase 3:
- Implementing ML tools in the M-EDCDIS and the Shore Center
- Running same scenario as in phase 2 but with M-ECDI available, notably route exchange ship-ship and ship-shore.
- Compare the B/L runs with the simulations where the M-EDDIS were used.
Main M-ECDIS functions
The MONALISA ECDIS (M-ECDIS) is an ECDIS based on Transas’ NaviSailor 4000 with additional functionalities such as:

- The possibility to send routes and schedules to a shore centre.
- The possibility to receive routes and schedules from a shore centre.
- The possibility to exchange routes with other vessels.
- The availability of sending and receiving text messages (chat) to and from a shore centre.
- The possibility of graphically displaying the progress of the vessel according a determined schedule (ETA Box).
- The possibility to display graphically where vessels meet when following their route respectively (Route Rendezvous).

Shore Center
In addition to the functionalities already found in standard VTS systems the shore centre is intended to provide the possibility to support the STM concept with the following:

- Receive and transmit routes from and to ships including their verification and possibility to suggest changes.
- Chat function to and from ships.
- Possibility to display overlays such as MSP, MSI and No Go Areas.
- Possibility to export routes to an external service provider for flow management analysis and de-conflicting of routes.
- Possibility to highlight conflicting routes and anticipated conflict area between ships based on routes and planned speed.
- The possibility to assign a schedule for any vessel to allow for a safe and smooth traffic flow.
- The possibility to detect a vessels deviation from the agreed schedule and or intended route.

Scenario Description
The simulator exercise took place in the Kattegat in an area between north of the island of Anholt to north of the Great Belt Bridge following Route T as indicated below. The entrance to the Baltic Sea, although conspicuously buoyed, presents difficulties to especially large vessels due to narrow waters, sharp bends, currents and shallow depths. The scenario reflected a real traffic situation identified by SSPA by analysing AIS data in the area defined over a period of 3 months August-October 2014. All participating ships had their route and schedule preplanned and uploaded on the ECDIS.
Figure 17: Starting positions of vessels in the EMSN Simulations.
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