ESABALT D4.1
System Architecture
## REVISION LIST

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1 Introduction

This report summarizes the results of Work Package 4 (WP4) of the ESABALT project: System Architecture. The ESABALT concept, system architecture and services were formulated in WP1 (Concept Refinement and Validation). Over the course of the project, these aspects of the system have evolved through the work performed on WP2 (Identification of Users and Stakeholders and User Requirements Analysis) and WP3 (State-of-the-art Analysis and Technology Evaluation), and the current document will attempt to represent the latest version of these aspects. The inputs to this document thus are the results of WP1, WP2, and partial results of WP3.

This deliverable document holds the findings of the three sub-tasks under WP4, viz. Generate Functional Specifications and Sub-system Interface Requirements, Evaluate System Architecture to User Requirements Traceability, and Develop Server Data Model and API. Even though this document is not strictly structured to mirror these sub-tasks; the overall work presented here satisfies the expectations from each of the sub-tasks.

The report begins with a short reintroduction to the ESABALT system architecture, including its constituent modules. The details are provided in D1.1 (System overview report of the integrated solution and its associated services) of WP1, and therefore not reconsidered here. Next, this document describes the recent results on integrating Earth Observation (EO) techniques to the ESABALT system. In Section 4 is described the central data server, including its data and storage model and access interfaces with the other modules. In the following section, services and functionality of the ESABALT system are elaborated (as compared to the description in WP1) using functional flow block diagrams. Special attention is paid to ensure that the User requirements as described in WP2 are satisfied, as shown in Section 6 and Section 7.

2 System Architecture in Brief

The ESABALT project is a feasibility study to determine the necessary research and development (R&D) activities towards a novel system for enhancing maritime safety. The name ESABALT is an acronym for “Enhanced Situational Awareness to Improve Maritime Safety in the Baltic.” Thus, the project focuses on the Baltic Sea as a testbed for the system and service concept. Funding is provided by the Joint Baltic Sea Research and Development Programme (BONUS) together with partner countries Finland, Sweden, and Poland. The partners in the ESABALT consortium include the Finnish Geodetic Institute, Furuno Finland Oy, SSPA, and Maritime University of Szczecin.

The term situational awareness refers to the abstract concept of being aware of one’s current or developing situation. In the maritime context, a vessel’s crew must maintain good situational awareness in order to safely and efficiently operate the vessel. This includes awareness about the environment
(e.g. developing weather conditions), the maritime traffic surrounding the ship, and the condition of one’s own vessel and crew. Especially in the case of an emergency, situational awareness may also include information about the condition of other ships, such as a damaged ship whose navigational ability has been jeopardized. In a general sense, situational awareness encompasses any information that can potentially have an effect on the crew’s objectives, namely safe and efficient navigation of one’s own vessel. In addition to this, situational awareness is an important concept for Vessel Traffic Services (VTS) and Search and Rescue (SAR) centres, who must maintain good situational awareness in order to fulfil their missions.

ESABALT aims to increase the safety of all vessels operating in the Baltic Sea by providing tools and services which enhance situational awareness. The primary services that ESABALT will provide are intelligent marine navigation and routing, efficient emergency response, and environmental monitoring and reporting with emphasis on cross-border functionality. This is achieved using the latest technological advances in sensing, positioning, e-Navigation, Earth observation systems, and multi-channel cooperative communications. In addition, ESABALT aims to facilitate crowdsourcing of relevant information from a multitude of users. That is, by reporting information to a central repository, all end-users will be able to achieve a greater level of situational awareness than they would by acting independently. A guiding tenet of the ESABALT concept is that all maritime users in the Baltic Sea can operate more safely by collaboratively building and maintaining situational awareness. The various elements of this concept are depicted in Fig. 2.1.

![Figure 2.1](image-url) ESABALT integrates relevant maritime technologies through a dedicated situational awareness server, providing innovative services to end-users and stakeholders in the Baltic Sea region.

Figure 2.2 describes the ESABALT system architecture. The ESABALT data server is the central module which holds all the crowdsourced data from the individual ESABALT terminals. The terminals are onboard ships, which may include pleasure craft, commercial vessels and authorities vessels. The onboard terminals are the primary interface to the ESABALT system. The users of the terminals are allowed access to the various services and functionalities of ESABALT, including the crowdsourced data from other
terminals/ships, reports on ice, pollution and weather conditions, information about nearby ships, and ability to report their own information to the data server. The operation of the terminals is supported by the three primary technology pillars of the ESABALT system – Navigation, Sensing and Communication. The constituent technologies under each pillar are shown alongside. The control room hosts the administrators who maintain the ESABALT system and ensure its reliable and continued availability to the users. The sensor stations may be land-based or sea-based and contribute to the information provided by users about the environment around the Baltic Sea.

Figure 2.2 ESABALT system architecture showing the different modules, the central position of the data server, and the three technology pillars.
3 Integrating EO technologies into the ESABALT System

As described earlier, the ESABALT system will assess the feasibility of providing real-time maritime traffic monitoring and a marine environment observation system relevant for maritime transportation and accident prevention for all maritime users in the Baltic Sea.

One of the core tasks of ESABALT project will be to assess the feasibility of integrating the state-of-the-art EO products into the situational awareness platform. EO satellites play an important role in the remote sensing (RS) of marine environment due to their capability to produce wide-area information. Synthetic Aperture Radar (SAR) is a RS technology which is widely utilized in maritime surveillance and monitoring. The major advantage of SAR is the use of microwave radiation which enables the acquisition of EO data through clouds during day or night. SAR data is operationally used, for example, to create near real-time sea ice maps, to detect oil spills and ships and to measure wave heights and the speed and direction of sea surface currents and winds. Sentinel-1 is a two SAR satellite constellation of the European EO Copernicus programme and one of its priority areas is maritime monitoring and safety of navigation. The Sentinel-1 data is provided free-of-charge for all users. Once the constellation is completed it will enable daily coverage for the Baltic Sea, improving the quality and confidence of the real- and near-real-time and forecasting maritime products.

Objective of this Section is to present solutions for integrating state-of-the-art Sentinel-1 data to a situational awareness system, such as ESABALT. The required steps to transform Sentinel-1 SAR data to value added data which can be utilized in certain functionalities aiding navigation, situational awareness and maritime safety will be investigated. These functionalities include, for example, route optimization, re-routing and receiving and displaying sea ice and pollution reports (e.g. oil spills). The feasibility of the SAR data in these functionalities will be assessed through case scenarios, such as ship requesting re-routing due to severe sea ice conditions or to avoid an area with a possible oil spill event; or if a ship without AIS (Automatic Identification System) signal needs to be located. Feasibility of two alternative methods for integrating SAR data to ESABALT system is studied. First option is to acquire the SAR data from the Sentinel-1 data centers and process the data in ESABALT servers into value added data (e.g. sea ice maps) to aid in the decision making within the specific functionality. The second option is to utilize and integrate data from already operational services utilizing EO data.

The results indicate that state-of-the-art SAR data can be integrated to a maritime navigational system improving situational awareness and maritime safety. Major challenge is that real-time navigation requires short revisit times from the satellites. For Sentinel-1 data, this will be improved by the launch of Sentinel-1B satellite in late 2015. Acquiring the data directly from the SAR data centers and performing the data processing in the ESABALT servers requires development and implementation of automated data processing chain. This option would provide system independent of third-party systems and data products and could be more flexibly modified to new requirements.
Whereas, using EO data products from already operational services may limit the usability and modifiability of the data for some functionalities.

Figures 3.1 and 3.2 describe the process flow of the options for integrating EO data to ESABALT system. The EO data products will be downloaded and processed in the ESABALT servers to valued added information as soon as new EO data is available from the data distributor. The new value added information is updated to ESABALT server where it can be utilized in ESABALT functionalities, such as route optimization.

In Figure 3.1, general pre-processing is performed to the SAR images (block 3.0), which prepares the images to be processed to value added information. This general pre-processing may include for example radiometric calibration, geometric correction and land area masking. In block 4.0 the actual value added information is created by further processing the pre-processed SAR images, for example, to maps describing sea ice conditions, oil spill information or detected ships without AIS. Each product is produced using specific algorithms developed for the task. In Figure 3.2, the block 3.0 may include transformations such as transforming raster to vector data, coordinate system transformations or some data type transformations.
4 ESABALT Server Data Model and Application Program Interface

The ESABALT data server is the central module in the ESABLT project. It consists of two components: the storage system and the server control system. The main function of the storage of the server system is to save and update the information from land-based authority users, the authority vessels, the commercial vessel, and the sensor station. The server control system is designed to manage and control all the information in the data server.

4.1 Services Provided by ESABALT Data Server

4.1.1 System Management

System management aims to manage the system state, set the profile and/or parameters of the system, and authenticate the operator of the system. For example, the system is started up when the operator turns the operator switch.
to the "on" position. The operator will be asked to enter the password of the system to continue the further operation on the system. If authentication process is passed, then the servicing of data server can begin and the system will automatically run according to the default parameters or the parameters specified by the current operator.

**System Initialization**

The system is run when the operator switch on the data server system. The system initialization includes System Startup, network initialization, the internal database update. The system parameters are initialized with override options and/or default settings in the system settings.

**System Termination**

The system is shut down when the operator makes sure that no service will be provided, and then turns the operator switch to the "off" position. All the connection to the outer database and vessels will be shut down. The key information will be saved to a log file.

**System settings**

System settings include system and security settings, network and communication method settings, hardware and sound settings, the type of user account settings, appearance and personalization settings, clock and time settings, language and input method settings.

**Key system info backup**

Important operation and the information will be saved in a log file. For example, the request from authority vessels, command from land based authority users etc.

**User Management**

The user management is to manage information of the user/operator of the data server system. It includes the following submodules (see Figure 4.3).
4.1.2.1 User profile management

User profile management includes:

- New user registration. Registration information of a new user includes the username, password and other basic personal information, such as the date of born, the gender etc.
- Information update/change of an existed user.
- Old user deletion

4.1.2.2 Administrator management

Besides the common user or operator of the system, administrator has more priority in the system. This module defines and manages the priority of the administrators.

4.1.2.3 User authorization

During the log-in, the username and password is required to be checked with the internal personnel database.

4.1.3 Vessel Management

The vessel management includes communication with the vessels to get the request information, query vessel information from the internal vessel database, register/update the vessel information in the internal vessel database. Figure 4.3 gives the submodule of the vessel management.
4.1.3.1 Communication with the vessels

With suitable communication methods (mainly by wireless communications), the data server could

- get the basic identification information from vessels
- distribute the information to vessels

4.1.3.2 Query vessel information

The data server may query the vessel information from the internal vessel database to acquire the request state of the vessel.

4.1.3.3 Register vessel information

If the vessel information is not found in the vessel database, the data server control system automatically register the vessel information in the vessel database, which further includes

- add a new vessel into the system
- delete one vessel into the system

4.1.3.4 Vessel state update

If the current state of a vessel has been confirmed to be changed, the control system changes and therefore updates the state of the vessel in the database.

4.1.4 Environment Awareness

The function of environment awareness includes update the weather reports, update the pollution reports if any and update maps information.
4.1.4.1 Update weather reports

The weather reports are updated from the weather website, e.g. www.FMI.FI. Ice alarming and storm alarming information could also be updated from the vessel reports.

4.1.4.2 Update pollution reports

The pollution reports are updated from website or from the warning information of vessels.

4.1.4.3 Update maps

The map information is updated from website. Since Map information is not changed very often, it is suggested that maps are download offline and stored in the data server.

4.1.5 Sensor Station Management

Sensor station management includes access data from the sensor station, validates the sensor data with other data source and invalidated data processing.
4.1.5.1 **access data from the sensor station**

Data from sensor station will be transmitted to data server. After validation with other data source, the database in the data server will be updated based on the consistent data.

4.1.5.2 **Sensor data validation**

The data sensing from the sensor station will be cross-check and validated with other source of data from other sources. The consistence check includes:
- check the sensor data with the vessel database
- check the sensor data with the pollution database
- check the sensor data with the weather database
- check the sensor data with the vessel database

4.1.5.3 **Invalidated data processing**

The data from the data sensors that has not passed the validation check will be regarded as the invalidated data. The possible processing includes:
- alarming generation
- report to authority vessels
- report to land user authority users
- sensor failure detection

4.2 **Database Requirement of Each Service**

In the data server system, the internal database includes system setting database, the user database, the environment awareness related database, the vessel management database and the sensor station database. Based on different environmental information, the environment awareness related database includes map database, the weather info database, the pollution info database. Figure 4.7 and Figure 4.8 shows the internal databases in the server and their relationship with outside database.

The design of the system setting database and the user database are the common module in many general softwares, which have the routine procedure for the design. To save the limited space, the details for such database are omitted here.

4.2.1 **The vessel database**

The database includes:
- the basic information of the vessel,
  - country
  - IMO
  - Maritime Mobile Service Identity (MMSI)
  - vessel name
  - vessel photo
  - the type of the vessel: e.g. the authority/passenger/chemical tank/fish carrier/ tug…
  - the size of the vessel: length * breadth
positioning related information
  - current position information \((x_i, y_i, z_i)\): \(x_i\) - latitude, \(y_i\) - longitude, \(z_i\) - altitude).
  - information from inertial sensors, e.g. heading, speed, accelerometer
  - the last time of the received position information

- the activity of each vessel
  - the last known port
  - the current port
  - sea area
  - destination

4.2.2 The situation awareness database

4.2.2.1 The internal weather database
The weather database includes the weather information for Baltic sea areas and the coastal station. The information related includes:
- temperature (max. /min./current temperature)
- wind (speed, orientation)
- gale
- gust
- visibility
- ice cover
- wave height
- water level
- pressure
- cloudy
- dew point
- warning message
- rain area
- clouds
- time for the update information

The weather information is considered to obtained from www.fmi.fi. FMI has published its open data service on the website: http://ilmatieteenlaitos.fi/avoin-data-pikaohje. It is suggested to use JavaScript library MetOLib to implement API classes to request weather data from the Web Feature Service (WFS) server of the Finnish Meteorological Institute INSPIRE Atmospheric Features and Geographical Meteorological Features guidelines compatible WFS Download Service server at http://data.fmi.fi.

4.2.2.2 The map database
There are a number of commercial sources for maritime maps, which every vessel in the Baltic Sea is able to procure. However, for the purposes of use in ESABALT, we also consider here other options.

OpenSeaMap (example user interface is shown in Appendix 1) is a crowdsourced map application for maritime users. A similar application may be considered to be used in the data server to download and update sea
maps in ESABALT. OpenSeaMap is a free nautical chart, which can be downloaded from [http://www.openseamap.org/?L=1](http://www.openseamap.org/?L=1). OpenSeaMap-charts can be also used on board even without access to internet - with an onboard-computer, a notebook or netbook, on Android tablet or -phone, iPad or iPhone, Windows tablet, a PDA or with a Garmin chart plotter or a Garmin GPS-device.

Other choice for downloading and updating the sea map could be Navionics ([http://www.navionics.com/en](http://www.navionics.com/en)). Navionics specializes in the manufacture of electronic navigation charts and systems for marine and outdoors use.

With regards to the electronic navigational chart, the OpenCPN is a free software (GPLv2) project to create a concise chart plotter and navigation software, for use during the voyage or as a route planning tool. OpenCPN is developed by a team of sailors using real world conditions for program testing and refinement. For more details, see [http://opencpn.org/opcn/](http://opencpn.org/opcn/). Another similar alternative could be Fugawi Marine 5 ([http://marine5.fugawi.com/](http://marine5.fugawi.com/)).

### 4.2.2.3 Earth observation satellite images

Following are some services that share forecasts and near-real time maritime products utilizing EO data.

**Ice maps: MyOcean-project**

By registering to this service, it is possible to either view the images online or download them for remote/offline use. The data is in netcdf-format, so a special software capable of opening files in netcdf-format is necessary. More details can be obtained at [http://www.myocean.eu/](http://www.myocean.eu/)

The ice maps provided by the MyOcean service is produced by the Finnish Meteorological Institute (FMI). However, MyOcean only shows the ice concentration and not for example the ice drift, which would be available from the FMI data, which is produced after processing of the raw EO images. The same daily ice information which is in MyOcean can also be downloaded as pdf navigation map from FMI at [http://cdn.fmi.fi/marine-observations/products/ice-charts/latest-full-color-ice-chart.pdf](http://cdn.fmi.fi/marine-observations/products/ice-charts/latest-full-color-ice-chart.pdf)

**Wave-forecast (not downloadable):** [http://en.ilmatieteenlaitos.fi/wave-forecast](http://en.ilmatieteenlaitos.fi/wave-forecast)

FMI has also opened most of their data to public, so the ice maps and other forecast products can be downloaded with WFS (Web Feature Service), however this option is still under test.

**Maps and information related to oil spill detection services:**

We have not yet found any oil spill detection services that would have open data policy. The oil spill detection service in Europe is handled by EMSA's CleanSeaNet, available at:
http://emsa.europa.eu/operations/cleanseanet.html

If access to this service has to be requested for ESABALT, registration may be necessary to EMSA’s CleanSeaNet. However it is not certain how demanding process that is. There is link to "Data request procedure" in the page (link above) which gives some more information.

The CleanSeaNet Service provides a range of products including:
- satellite radar images;
- oil spill statistics;
- vessel detection data;
- additional Member State data, e.g. on confirmation of spills.

4.3 Data and Physical Interface to Every System Module

It is supposed that the signal from wireless cellular communications is well received in the coastal Baltic Sea area. Therefore, except the traditional data communication method, such as the maritime satellite communications (Very Small Aperture Terminal (VSAT)) and standard VHF based AIS, information may be transmitted and received by cellular networks, e.g. 3G/4G networks. The physical interface of data server system with the Internet is standard Ethernet RJ45 100M/1G interface or Open Virtual Private Network interface. For the sensor station, the interface is either mobile 3G/4G, standard Ethernet RJ45 100M/1G, or Inter VTS Exchange Format (IVEF) interface.
Figure 4.7 Database requirements for the various services provided by the ESABALT data server.

Figure 4.8 ESABALT server interacts directly with the following external databases.
5 ESABALT Services and Functionality

The different functionalities of the ESABALT system aim to satisfy the following three overarching services: (1) intelligent marine navigation and routing, (2) efficient emergency response, and (3) environmental monitoring and reporting with emphasis on cross-border functionality. Each of these has been described in D1.1 and will be discussed in brief below.

5.1 Intelligent Marine Navigation and Routing

Currently, marine navigation and routing is comprised of a relatively manual set of tasks, involving the use of a navigation system, radar, and ECDIS (or ECS), as well as paper charts, which are increasingly used as only a back-up source. In addition, navigators must manually integrate weather information and operational constraints into their duties. In winter conditions, navigators must independently decide the safest and most efficient route through ice infested waters, as well as coordinate their possible assistance from ice breakers.

The ESABALT system will investigate the feasibility of creating an intelligent marine navigation and routing service that will take into account many different factors related to the maritime traffic situation, weather situation, and (during wintertime) the ice conditions. As much as possible, the service should aim to automate the route planning functions, while still offering the navigators alternative routes to choose from. Also, the service should provide periodic updates concerning the traffic and weather situations, including ice conditions, during the course of a voyage.

5.2 Efficient Emergency Response

ESABALT system users are logically classified into pleasure craft, commercial vessels and authority vessels. Vessels have compulsory onboard emergency response equipment required by IMO. The majority of pleasure boats, however, do not have any emergency response equipment on board. In emergency situations, a mobile phone is often the device used. In emergency situations, events may happen very rapidly, and telephone numbers where to call are not always immediately available. This is the background where ESABALT could give benefits especially in small boats’ emergency reporting.

The ESABALT GUI for small boats could include easy-to-use reporting mechanisms for different type of emergency situations, e.g. engine failures, lack of gasoline, man overboard, vessel groundings, etc. In emergency situations, information could be forwarded to authorities, volunteer-based civil organizations, or to other vessels close to the boat, in order to initiate different types of responses. ESABALT automatic mechanisms might be used in the forwarding processes.
Also, the ESABALT vessel system might have the same kind of response mechanisms available, although it is not the intention to build any parallel systems to the ship’s own emergency response equipment. External data sources might provide information concerning ship emergencies automatically to the ESABALT system. Value-added information related to an emergency situation, such as the assisting vessels’ route and status could be forwarded to the ESABALT system.

5.3 Environmental Monitoring and Reporting

Annex VII of the Helsinki Convention requires signatories to “request masters or other persons having charge of ships and pilots of aircraft to report without delay and in accordance with this system on significant spillages of oil or other harmful substances observed at sea. Such reports should as far as possible contain the following data: time, position, wind and sea conditions, and kind, extent and probable source of the spill observed.” ESABALT can facilitate this type of environmental monitoring and reporting by providing the interfaces and automatic forwarding of reports to the appropriate authorities. In particular, many operators of small boats may not be aware of the requirements or guidelines regarding reporting of observed pollution. Therefore, ESABALT can play a key role in encouraging these users to report observed pollution. This is especially relevant to the coastal areas of the Baltic, where comprehensive and timely reporting of environmental pollution is critical to ensuring a rapid and effective response from the appropriate environmental authorities.

5.4 Further Development of Associated Services

The input to this task was received from the following WP sections completed earlier during the project duration:

1. WP 1 - Preliminary thoughts on the system architecture
2. WP 1 – List of ESABALT services and their functional flow block diagrams (FFBDs)
3. WP 1 – Examples of user interface screens
4. WP 2 – List of system requirements
5. WP 3 – Knowledge of state-of-art in maritime navigation, sensing and communication technology pillars

The functionality of the system is designed to be modular, enabling easy addition of new functionality or removal of unwanted ones without disturbing the overall system. The ESABALT system consists of the following terminal types, which influence the system functionality and data/physical interfaces between the modules:

1. Pleasure craft
2. Commercial vessel
3. Authority vessel

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4. ESABALT control/admin room  
5. ESABALT data server  
6. Sensor station  

For simplicity of the reader, the general system architecture and module interfaces is presented again in Figure 5.1.  

The ESABALT terminal onboard ships and in the Control Room is based on the ECS (electronic chart system) using standard S57 charts and utilizing GUI for added value ESABALT services. ESABALT terminal has own profiles and functions to each user groups: small boats (pleasure craft), commercial ships and authorities vessels. The ESABALT terminal is designed to integrate (rather than supplement) the existing maritime electronic systems onboard vessels. The number of devices that are integrated with the terminal determines the number of functions it is able to perform.  

Following is a list of ESABALT software modules which enable it to offer the expected functionality and associated services:  

1. System registration and log-in  
2. Display vessel position and submit to ESABALT server  
3. Display vessel route and submit to ESABALT server  
4. Display position and information about nearby ships  
5. Display past track and planned route of nearby ship(s)  
6. Report an unidentified vessel  
7. Route optimization request to ESABALT server and submit the selected route  
8. Make an update to vessel route and submit to ESABALT server  
9. Display situational awareness reports – weather, sea ice, pollution etc.  
10. Report situational awareness – sea ice, pollution, oil spill, violating ship etc.  
11. Report and display ship(s) violating maritime rules  
12. Submit vessel radar tracks to ESABALT server  
13. Submit messages/warnings/alarms to ESABALT server  
14. Display messages/warnings/alarms from ESABALT server  
15. Speed-reporting of emergency situations for pleasure craft  

The software modules are described so that the reader will obtain an idea of which terminal type(s) support the module, which terminal types interact during the operation of the module, the functional flow block diagram of the module, and the data interface (what data is exchanged and with which other terminal type) during the operation of the module.
5.4.1 Log-in module

This functionality is applicable to all terminal types.

<table>
<thead>
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<th>Data In</th>
<th>Data In From</th>
<th>Data Out</th>
<th>Data Out To</th>
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</thead>
<tbody>
<tr>
<td><strong>ESABALT Terminal</strong></td>
<td>• Data on home screen according to user rights</td>
<td>• ESABALT server</td>
<td>• Login information</td>
</tr>
</tbody>
</table>
5.4.2 Display vessel position and submit to ESABALT server

This functionality is applicable to pleasure craft, commercial vessel and authority vessel.

<table>
<thead>
<tr>
<th>Step</th>
<th>Action</th>
</tr>
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<tbody>
<tr>
<td>1.0</td>
<td>Query INS for location</td>
</tr>
<tr>
<td>2.0</td>
<td>Generate bounding box</td>
</tr>
<tr>
<td>3.0</td>
<td>Retrieve current map tile from local database</td>
</tr>
<tr>
<td>4.0</td>
<td>Display map tile</td>
</tr>
<tr>
<td>5.0</td>
<td>Display current position of ship</td>
</tr>
<tr>
<td>6.0</td>
<td>Submit own position to ESABALT server</td>
</tr>
</tbody>
</table>

Data In | Data In From | Data Out | Data Out To
---|---|---|---
**ESABALT Terminal** | **Global Positioning System, Integrated Navigation System** | **Own position** | **ESABALT server**
- Position in the protocol IEC61162 format | - Map tile | - Own position | - ESABALT server
- Map tile | - Local map database | | |
5.4.3 Display vessel route and submit to ESABALT server

This functionality is applicable to pleasure craft, commercial vessel and authority vessel.

![Diagram of ESABALT System Architecture]

**Data In**
- Vessel route in the protocol IEC61162 format
- Information for slider functionality

**Data In From**
- From ECDIS or chart plotter or local route storage
- ESABALT server

**Data Out**
- vessel route

**Data Out To**
- ESABALT server

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5.4.4 Display position and information about nearby ships

This functionality is applicable to pleasure craft, commercial vessel and authority vessel. Crowdsourcing will enable ships to locate, identify and submit to ESABALT server information about vessels not visible on AIS (ships with their AIS transponder off or damaged). When such data on a particular ‘invisible ship’ is submitted by multiple vessels, the data (ship type, approximate location etc.) will be considered as ‘widely reported’ (reported by multiple sightings but not yet authenticated) in ESABALT server. Such a ship can also be displayed as a nearby ship through this functionality.
5.4.5 Display past track and planned route of nearby ship(s)

This functionality is available to pleasure craft, commercial vessel and authority vessel. The primary benefit of this functionality over AIS is that through crowdsourcing it will allow ships to view the past and intended routes of nearby ships so as to avoid route conflict situations. The limitation is that ships are free to not disclose their routes to ESABALT. In this case, the ship, its heading and other information will continue to be displayed in the map containing nearby ships, but its intended route will be shown as “Unknown”.

<table>
<thead>
<tr>
<th>Data In</th>
<th>Data In From</th>
<th>Data Out</th>
<th>Data Out To</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Name, position and information of nearby ships in the protocol IEC61162 format</td>
<td>• AIS</td>
<td>• Search criteria: ship’s own position, geo-area, search ship type</td>
<td>• AIS</td>
</tr>
<tr>
<td>• Name, position and information of nearby ship(s) marked as inviable in AIS</td>
<td>• ESABALT server</td>
<td>• Search criteria: ship’s own position, geo-area, search ship type</td>
<td>• ESABALT server</td>
</tr>
</tbody>
</table>
5.4.6 Report an unidentified vessel

This functionality is available to commercial vessel and authority vessel. The primary benefit of this functionality is that through crowdsourcing it will allow a ship to identify other nearby ship(s) which are not visible on AIS, either due to their AIS transponders being turned off or damaged. When the ESABALT server receives multiple reports about an unidentified ship sighting through crowdsourcing, and the approximate location of the unidentified ship(s) matches in all reports, the information will be accorded a level of ‘widely reported’. Other levels of crowdsourced information can be decided while designing the software interface.
5.4.7 Route optimization

This functionality is applicable only for commercial vessel and authority vessel.

Optimized route algorithm in ESABALT server

1.0 Accept the criteria for identifying optimized route (ice-aware, oil spill-aware, etc)

2.0 Retrieve the relevant charts from the server (ice-charts, ice-breaker positions, oil spill/environmental pollution reports)

3.0 Execute the algorithm for optimized route based on user criteria and retrieved chart data

4.0 Return the routes returned by the algorithm to the remote terminal

User → ESABALT Terminal → ESABALT Server
5.4.8 Route update

This functionality is available for commercial vessel and authority vessel. It allows the vessel to make a change in its originally planned route, verify the new route for correctness, and submit this new route to ESABALT server.

### Data Flow Diagram

```
User --> ESABALT Terminal --> ESABALT Server
```

### Table: Data Flow

<table>
<thead>
<tr>
<th>Data In</th>
<th>Data In From</th>
<th>Data Out</th>
<th>Data Out To</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESABALT Terminal</td>
<td>• Route options</td>
<td>• Route optimization criteria</td>
<td>• ESABALT server</td>
</tr>
<tr>
<td>• Information for slider functionality</td>
<td>• ESABALT server</td>
<td>• Selection of optimized route from options returned by server</td>
<td>• ESABALT server</td>
</tr>
</tbody>
</table>

### Algorithm Steps

1.0 Module_2

2.0 Activate function to update route in ESABALT

2.1 Continue to show the original route in dashed line format

3.0 User action – update route on the map

4.0 Algorithm to verify the correctness of the new route

5.0 Prompt user to submit, discard, or change the new route

6.0 Submit new route to ESABALT

7.0 Display only new route on map

8.0 Discard new route

9.0 Continue to display original route

10.0 Overlay Sliding window functionality and message alerts
5.4.9 Display situational awareness reports

This functionality is available for pleasure craft, commercial vessel and authority vessels. The concept to display different reports (weather, sea ice, pollution etc.) is the same and described in the functional flow diagram below. The difference for every report type is in the number of technology sources and types which can feed information into the ESABALT terminal. For example, in case of weather reports the primary inputs are from the weather reports stored on the ESABALT server, the ESABALT user crowdsourced updates, and RADAR images about the developing local weather conditions. Perhaps for sea ice reports, the input source may be a sea ice RADAR, EO images or perhaps also a special camera. In case of pollution reports, input source can be EO images and/or aerial images from a reconnaissance plane. The following block diagram can be updated/expanded based on the input source for the particular reports.
5.4.10 Report to ESABALT on situational awareness

This functionality is available for only commercial ships and authority vessels. It allows the vessels to be local monitoring points by allowing them to report on the nearby situation in ESABALT. Multiple reports about a local event such as heavy weather, fog, moving sea ice etc. will allow to raise the level of the information as 'widely reported' to allow other ships to treat this information as genuine, yet not officially authenticated.
D4.1: ESABALT System Architecture

3.0 ESABALT terminal displays the map of the local sea area.

2.0 Activate function to report situational awareness to ESABALT.

4.0 On the map mark the approximate location and extent of the affected area (heavy weather, sea ice, pollution).

5.0 Present an option to the user to enter additional information, warnings in a text field.

6.0 Submit to ESABALT server.

7.0 ESABALT server algorithm for assigning levels to a piece of crowdsourced data.

8.0 ESABALT server acknowledgement.

5.4.11 Report and display ship(s) violating maritime rules

This functionality is available for only commercial ships and authority vessels. It presents yet another example of how crowdsourcing can prove useful for maritime situational awareness. If reports of violations against a vessel are received from multiple sources, the level of this information can be raised to ‘widely reported’. This functionality can also be used to display nearby ships that are marked through crowdsourcing as violating maritime rules. Such ships will be marked on the ESABALT display of nearby ships with special color or warning symbol, with a short description about their transgressions.
3.0 On the map mark the violating ship

4.0 Present an option to the user to enter additional information in a text field

5.0 Submit to ESABALT server

6.0 ESABALT server algorithm for assigning levels to a piece of crowdsourced data.

7.0 ESABALT server acknowledgement

---

**5.4.12 Submit vessel radar tracks to ESABALT server**

This functionality is available to commercial vessels and authority vessels.
5.4.13 Submit messages/warnings/alarms to ESABALT server

This functionality is central to the ESABALT system and is available to all terminal types. It allows the users of the system to write short messages with an appropriate alert level. This feature will support the crowdsourcing capability by being a broadcast medium to all ships using ESABALT. The user interaction on the message board is expected to maintain a minimum level of information quality through self-filtering.
**5.4.14 Display messages/warnings/alarms from ESABALT server**

This functionality is central to the ESABALT system and is available to all terminal types. It allows the users of the system to read short messages posted by other users. These messages are displayed in the message section of the ESABALT terminal software interface. Users will be allowed to shut off the message board, however messages of highest alert level will continue to be received and displayed.
5.4.15 Speed-reporting of emergency situations for pleasure craft

This functionality is available for pleasure craft, but can be easily expanded to include also commercial vessels and authority vessels. It allows the crew of a vessel in need of emergency help (in situations such as man overboard, out of fuel, run aground, hull compromised below the water line, etc.) to submit through a very simple ESABALT system user interface a very quick notification to the authorities about the emergency situation. The total time to submit this information should not take more than 1-2 minutes. The functionality can also be expanded to include suggestions from ESABALT on how to manage the particular situation, as the solutions to common problems are often similar and repetitive. In case of commercial vessels, ESABALT may be designed to automatically collect data from other onboard devices such as Printer Log (which saves all alarms that the ship generates) and pass it to the server.
### D4.1: ESABALT System Architecture

<table>
<thead>
<tr>
<th></th>
<th>Data In</th>
<th>Data In From</th>
<th>Data Out</th>
<th>Data Out To</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ESABALT Terminal</strong></td>
<td>• Predefined solutions or suggestions to the emergency situation</td>
<td>• ESABALT server</td>
<td>• User’s emergency message and vessel position</td>
<td>• ESABALT server</td>
</tr>
<tr>
<td><strong>ESABALT Server</strong></td>
<td></td>
<td></td>
<td>• Position and description of emergency situation from the vessel requesting assistance</td>
<td>• ESABALT control room, land-authorities and vessels in vicinity to the one requesting assistance</td>
</tr>
</tbody>
</table>
6 Challenges in Data Crowdsourcing in the Maritime domain

The functional descriptions in Section 5 state a subset of the projected capabilities of the ESABALT system. It may be possible to integrate more of the usual onboard electronic systems such as Propeller Load Control Panel, Operator Control Panel, Printer Log, etc. which would allow even more information and alerts from the vessel to be distributed automatically to the ESABALT server (crowdsourced), thus improving the quality and content of the situational awareness information, without burdening the crew with additional tasks.

As the amount of information automatically outsourced increases through integrating ever more devices into ESABALT, it presents some unique challenges. These challenges were brought to our notice during discussions and interviews with Marine Officers onboard the VikingLine cruise ship ‘Amorella’, plying between Turku, Finland and Stockholm, Sweden.

The first challenge is of data overload, requiring more effort from the ESABALT user to extract information which is really relevant. This can be solved through suitable summarization and categorization of the crowdsourced data and maintaining an adequate frequency of data transfer. The added benefit will be to maintain the data communication bandwidth within the threshold offered by the vessel’s communication systems.

The second challenge is to achieve equilibrium between the amount of crowdsourced data (necessary for successful adoption, maintenance and continued use of the ESABALT system) and the need for the crew and shipping companies to maintain privacy of their operations. It is assumed that this project is a feasibility study of developing the ESABALT system model and thus describes all possible functionalities and capabilities which can be incorporated in such a system. Whether to actually include all of them in a future deployable prototype, and participation in which of them should be left to the discretion of the crew is outside the scope of this project mandate, can be debated in the future.
7 Mapping of System Architecture with User Requirements

This section describes the mapping between the ESABALT system architecture and system requirement specification as given in Section 5.3 ‘Requirement Specification – Final List’ of WP2 Deliverable 2.1 ‘Identification of Users and Stakeholders and User Requirement Analysis’. The system requirements are numbered in the form SR_1 to SR_84, and here we describe which functional modules are responsible for fulfilling each requirement.

<table>
<thead>
<tr>
<th>Req. No.</th>
<th>Requirement Definition</th>
<th>Mapping to Sys. Architecture</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR_1</td>
<td>The access to the system should be restricted to authorized (registered) users.</td>
<td>Module 1: Login Module</td>
</tr>
<tr>
<td>SR_2</td>
<td>Users can be assigned to one or many of categories which define the access rights to</td>
<td>ESABALT server contains System Management, Personnel Management, Communication Management and Vessel</td>
</tr>
<tr>
<td></td>
<td>enter and/or read specified types of information.</td>
<td>Management modules which contain databases with User profiles and permissions, Vessel profiles and permissions and Data protection levels. In addition every functional module describes the terminal types that have access to that particular functionality.</td>
</tr>
<tr>
<td>SR_3</td>
<td>Every user has the access to non-protected information.</td>
<td>System architecture ensures that all communication and ESABALT activity passes through the server</td>
</tr>
<tr>
<td>SR_4</td>
<td>Depending on their access rights the user can read more detailed information.</td>
<td>The ESABALT software will identify the terminal type (pleasure craft, commercial vessel, authority vessel etc.), user type (system admin, main user, non-contributing user etc.) and data protection levels before presenting the next user interface (UI) screen.</td>
</tr>
<tr>
<td>SR_5</td>
<td>Every registered user should have possibility to enter information to the system.</td>
<td>ESABALT system will use the default internet access technology available on the vessel: mobile broadband, WLAN, VHF-data etc. Communication will be without any latency. If internet is unavailable, data and messages can be downloaded/uploaded the instant connectivity is reestablished. Until then, the system will use the resources in the local storage.</td>
</tr>
<tr>
<td>SR_6</td>
<td>Depending on their access rights the user can enter information to the system.</td>
<td>Same as SR_1</td>
</tr>
<tr>
<td>SR_7</td>
<td>The user can supplement previously entered information by: adding new facts, posting</td>
<td>All functional descriptions provided in Section 5 of this document</td>
</tr>
<tr>
<td></td>
<td>comments, descriptions, interpretations, pointing a priority of information.</td>
<td></td>
</tr>
<tr>
<td>SR_8</td>
<td>All users have on-line Internet connection.</td>
<td></td>
</tr>
<tr>
<td>SR_9</td>
<td>All users have to have an authorization system.</td>
<td></td>
</tr>
<tr>
<td>SR_10</td>
<td>The system provides information which increase situational awareness in the Baltic.</td>
<td></td>
</tr>
<tr>
<td>SR_11</td>
<td>All gathered information could be stored on system servers.</td>
<td>System architecture ensures that all communication and ESABALT activity passes through the server</td>
</tr>
<tr>
<td>SR_12</td>
<td>The system shall present main sources of information.</td>
<td>Same as SR_10</td>
</tr>
<tr>
<td>SR_13</td>
<td>The system should have at least the following categories of information: weather information, navigational information, navigational warnings, traffic information, detailed information about the nearest vessels.</td>
<td>Addressed in functional modules 3, 4, 5, 7, 8, 9, 12 in Section 5 of this document</td>
</tr>
<tr>
<td>SR_14</td>
<td>The system should be able to display the position of one's own ship.</td>
<td>Module 2: Display vessel position and submit to ESABALT server</td>
</tr>
<tr>
<td>SR_15</td>
<td>The system should be able to update local traffic database.</td>
<td>Module 6: Report an unidentified ship. Module 8: Submit updated route to ESABALT server. These functionalities help ESABALT to maintain an up-to-date record of ships in the Baltic Sea</td>
</tr>
<tr>
<td>SR_16</td>
<td>The system should be able to display the position of nearby ships.</td>
<td>Module 4: Display position and information about nearby ships</td>
</tr>
<tr>
<td>SR_17</td>
<td>The system should be able to update of one's route.</td>
<td>Module 8: Submit updated route to ESABALT server</td>
</tr>
<tr>
<td>SR_18</td>
<td>The system should be able to receive and display routes of other ships.</td>
<td>Module 5: Display route of nearby ship(s)</td>
</tr>
<tr>
<td>SR_19</td>
<td>The system should be able to receive and display weather reports.</td>
<td>Same as SR_13</td>
</tr>
<tr>
<td>SR_20</td>
<td>The system should be able to receive and display sea ice reports.</td>
<td>Module 9: Display situational awareness report(s)</td>
</tr>
<tr>
<td>SR_21</td>
<td>The system should be able to receive and display pollution reports (e.g. oil spills).</td>
<td>Same as SR_20</td>
</tr>
<tr>
<td>SR_22</td>
<td>The system should be able to submit pollution reports.</td>
<td>Module 10: Report to ESABALT on situational awareness</td>
</tr>
<tr>
<td>SR_23</td>
<td>The system should play a key role in encouraging small boat users to report observed pollution.</td>
<td>Module 13: Submit messages/warnings/alarms to ESABALT server</td>
</tr>
<tr>
<td>SR_24</td>
<td>The system should be able to submit ship violation (e.g. traffic separation schemes) reports.</td>
<td>Module 11: Report and display ship(s) violating maritime rules</td>
</tr>
<tr>
<td>SR_25</td>
<td>The system could be able to support and to ensure the quality of the reporting of required information to authorities, agencies, ports, carrier and others.</td>
<td>ESABALT server databases containing actual data will include a column representing the authenticity level of each data item. The crowdsourcing principle will enable self-filtering and self-regulation to the submitted information. Warnings and alerts repeated by multiple sources will climb the authenticity levels as their frequency increases. This will support the control room in maintaining the quality of information in the ESABALT system. System admins and authority users will mark low quality information for easy identification by users.</td>
</tr>
<tr>
<td>SR_26</td>
<td>Information are entered into the system belongs to one of defined categories.</td>
<td>Users will be required to select 'type of message' when entering free-text. ESABALT server databases holding actual</td>
</tr>
</tbody>
</table>
### SR_27
Various objects like vessels, ice cover, oil spills and other are shown on the map.

### SR_28
The system should be able to route optimization.

### SR_29
The system should aim to automate the route planning functions, while still offering the navigators alternative routes to choose from.

### SR_30
The system can present proposed solutions in current navigational situation.

### SR_31
The system can display information's interpretations as a result of automatic inference process.

### SR_32
The system should be able to identify hazards.

### SR_33
The system could be able to determine the risk.

### SR_34
The system could be able to determine the causes.

### SR_35
The system could be able to provide risk control option.

### SR_36
The system could be able to support the operation of the vessel in such a way that dangerous situations are avoided or detected so that they can be avoided.

### SR_37
The system could be able to inform about dangerous or irregular situations.

### SR_38
The system could be able to optimize the transport operation and the operation of the vessel with respect to safety, environmental protection, security and efficiency.

### SR_39
The system could be able to support the handling operations in such a way that dangerous situations are avoided or detected so that they can be avoided.

### SR_40
The system could be able to monitor the passengers and the cargo in such a way that damage and irregular or dangerous situations can be detected and if possible avoided.

### SR_41
The system is designed to provide an enhanced situational awareness solution for ships operating in the Baltic. Due to this assumption system shall present alert/warning if system/user leaves or is about to leave Baltic Area.

Information will have a column identifying the category of the information. All functional modules described in Section 5 of this document are map-based. Map database in ESABALT server will hold maps to be used in the functionality. Also ESABALT terminals can use the maps from ship-based ECDIS and chart-plotters.

Module 7: Route optimization. Same as SR_28

The ESABALT system integrates navigation, earth observation, and communication systems along with crowdsourcing to present a holistic picture of the current maritime situation in the Baltic Sea. Users are warned about hazards and their geographical extent such as pollution, sea ice, rough weather etc. Also, the system takes into consideration these situations and other risks while it recommends an optimized route (Module 7) to the requesting vessel.

Every new ship entering the Baltic Sea will be able to register to the ESABALT system. The system administrators will verify the vessel type and current location before it can be registered on the system. Every registered ship will be allowed to login (or continue using the system) only if it is in the Baltic Sea area. This will be...
<table>
<thead>
<tr>
<th>Requirement</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR_42</td>
<td>The system should display all information about the event, especially when they are not consistent; information should contain data about the source of their origin. The data presented will contain also the source information. The message board will list the user ID (and details if clicked) of the message author.</td>
</tr>
<tr>
<td>SR_43</td>
<td>The system should give the possibility to verify the authenticity of presented information in ex. using threshold of the number of reports about event. Same as SR_25</td>
</tr>
<tr>
<td>SR_44</td>
<td>The system gives to the user the possibility to display selected groups of information only. Module 14: Display ESABALT message/warning/alert, which includes the possibility for the user to filter the message types while requesting for data from the server. The terminal software interface will include possibility to sort, group, and filter local information on the message board.</td>
</tr>
<tr>
<td>SR_45</td>
<td>Information given by institutional users (ex. meteorological service, SAR, authorities) should have default status of trusted/authentic. Same as SR_25. In addition, ESABALT data provided by authorities will be marked as 'authenticated'.</td>
</tr>
<tr>
<td>SR_46</td>
<td>Information and data are presented in formats and measurement units used in marine navigation. ESABALT server databases will be designed to hold data in the proper maritime formats. ESABALT software interface will be designed to display data in in the proper maritime formats.</td>
</tr>
<tr>
<td>SR_47</td>
<td>High priority information are displayed even if the group they are belong to is excluded of displaying/tracing. Module 14: Display ESABALT messages/warnings/alerts.</td>
</tr>
<tr>
<td>SR_48</td>
<td>Most of information should be presented in graphic and short text message form. Additionally some warnings (ex. about collisions) should contain wider description. This requirement will be handled by the ESABALT software interface in the user terminal.</td>
</tr>
<tr>
<td>SR_49</td>
<td>The user interface for small boats should include easy-to-use reporting mechanisms for different type of emergency situations, e.g. engine failures, lack of gasoline, man overboard, vessel groundings, etc. Module 15: Speed-reporting of emergency situations for pleasure craft</td>
</tr>
<tr>
<td>SR_50</td>
<td>The user interface and working manner of the system should meet the standards for navigational information systems (ex. ECDIS, ARPA, AIS). This requirement will be handled by the ESABALT software interface in the user terminal.</td>
</tr>
<tr>
<td>SR_51</td>
<td>The user interface should be as simple as possible in order to prevent information overload – only the basic information should be presented, detailed information should be available on demand only. This requirement will be handled by the ESABALT software interface in the user terminal.</td>
</tr>
<tr>
<td>SR_52</td>
<td>The user interface should provide intuitive handling and access to detailed data. This requirement will be handled by the ESABALT software interface in the user terminal.</td>
</tr>
<tr>
<td>SR_53</td>
<td>The user interface should be developed for different languages and allow them to change on demand. This requirement will be handled by the ESABALT software interface in the user terminal.</td>
</tr>
<tr>
<td>SR_54</td>
<td>The user interface features compatible with</td>
</tr>
<tr>
<td>Requirement</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td>SR_55</td>
<td>The user interface: information presentation comply with navigational standards and guidelines.</td>
</tr>
<tr>
<td>SR_56</td>
<td>The system should provide continuous access to data residing on the server.</td>
</tr>
<tr>
<td>SR_57</td>
<td>Information should appear in the system as soon as possible to give a time for making a decision by users.</td>
</tr>
<tr>
<td>SR_58</td>
<td>Information transmitted in the system should be made available to users immediately after their introduction/approval.</td>
</tr>
<tr>
<td>SR_59</td>
<td>Information should be provided in the form of messages to minimize transmission time.</td>
</tr>
<tr>
<td>SR_60</td>
<td>Information should be provided in the form of messages that minimize the risk of transmission error (use of checksums, error correction, ...).</td>
</tr>
<tr>
<td>SR_61</td>
<td>Information should be certified with use of digital signatures associated to individual users (account).</td>
</tr>
<tr>
<td>SR_62</td>
<td>The transmission of information should be encrypted.</td>
</tr>
<tr>
<td>SR_63</td>
<td>Information with lower priority should be collected by the client program in defined intervals of time (ex. POP method).</td>
</tr>
<tr>
<td>SR_64</td>
<td>Warnings should be sent by the system to all logged-in client programs (ex. PUSH method).</td>
</tr>
<tr>
<td>SR_65</td>
<td>Upon logging into the system, the client program gets first all posted warnings and after that all other pending information.</td>
</tr>
<tr>
<td>SR_66</td>
<td>The client program should be written for mobile devices working under control of the Android Operating System.</td>
</tr>
<tr>
<td>SR_67</td>
<td>There may also be created a client software for other mobile (ex. iOS, Windows Mobile) and desktop (ex. Windows, Linux, MacOS) environments.</td>
</tr>
<tr>
<td>SR_68</td>
<td>There may also be created a thin client accessible via web browser.</td>
</tr>
<tr>
<td>SR_69</td>
<td>Information should be presented in English.</td>
</tr>
<tr>
<td>SR_70</td>
<td>The system can give possibility to enter...</td>
</tr>
<tr>
<td>Requirement</td>
<td>Description</td>
</tr>
<tr>
<td>-------------</td>
<td>-------------</td>
</tr>
<tr>
<td><strong>SR_71</strong></td>
<td>The system can give the possibility to translate presented information. Such information is marked as untrusted.</td>
</tr>
<tr>
<td><strong>SR_72</strong></td>
<td>The system should have a multiplied backup servers (or work in a distributed architecture), what will make possible to operate in a situation of failure.</td>
</tr>
<tr>
<td><strong>SR_73</strong></td>
<td>Time between the failure and restart the system to fully operate should be minimized.</td>
</tr>
</tbody>
</table>
| **SR_74** | The system shall fulfil as many as possible requirements listed in:  
IEC 60945 norm: Navigation and marine radiocommunication equipment and systems – general requirements,  
IEC 60936 norm: Guidance of for using AIS information display on radar screen,  
IEC 62288 norm: Navigation and marine radiocommunications equipment and systems – Presentation of navigation-related information on shipboard displays – requirements for handling and operation, methods and performance. |
| **SR_75** | The system shall be consistent with:  
IHO S-52 Specification for chart content and display – aspects of ECDIS, 1996,  
IHO S-57 ENC product specification, 2000,  
IHO S-52 Colour and symbol specification for ECDIS. Appendix 2, 2004,  
IMO, Resolution A572(14), General provisions on ships’ routing, IMO, London 1985,  
IMO, Resolution MSC 71(69), Amendments to the General Provisions on Ships' Routing, IMO, London 1998,  
IMO SN circular 243, guidelines for the presentation of navigation related symbols, terms and abbreviations, 2004,  
IMO Resolution MSC.191(79) - Performance standards for the presentation of navigation-related information on shipborne navigational displays,  
IMO SN circular 266, maintenance of electronic chart display and information system (ECDIS) software, 2007. |
| **SR_76** | The system should be created based on the selected methodology for software quality control. |
| **SR_77** | The system should be a program installed on computer or mobile device. |
| SR_78 | The system for mobile user might have the same kind of response mechanisms available, although it is not the intention to build any parallel systems to the ship's own emergency response equipment. | The ESABALT system will integrate some of the existing maritime tools, and not compete with them. |
| SR_79 | The system should be able to use on-line and off-line maps. | Maps will also be stored on the local terminal map database for offline use. |
| SR_80 | Despite comprehensive utilization of GNSS systems, the system should have automatic dead reckoning function. | ESABALT will rely on the vessel's Integrated Navigation System for positioning, which may also include non-GNSS solutions. |
| SR_81 | The system should allow to present Virtual Aids to Navigation. | If the vessel navigation and chart systems are compatible with V AToN, they will appear in the ESABALT terminal user interface. This can be handled during the software development phase. |
| SR_82 | The system should be independent of other navigation/information systems. | The ESABALT system integrates the onboard electronic equipment and is therefore at least partially dependent on them for its complete operation. In the absence of the electronic devices, users can still use ESABALT as a standalone system to relay messages to other users. |
| SR_83 | The user manual handbook and context help should be developed. | During the current implementation of the project, the deliverable D5.1 Prof-of-concept report will represent the handbook for the developed system prototype. |
| SR_84 | Authorities' vessels have to be equipped (in addition to standard equipment) with oil radar, ice radar and surveillance camera. | ESABALT terminal onboard the authority vessel will have the capability to integrate information from these devices. |
8 Conclusions

In this document, we have described the ESABALT system architecture in terms of its constituent modules, functionalities and services. After a brief reintroduction to the concept of ESABALT, we describe the architecture of the data server. This includes the high-level description of the databases and interfaces to the other modules of the system. This is followed by a description of the services performed by the system and the various modules that interact during each functionality. This also describes the data interface between the different modules during the operation of the system. The document also includes a mapping between the system architecture against the system requirements as described in Deliverable 2.1. This mapping shows that the requirements are taken into account while designing the system architecture.

Overall, we hope that this document will enable the reader to follow a logical progression from the system concept to the system architecture and system services. This should form a basis for the next phase of the project: software development and proof-of-concept implementation.
Appendix 1: Example User Interface – OpenSeaMap

MAP Interface:

Individual Vessel Information (by clicking on the vessel icon):
Additional Vessel Information: Technical Specifications

**NORMAND DRAUPNE**

- **IMO:** 8406470
- **MMSI:** 258344000
- **Call Sign:** LNZJ3
- **Flag:** Norway (NO)
- **AIS Type:** Other
- **Gross Tonnage:** 3385
- **Deadweight:** 2500 t
- **Length x Breadth:** 76.68m x 18.01m
- **Year Built:** 1985
- **Status:** Active

Additional Vessel Information: Last Position Received

- **Info Received:** 1 min ago (2015-01-28 09:26)
- **Area:** Baltic Sea
- **Latitude / Longitude:** 55.08544° / 13.22614°
- **Status:** Underway using Engine
- **Speed/Course:** 7.8kn / 348°
- **AIS Source:** 2190

Additional Vessel Information: Event History

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<thead>
<tr>
<th>Vessel Name</th>
<th>Time (UTC)</th>
<th>Event</th>
<th>Area</th>
<th>Port</th>
<th>Speed (kn)</th>
<th>Course (°)</th>
<th>Latitude (°)</th>
<th>Longitude (°)</th>
<th>Show on Map</th>
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<tbody>
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<td>Baltic Sea</td>
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<td>0.2</td>
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<td>2015-01-26 09:42</td>
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Map data ©2015 GeoBasis-DE/BKG (©2009), Google
Additional Vessel Information: Latest Position

<table>
<thead>
<tr>
<th>Vessel Name</th>
<th>Position on Map Interface</th>
<th>Nearby Vessels</th>
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<tr>
<td>NORMAND DRAUPNE</td>
<td>2016-01-26 08:02:00 (UTC)</td>
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<tr>
<td>Speed (kn)</td>
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<td>Course (°)</td>
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<tr>
<td>Distance to (NM)</td>
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<tr>
<td>Bearing (°)</td>
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<tr>
<td>ONSKJY-134</td>
<td>7.8</td>
<td>124</td>
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<tr>
<td>NELS Dacia</td>
<td>8.6</td>
<td>158</td>
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<tr>
<td>ELIG D</td>
<td>7.6</td>
<td>101</td>
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<td>KATRIN</td>
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<td>PIGARDO</td>
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</table>

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## Last Updated Information about Current Voyage

### Voyage Related Info (Last Received)

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<thead>
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<th>TRELLEBORG [SE]</th>
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<tr>
<td><strong>Destination</strong></td>
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<td><strong>ETA</strong></td>
<td>2015-01-28 12:30 UTC</td>
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<tr>
<td><strong>Last Known Port</strong></td>
<td>TRELLEBORG [SE] (2015-01-23 14:59:00)</td>
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<tr>
<td><strong>Previous Port</strong></td>
<td>ROSTOCK [DE] (2015-01-16 15:13:00)</td>
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<td><strong>Draught</strong></td>
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<td><strong>Speed recorded (Max / Average)</strong></td>
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### Recent Port Calls

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<th>Departure (LT)</th>
<th>In Transit</th>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
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