ESABALT System Overview
## REVISION LIST

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<th>Date</th>
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<tr>
<td>05/08/2014</td>
<td>0.1</td>
<td>Template created.</td>
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<tr>
<td>01/09/2014</td>
<td>1.0</td>
<td>Version ready for submittal.</td>
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**DELIVERABLE DETAILS:**

<table>
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<tr>
<th>Deliverable number:</th>
<th>1.1</th>
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<tbody>
<tr>
<td>Work package leader:</td>
<td>FGI</td>
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<tr>
<td><strong>Deliverable name:</strong></td>
<td>System overview report of the integrated solution and its associated services (Short title: ESABALT System Overview)</td>
</tr>
<tr>
<td>Nature of the deliverable:</td>
<td>Report</td>
</tr>
<tr>
<td>Dissemination level:</td>
<td>Public</td>
</tr>
<tr>
<td>Delivery month:</td>
<td>T6</td>
</tr>
<tr>
<td>Date submitted:</td>
<td>2 September 2014</td>
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1 Introduction

This report summarizes the results of Work Package 1 (WP1) of the ESABALT project: Concept Refinement and Validation. The goal of this work package was firstly to refine the ESABALT concept from its initial formulation, which was conceived and formulated in early 2013 during the proposal phase of the project. Secondly, we wanted to validate this initial concept by reaching out to the maritime community—the potential users of the ESABALT system—to gauge the need and willingness to adopt such a system, as well as to gather general feedback, in order to refine the ESABALT concept. Lastly, we conducted several activities aimed at generating initial conceptions of how the ESABALT system and associated services could be implemented.

It is important to note that this work package was conducted mostly in parallel with two other substantive work packages: Identification of Users and Stakeholders and User Requirements Analysis (WP2) and State-of-the-art Analysis and Technology Evaluation (WP3). It was foreseen that the results of these two work packages would potentially impact the overall ESABALT concept, as well as the system design and associated services. For this reason, the detailed design activities were reserved for another work package (WP4: System Architecture), which will be initiated upon the conclusion of WP1.

The emphasis of this report will be a description of the currently envisioned ESABALT system and associated services. This should not be misconstrued as final system overview. It is fully anticipated that the system and services will evolve during the design process. In essence, this report provides a “point of departure” from which to consider alternative concepts and system architectures. The current architecture represents our best current understanding of how the overall goal of ESABALT—to enhance situational awareness for all ships operating in the Baltic—can be met.

2 Background

ESABALT is a research and development (R&D) project studying the feasibility of 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. 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 the figure above.

2.1 ESABALT Use Case Scenarios

Although the ESABALT concept is in an early stage of development, its utility can be envisaged in a variety of different user scenarios. Some examples are described in the following section.

An oil spill occurs in the Baltic. A damaged tanker is leaking oil. Recovery and mitigation activities must be initiated quickly, but it inevitably takes time for authorities to arrive to the affected area. Ships in the vicinity of the leaking
oil must be warned to stay away so as to not exacerbate the oil’s spreading. This is accomplished in mere minutes through an emergency alert issued by the ESABALT system. At the same time, observations from ships already in the area can provide critical information as to the extent of the oil spread. ESABALT provides the means to gather this information for immediate analysis by the appropriate authorities.

A response fleet helicopter arrives to the area and deploys a mobile sensor platform to provide continuous monitoring of the situation, as well as an enhanced communication infrastructure. This mobile platform is seamlessly integrated with the ESABALT situational awareness system.

**Dozens of ships are beset in ice.** Converging ice fields, driven together by gale force winds, cause dozens of ships to become beset in ice. This information is immediately broadcast throughout the Northern Baltic as an ESABALT alert, and dozens more ships are re-routed in order to avoid the converging ice fields, thus avoiding the same fate.

Two large passenger ships are quickly drifting closer to one another and require immediate icebreaker assistance to avoid collision. Other ships in need of icebreaker assistance must be prioritized according to their condition and cargo details. The ESABALT system facilitates this prioritization, as ships are able to provide details of their situation. They can also view the status of the icebreaker fleet and see where they reside in the queue. The captains of five mid-size vessels, whose situation is less precarious, attempt to free their ships by their own power. Three are successful, but two remain stuck in the ice field. The ESABALT system is updated accordingly.

**A severe geomagnetic storm erupts.** The ESABALT system provides an alert that GPS and other GNSS signals may be disrupted or positioning error may increase significantly. Due to its integration with space weather monitoring, the alert is issued more than 10 hours before any effects can be noticed. Many ships are equipped with back-up navigation systems, which are mostly unaffected by geomagnetic storms. Their accuracy, however, degrades over time. The situation is particularly dangerous in some areas due to foggy conditions. The ESABALT maritime traffic monitoring system updates the error ellipses according to the utilized navigation system of each ship. Those ships not having any back-up navigation system are plotted according to their last known location, and further warnings to all ships in the vicinity have been issued. Ships whose position reporting capabilities have been compromised are requested to manually report their estimated position and course and to avoid high traffic areas.

**Multiple ships collision in narrow channel.** In difficult navigational conditions – visibility restricted by fog and in heavy traffic – a collision involving three ships occurs. Due to the serious damage to the ships and a threat to the health and life of humans, it is necessary to plan and conduct an efficient and effective search and rescue operation. Services responsible for coordinating search and rescue operations use information from the ESABALT situational awareness system to determine the necessary forces.
and means to carry out the operation. They choose the method of survivors search and rescue. At the same time, developing information about the incident will be used by the services responsible for the vessel traffic monitoring and management (VTS), in order to redirect traffic.

2.2 ESABALT Research Approach and Project Plan

The ESABALT consortium is committed to user-driven R&D. The end-user and stakeholder community is being engaged in the development through a number of dedicated tasks and using methods such as surveys, interviews, and workshops. On this basis will the system requirements being developed (WP2). The requirements specification in turn will allow us to formulate system assessment criteria in terms of situational awareness and maritime safety improvement. The concept was evaluated and validated based on user feedback (see Section 3), and the fully developed solution will also be evaluated by potential end-users (WP5).

The approach to assessing the feasibility of the ESABALT concept is to use a combination of analysis, lab and field tests, simulations, and full-scale demonstrations. Different portions of the overall solution will be developed to a prototype level and demonstrated and together these demonstrations and simulations will constitute a “proof-of-concept” after careful evaluation of their results.

The project can be summarized by three development phases: 1) Concept refinement, analysis, and system design, 2) Proof-of-concept, and 3) Viability Analysis and Roadmap Development. In addition to this one, a number of reports will document the results of each phase and published on our website for public feedback. Finally, the development roadmap and a set of related recommendations will be presented to BONUS and the wider user community. This will serve as a guide for how the ESABALT concept can be further developed into an operational system.

3 User Survey

During the early phase of the project, a user survey was prepared through cooperation between all consortium partners. The goal of the survey was to collect user feedback concerning the ESABALT concept, in order to refine and validate it. The survey was conducted using a leading web-based survey service. It was distributed by all partners using their own networks and contacts. In addition, a link to the survey was posted to a number of maritime-related online communities. Lastly, a small prize was offered as an incentive for potential users to participate in the survey. The prize was to be raffled off to all who wished to participate, provided they complete the survey.

In total 186 responses to the survey were recorded. Twenty of these responses were deemed not usable due to the survey not being completed fully. In fact, many more respondents did not fully complete the survey (only a few questions were marked mandatory); however, those surveys which included some useful information were identified and included in the results.
In addition, by design some of the questions were not visible to all respondents, based on their answers to previous questions. For example, if a respondent answered that they had no experience operating or working on a commercial vessel, then questions related to commercial vessels were not displayed. Thus, the total number of responses to each question ranges from a minimum of 98 to a maximum of 166.

3.1 Background of respondents

The respondents to the survey represent a wide range of countries, based on the answers to the “country of residence” question. In total 21 countries were identified. The respondents are concentrated in countries bordering the Baltic Sea, which was in fact our intention. In total nearly 78% of the responses came from Baltic countries. A large proportion of these came from the countries represented by the ESABALT consortium (Finland, Sweden, and Poland), which is most likely a function of how the survey was distributed. Despite this fact, the consortium is quite satisfied with the number and geographic distribution of the respondents. Due to the extra-national nature of the maritime industry, respondents most likely have experience beyond the shores and coasts of the countries where they reside. We did not specifically ask which respondents had experience in the Baltic Sea but focused instead on maritime experience in general.

The vast majority of respondents were male (95%). This was despite specific efforts to target females in our networks who have maritime experience. We regret this gender gap, but we must recognize that it is simply a reality of the maritime industry. It would require a much more concerted effort to achieve a more balanced gender distribution of respondents, such as approaching women’s groups in the maritime industry and asking for help in distributing the survey. We did not take this approach, due to time constraints of the work package.

The age distribution of the respondents likely reflects the general industry distribution. 46% were in the range 35-54, 29% were in the range 25-34, 17% were 55 and older, 7% were in the range 18-24, and one respondent was under 18.

The education level of respondents was overall quite high. This may reflect how the survey was distributed, since many of those in the consortium’s network have high education levels. Nearly one-third (32.7%) reported having a master’s degree and nearly 10% reported having a Ph.D. or equivalent. Nearly one-fourth (24.2%) reported a bachelor’s degree and 15% reported a professional school. We asked these respondents to specify the type of professional school; most identified a maritime college/academy/university. The remaining 18% had either graduated high school (8%) or had some college but no degree (10%).

Perhaps the most important background information about the respondents was regarding their maritime experience. The vast majority of respondents
had at least some experience operating or working on a vessel (93%). Of the 12 respondents who indicated no experience, several came from maritime-related fields such as maritime traffic management or “other maritime service provider”. In addition, many came from fields such as education or research/science, so we cannot rule out that they have no knowledge of the maritime operating environment. Discussion of the industrial background of respondents will be discussed further below.

More than one-fourth of respondents (28.5%) reported extensive amateur or professional experience with pleasure boats or yachts, which was defined as 100+ hours per year and 5+ years of total experience. 17% reported “significant amateur experience,” 15.2% reported “medium amateur experience,” and 18.2% reported “limited experience”.

Next we asked about experience operating or working on commercial vessels, which we defined as those vessels having 50 m or greater length overall. One-third reported extensive experience, which was defined as 10+ years total experience. 12.1% reported “significant amateur experience,” 9.1% reported “medium amateur experience,” and 16.4% reported “limited experience”.

Finally, for those indicating commercial shipping experience, we asked about the role(s) he or she had performed on a professional class ship. 45% reported having served as chief officer or first mate, 38% as second officer/mate, 33% as third officer/mate, 33% as ordinary seaman, 32% as deck cadet, 30% as captain or master, and 22% as able seaman. A number of other roles were identified in lesser amounts, such as chief engineer (8%), second engineer (5%), motorman (5%), and engine cadet (5%). A total of 12% identified “other” roles and indicated a range or different positions, ranging from inspector to pilot to catering.

We also asked about the industry background of the respondents. 28% came from the commercial shipping industry, 8.4% from marine engineering, 7.2% from pilot (marine), 4.2% from maritime traffic management (e.g. VTS), and 11% came from “other maritime service provider”. In addition, 6.6% came from government/military and 11% came from research/science. One respondent came from search and rescue services. The remainder came from various industries, including education (6%), consulting (4.2%), aerospace/aviation/automotive (3.6%), and engineering/architecture (3%). The vast majority of respondents who identified non-maritime industries had also indicated at least some experience operating pleasure boats or yachts, thus, justifying their participation in this survey.

### 3.2 Questions related to the situational awareness and safety

Next we asked a number of questions aimed at gauging the respondents familiarity with principles central to the ESABALT concept. We asked if they are familiar with the concept of situational awareness, and the vast majority (85%) answered “yes”. Those answering “no” were presented with a brief
description of the concept, in order that they could proceed with the next questions in an informed manner. Then, we asked respondents to rate on a scale of 1 to 5 (1 = least important, 5 = most important), how important is situational awareness in maintaining safe maritime operations? The average of the ratings given was 4.4 with a minimum of 2.0 and a maximum of 5.0.

Continuing on the topic of safety, we asked respondents to rate the main hazards for vessels in the Baltic Sea (1 = least hazardous, 5 = most hazardous). Six hazards were given as examples, and several blank rows were provided to list additional hazards. The highest rated hazard was “other ships” (average: 3.99), followed by “stormy weather” (average: 3.34), “ice” (average: 3.26), and “fog” (average: 3.13). “Floating debris (e.g. containers, timber, etc.)” received an average rating of 2.37 and piracy received 1.27. Although piracy is not really a credible threat in the Baltic Sea today, we included this as a reference to help calibrate the rating scale. There was also a column for not applicable (“N/A”) and 18.5% marked this as their response for piracy. Answers of “N/A” are not counted in the averages listed above. Many additional hazards were also listed in the blank rows provided. These are difficult to summarize because respondents used different words to describe similar hazards, but commonly identified hazards included fatigue, groundings, incompetent crews, dense traffic, pleasure crafts, small crew sizes, and restricted/shallow waters.

Next we asked what should be improved in order to operate the vessel in a safer and more efficient way. Similar to above, we used a scale from 1 to 5 (1 = least needed, 5 = most needed), and we provided examples as well as blank rows. Of the six examples given, the highest rating received by far was for “seaman’s training” (average: 4.27). This is followed by “other sensors and associated equipment (e.g. radar)” (average: 3.78), “communications technology” (average: 3.74), “access to information sources (e.g. satellite imagery)” (average: 3.50), “positioning technology” (average: 3.37), and “decision support systems” (average: 3.34). Again, many write-in answers were provided, and commonly identified were AIS, language skills, VTS services, better regulation of rest hours, and increased use of traditional lookout methods.

3.3 Questions related to crowdsourcing

The next set of questions related to the concept of crowdsourcing. First, we asked about familiarity with this concept, and 56.8% answered “yes” that they were familiar with this principle. We note that this is significantly lower than the rate for situational awareness but still a majority. Again, those answering “no” were presented with a brief description of the concept, in order that they could proceed with the next questions in an informed manner. Next we asked, “Do you think that this method (i.e. crowdsourcing) of collecting and exchanging information is feasible at sea?” A clear majority (86%) answered “yes”. For those answering “no,” we asked them to provide the main reasons they think it is not feasible. Fourteen respondents provided responses to this, and summarizing these, common reasons cited include questions about the
reliability of the information and limited available time for crew members to support this. These are very valid concerns that must be taken into account in future development of the ESABALT concept. The relatively low number of negative responses, however, indicates that, while all may not contribute to this type of crowdsourcing approach, many (i.e. a strong majority) at least believe it is feasible.

Next we asked what types of maritime information they think could be collected using crowdsourcing. Eleven examples were given, and respondents could mark as few or many as they wished. In addition, there were blank rows to write-in other categories. The most commonly identified information types included: “maritime traffic information” (78%), “emergency/SOS/mayday situations” (75%), “information about potentially hazardous situations” (75%), “sea ice information” (72%), “weather information (e.g. wind speed)” (71%), “near miss / close call incidents (i.e. situations where safety was jeopardized but no casualties actually occurred)” (68%), “environmental pollution” (64%), and “wave heights” (56%). The other three provided categories were all selected between 37.5% and 39.3% of the time. Three write-ins were also provided.

The next two questions were concerned with user interfaces. We asked firstly, “What is the most suitable method (user interface) for entering crowdsourced information from a boat (e.g. pleasure boat)?” The results were fairly evenly split between “PC or web application” (35.8%), “mobile phone or other small device” (31.2%), and “tablet or similar medium-sized device” (27.5%). 5.5% marked “other” and provided write-in answers. Other suggestions included AIS, chartplotter, and VHF or other radio equipment. Then, for those respondents who had previously indicated at least some commercial shipping experience, we asked a similar question but for commercial ships. We also provided one additional answer option, “integrated with existing bridge system,” which proved to be the most popular (50%). This was followed by “PC or web application” (38.8%), “tablet or similar medium-sized device” (6.1%), and “mobile phone or other small device” (1.0%). 4.1% marked “other” and provided write-in answers, which included “integrated with nav system,” VHF, AIS, and sat-com.

Finally, we asked a question similar to a previous question but emphasizing individual willingness to participate in crowdsourcing of maritime information (“If you had a chance and/or technical possibility to participate in crowdsourcing of maritime information, would you participate?”). A clear majority (86.4%) again answered “yes”. In addition, of the 117 who answered “yes” to the earlier question about the feasibility of crowdsourcing at sea, only 10 answered “no” to this later question about their willingness to participate (four also skipped the later question). This shows that not only do a large majority feel this method is feasible, but they themselves would be willing to participate in crowdsourcing at sea. We also asked about the reasons for those answering “no.” A common reason (5 times), as before, was that they do not have enough time. Three respondents also indicated (essentially) that they did not see the value in crowdsourcing maritime information. Considering the number of people involved in the survey, the low frequency of these
reasons, although valuable as feedback, is an indication that most mariners would in some way be able to participate in maritime crowdsourcing.

3.4 Summary of results

In summary, the user survey mainly validated the overall ESABALT. There seems to be a general agreement that this type of system would improve maritime safety and that mariners would, for the most part, be willing and have the capability to participate in the crowdsourcing aspects (if given the technical capability). If there were to be one refinement, then perhaps a greater emphasis should be placed on autonomy, rather than manual user input. Also, based on the results, the importance of designing an easy-to-use intuitive interface cannot be underestimated. Crews have little available time and, in some circumstances, are poorly trained. ESABALT should not introduce additional burden either for training or for operations.
4 System architecture

The overall system architecture has been envisioned as a distributed network, where different user and data source groups are connected via the internet. This includes small boat systems (i.e. pleasure boats), ship systems (i.e. professional vessel systems) and authorities’ vessel systems, as well as ESABALT sensor station systems and the authorities onshore control center system. The ESABALT sensor station system may be a fixed shore based station or a vessel-based mobile system which is performing a specific task in a defined location or area. External data sources (e.g. satellite data) are connected to the ESABALT server via the network.

Different communication protocols and standards can be used to link these different nodes in the system, such as standard TCP/IP, IVEF, and secure connections utilizing SSL/TLS, such as OpenVPN.

This architecture is depicted below in Figure 4.1.

![Figure 4.1 ESABALT system architecture](image)

Next, the nodes connecting to the network may themselves have different architectures, depending on the type of vessel or user, its capabilities, and its role in the overall system. For example, so-called “small boat systems” are expected to have less capabilities and mainly intended to be used by pleasure boat navigators. Each group is separately described in the below Sections 4.1 to 4.5.

4.1 Small boat system

In the small boat system (see Figure 4.2) the user interface may be, for example, a tablet-based application that is connected to an ESABALT gateway via a wireless router. This gateway can then connect to the ESABALT server through one of a number of different communication interfaces. Since these small vessels are expected to stay mainly in coastal
waters, one possibility is that they would use existing 3G/4G mobile networks to connect to the internet.

The ESABALT application would transmit the boats’ own position data and other specified crowdsourced type of information relevant to small boat navigators. Received ESABALT value-added information close to the boat and its route is displayed in the tablet GUI.

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**Figure 4.2** Small boat system
4.2 Ship system

The ship system (see Figure 4.3) is planned for professional vessels, which have different requirements than pleasure boat users. The ship system has more features available and can be utilized either using a tablet or PC application. The application receives its main sensor data from the ship’s existing navigation system (position and targets), and also the existing communication channel(s) are used.

The ESABALT application would transmit the ship’s own position data, possibly targets, route-related data, and other specified crowdsourced type of information relevant to ship navigators. Received ESABALT value-added information close to the ship and its route is displayed in the GUI.

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**Figure 4.3 Ship system**
4.3 Authorities’ vessel system

The authorities’ vessel system basic architecture is presented in Figure 4.4 below. This system has more functionalities than the ship system described in the previous section. Authorities’ vessels have more sophisticated sensing systems onboard – radars (surveillance, ice and oil spill detection) and surveillance cameras. These sensors can provide information to the ESABALT system, related to environmental monitoring and SAR related tasks, for example.

The ESABALT GUI in authorities' vessels is a Linux-based application running in a dedicated workstation PC. The workstation will receive advanced situational awareness information from the ESABALT system related to the authorities’ tasks.

Figure 4.4 Authorities’ vessel system
4.4 ESABALT sensor station

The ESABALT sensor station’s purpose is to deliver additional situational data related to needed ESABALT functionalities like SAR or environmental monitoring. Sensors to provide this data are surveillance radar, oil radar, and surveillance cameras. Also, other sensor data can be added flexibly when needed.

The sensor station can be either fixed type or a mobile station. The station is connected to the ESABALT network, and it provides data to the server to be further processed.

Figure 4.5 ESABALT sensor station
4.5 ESABALT control center

In the control center the operational picture will be built based on all data received from the network (i.e. situational awareness). Based on this data, operators can make decisions and also forward required data to other users. The control center system consists of communication system equipment, workstations, control units, and displays.

Several control centers can be located in different areas and also the role of centers can be different, each concentrating to its own areas and specific tasks.

![Figure 4.6 ESABALT control center](image-url)
5 Associated Services

A distinction has been made between the ESABALT system itself, i.e. the hardware, software, and infrastructure making up the technical system, and the associated ESABALT services. This allows us to consider different approaches to how the services can be organized, designed, operated, and maintained and to de-couple, as much as possible, the services from the technical system. Of course, it is not possible to consider either the system or the services in complete isolation, since it is the system that must implement the services. Likewise, it is the constraints and capabilities of the ESABALT system that allow us to envision different kinds of related services.

During the proposal phase of the project, three different associated ESABALT services were envisioned: (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 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 offers the possibility to create an intelligent marine navigation and routing service that takes 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 small boats (mostly pleasure boats) and ships (mostly professional users). Ships 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 ship 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

During WP4 and in particular Task 4.4, the ESABALT Associated Services will be defined in greater detail and documented in the deliverable System Architecture Definition and Associated Services Specification. This specification will be carried out in tandem with the system architecture definition activities of WP4. The expected delivery date of this deliverable is February 2015.
6 User interfaces

The next task of WP1 was to produce early-phase prototypes of the user interfaces to the ESABALT system. At first glance, this activity may seem premature. In the project, we do not yet have a detailed set of system requirements. The aim of this task was not to specify and develop the final set of interfaces that would be used by ESABALT, but rather this was an exercise in brainstorming and exploration of the possible forms that the ESABALT system could take, as viewed from the standpoint of the user.

As several different types of ESABALT users have been identified, we decided to focus first on the professional ship users, i.e. the ship system described in Section 4.2. This can be considered of medium complexity, compared to the small boat system and the authorities’ vessel system. Thus, the small boat system is envisioned to be a simplified version of the ship system and the authorities’ vessel system will be some custom version of the ship system with additional features and advanced capabilities.

Taking this approach, we divided the ship system user interface into four different views or “tabs”. These are called vessel, environment, navigation, and configuration. A common element in each of these views is the maritime chart interface, which dominates the user interface as a whole. This is because many of the functions of ESABALT are envisioned to be geospatial in nature, and a map is the most intuitive way to display geospatial information.

The main purpose of the vessel view is to display information related to vessels, including one’s own vessel, and to provide the facilities to connect to other vessels. In Figure 6.1 below, the ship’s own position is shown with the green oval. Other ships are shown with blue and red icons. The colours indicate the data source by which the ships are known. For example, blue indicates a vessel reported by AIS and red indicates a ship that reported its position directly to the ESABALT system. Clicking (or “tapping”) on a vessel’s icon displays more information about the vessel, as shown in Figure 6.2. Note that the information shown is for demonstration purposes only. The final set of displayed information will be specified at a later stage in the project.
Next, the **environment view** displays information related to the environment in the vicinity of one’s own ship. This includes display of the ship’s own sensor data (air temperature, pressure, wind speed and direction, etc.), as well as data from other sensors (vessels and sensor stations). In the example shown below in Figure 6.3, wind speed and direction reported from four different locations are displayed. Again, the colour indicates the source of the data. For example, blue may indicate measurements from sensor stations (e.g. deployed by maritime authorities), whereas red may indicate a measurement made by another ESABALT user.
Many other types of environmental information may be displayed in this view. For example, in Figure 6.4, the user has made a selection to display sea ice. The sea ice is represented by polygons drawn in different colours. The different colors represent different ice classes, which vary in thickness and ice type (e.g. ridged ice, rafted ice, etc.). Clicking (or tapping) on the polygons displays additional information about the ice regions to the user.

The third view in the ESABALT user interface is the navigation view. The view is mainly used for route planning, as well as to display data from the navigation system of one’s own vessel. Figure 6.5 below shows one possible implementation of route planning functionality, where the user selects a starting and ending point, according to his or her needs, and the system generates a possible route or a set of possible routes for the user’s final selection. Different constraints, such as those based on ice conditions, can be specified by the user.
Finally, the configuration view provides an interface to specify and save user preferences for the application, in order to customize its appearance and functionality. At this stage in the project, it is too premature to design this user interface, as the application settings have not been specified. It is envisioned to be similar to the application settings seen in many mobile or tablet based applications.

7 Functional analysis

Another task of WP1 was to develop functional flow block diagrams (FFBDs) for a set of tasks that the ESABALT system is expected to perform. Due to the fact that not all of the system requirements are specified, we did not endeavour to develop FFBDs for all functions yet, but we identified eleven key functions that form the core of the ESABALT system. These include (1) displaying the position of one’s own ship, (2) updating local traffic database, (3) displaying the position of nearby ships, (4) route optimization, (5) updating of one’s route, (6) receiving and displaying routes of other ships, (7) receiving and displaying weather reports, (8) receiving and displaying sea ice reports, (9) receiving and displaying pollution reports (e.g. oil spills), (10) submitting pollution reports, and (11) submitting ship violation (e.g. traffic separation schemes) reports. The FFBDs for these functions are shown in the figures below.

7.1 Display Ship Position

The purpose of this function is to retrieve and display the position of one’s own ship in a map interface. The process flow for this function is described in Figure 7.1 below. In the figure, INS is an abbreviation for Integrated Navigation System.
7.2 Update Local Traffic Database

One of the important functions of the ESABALT system is to maintain awareness of the local maritime traffic environment. Information about local maritime traffic comes from one of three information sources: (1) AIS, (2) radar, (3) the ESABALT server. All ships have access to the ESABALT server, whereas only larger ships are expected to have AIS and/or radar. The function should be designed in such a way so that any missing elements do not prevent it from overall functioning. The function is depicted in Figure 7.2 below. Note that this function is initiated on a continuous basis after some time interval (to be specified later in the project).
7.3 Display the Position of Nearby Ships

Next, the ESABALT system should be capable of displaying the position of nearby ships. This function encapsulates the function “Display Ship Position” (described in Section 7.1), as well utilizing the local traffic database described in Section 7.2. Figure 7.3 depicts the overall function.

![Figure 7.3 Process flow describing the function to display position of nearby ships](image)

7.4 Route Optimization

ESABALT also offers route optimization functionality. In this function, the user specifies the desired destination, as well as a set of optimization criteria (to be specified later in the project), and the system sends a query to the ESABALT server. The ESABALT server then sends back a set of proposed routes according to the user’s criteria. The overall function is depicted in Figure 7.4 below.

![Figure 7.4 Process flow describing the function to identify optimum route between the ship’s current position and intended destination](image)
7.5 Route Update Function

At some points in time, for a variety of reasons, users may wish to update their planned route. Thus, ESABALT will provide such functionality, and the system will automatically send the updated route to the ESABALT server so that others will have access to that information. The entire route updating function is depicted in Figure 7.5 below.

Assumed starting point of function is the map interface, showing the current position of the ship and the currently planned route.

Figure 7.5 Process flow describing the function to update the ship’s route in ESABALT

7.6 Receiving and Displaying Other Ships’ Routes

Another functionality of the ESABALT system is to display the planned routes of other nearby ships. There are two possibilities for this function: (1) display the routes of all nearby ships with a single user action or (2) display the routes of individual ships based on separate user actions. We have not yet determined which possibility will be implemented, and because the process flows do not differ significantly both options are shown below.
Figure 7.6a Process flow describing the function to display the routes of all nearby ships

Assumed starting point of function is the map interface, showing the current position of the ship and the currently planned route.

Figure 7.6b Process flow describing the function to display the routes of a selected nearby ship

Assumed starting point of function is the map interface, showing the current position of the ship and the currently planned route.
7.7 Weather Report Function

Next, ESABALT should provide functionality to receive and display information regarding weather conditions. We envision two possible sources for this information: (1) the ESABALT server and (2) the ship’s radar (if available). The FFBD for this function is shown in Figure 7.7 below.

![Figure 7.7 Process flow describing the function to display weather conditions](image)

7.8 Sea Ice Report Function

Another important function of ESABALT is to receive and display information related to the sea ice conditions. Again, there are two possible sources for this information: (1) the ESABALT server and (2) the ship’s radar (if available). The FFBD for this function is shown in Figure 7.8 below.
The next function of ESABALT is to receive and display information related to pollution of the sea, as well as to allow users to report suspected pollution violations. Again, there are two possible sources for pollution information: (1) the ESABALT server and (2) the ship’s radar (if available and supporting, e.g. oil spill detection functionality). The FFBD for receiving and displaying pollution information is shown in Figure 7.9a below.
For reporting suspected pollution violations, ESABALT provides a simple function, where an area of the sea can be marked and textual information can be provided to authorities. In the case where a pollution violation is witnessed, a particular ship can be marked in the ESABALT application and a report made. This process is shown in Figure 7.9b below.
7.10 Violation Report Function

In addition to pollution, there may be other types of sea violations that ESABALT users report to authorities for further investigation, such as suspected violations of traffic separation schemes. The FFBD for reporting suspected violations is shown in Figure 7.10 below.

![Figure 7.10 Process flow describing the function to report a violating ship](image-url)
8 Conclusions

In this report, we have summarized the results of WP1 and provided a system overview of the ESABALT concept, which will be further developed in future work packages. The main results of WP1 are the following:

1. We conducted a web survey of potential users, and the results of this survey mainly validate the ESABALT concept. The respondents overwhelmingly supported the idea of improving situational awareness through increased information sharing and crowdsourcing. Some feedback suggested that the developed system should be as highly automated as possible.
2. The overall system architecture has been elaborated as a distributed network, consisting of small boat systems (i.e. pleasure boats), ship systems (i.e. professional vessel systems), authorities' vessel systems, sensor stations, and an onshore control center system. In terms of ship systems, the ESABALT capabilities range from relatively simple small boat systems to more complex and capable authorities' vessel systems.
3. Prototype user interfaces have been conceived, dividing the functionalities into four distinct interface views, known as the vessel, environment, navigation, and configuration views.
4. Functional flow block diagrams have been developed for eleven key ESABALT functions, presented in Figures 7.1 to 7.10.

The results of WP1 will be used as a starting point for Work Package 4, System Architecture, where the ESABALT system will be specified in greater detail. In addition to WP1, the results of Work Package 2, Identification of Users and Stakeholders and User Requirement Analysis, will be used to make possible modifications to the system architecture. Thus, the descriptions found in this report should be viewed as our current understanding of an evolving system concept, which will be further elaborated and modified over the course of the project.