ESABALT System

WP6: Economic and Non-economic Viability Analysis

Task 6.1. Analysis of the following aspects of system requirements: innovation, measurability, feasibility, availability.

Task 6.2. Analysis and evaluation of the system capability to fulfil the user requirements according to the proposed system services in political, economic, social and technological domains.

Task 6.3. System and services analysis with respect to availability, reliability, safety, security and credibility.

Task 6.4. Development (elaboration) of system options (variants) taking into account political, economic, social and technological aspects of system functionalities (services).

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Contents

Executive summary

The study conducted in this framework of the ESABALT project comprises one economic and five non-economic domains and is part of a feasibility study. Three stages of the system life cycle were considered: development, implementation and operation. Two phases of system development and implementation - basic and full - were taken into account.

In the economic analysis the attention was mainly drawn to operation costs both on the operator's and user's sides. These costs determine the range of system use (see chapter 6.2). Given that the ESABALT application will be an element of existing navigation systems and the satellite communication will be strongly limited, the user costs will not hamper to use the system. One can assume the same in reference to operator costs. The costs of other two stages – development and implementation – were not calculated. These costs can be determined more precisely after the road map is worked out. This is due to labour costs for making the system ready to use, which include operator side (server side) and applications on user's side as an additional plug-in in the already used navigation systems. The plug-in will allow the use of ESABALT services in the mentioned systems.

The technological issues were analysed on the basis of 16 existing systems and 21 research projects including ESABALT. The analysis allows to state that crowdsourcing is the unquestionable innovation of the ESABALT system. The possibility to develop and implement the ESABALT system was verified during the prototype tests in laboratory and in real conditions. The challenge for operators and users will be verification and validation of information (data) introduced by users. This is crucial for system credibility regarding safety and security of shipping. The defined and described phase I of system development and implementation can be completed with the use of proved existing technologies. Phase II, however, needs additional research focused on determining safe ship trajectory in different conditions, incl. restricted areas and difficult navigational conditions.

Investigating the political domain, one can underline the stability of goals and activities of EU countries. There is certain fear concerning non-EU countries regarding the mentioned stability, activity and readiness to cooperate. However, the availability to operate the ESABALT system in the Baltic Sea region seems to be highly achievable.

As for the social domain, there are positive trends observed in the Baltic Sea region (chapter 3.2), inter alia continuous development of information society, growth of living standards, lifestyle changes, more time for interests and hobbies, social attitudes promoting marine environment protection as well as sport and leisure activities. These positive trends are very important for the successful implementation and operation of the ESABALT system.

The project results acknowledge the achievement of TRL 4 (performed feasibility study) which is a good starting point for reaching TLR 7 (system as a product after tests in real conditions, ready to use/ready for operation) in the next project which will be a continuation of the current ESABALT project.

The Formal Safety Assessment allowed to identify threats, as well as measures to control and reduce the identified risks. Using cost-benefit analysis, the preliminary recommendations of risk control options in development, implementation and operation stages were formulated.

0 Introduction

The ESABALT concept seeks to enhance the situational awareness for all ships operating in the Baltic with the latest technological advances in positioning, e-Navigation, Earth observation systems, multi-channel cooperative Communications including user-driven *crowdsourcing* techniques for information gathering and integration.
Before the system based on this concept is further developed, the viability analysis for the economic and non-economic aspects should be carried out. The reason is the analysis and evaluation of the system capability to fulfil the previously identified requirements from the one side and system practicability from another. The mentioned analysis and evaluation consider the comparison with existing systems used at sea as well as concepts of systems developed under research programmes. This is important because of the actually used navigational systems and devices as well as projects oriented on safety and efficiency at sea. The corresponding tasks are pointed in WP6:

Task 6.1: The analysis of the following aspects of system requirements: innovations, measurability, feasibility, availability.

Task 6.2: The analysis and evaluation of the system capability to fulfil the user requirements according to the proposed system services in political, economic, social and technological domains.

Task.6.3. System and services analysis with respect to availability, reliability, safety, security and credibility.

Task 6.4. Development (elaboration) of system options (variants) taking into account political, economic, social and technological aspects of system functionalities (services).

This report is built on the results of previous WPs, especially of WP2, WP3 WP4 and WP5.
To carry out the above formulated tasks following system assessment criteria in terms of situational awareness and maritime safety improvement are proposed: *innovation*, *feasibility, functionality/usability, availability*, *reliability, safety, security, credibility and measurability.*

The achieved quantitative or/and qualitative values describing the system features allow the ESABALT system assessment as well as the comparison with other existing system.

Definitions
Innovation: new idea, device or process, the application of better solutions that meet new requirements.

Feasibility: aims to evaluation of the project's potential for success (legal, operational, economic, technical, schedule).

Viability: ability to succeed – to achieve the intended results.

Functionality/usability: the ability to perform a task or function; the degree to which system can be used to achieve specified user goals with effectiveness, efficiency and satisfaction, in a specified context of use.

Maritime University of Szczecin | Waly Chrobrego 1-2 | 70-500 Szczecin, POLAND
Tel: +48 91 480 9496 | www.am.szczecin.pl | z.pietrzykowski@am.szczecin.pl

Availability: the probability that a system is operational at required standard or accuracy in a given time.

Accuracy: the closeness of the agreement between the result of a measurement and the true value of the particular quantity (or a reference value determined empirically using internationally accepted and traceable calibration materials and standard methods), taking into account both, random and systematic factors.

Reliability: the probability that a given system will perform its intended function for a given period of time under a given set of conditions; reliability does not reflect how long it will take to get the system being serviced back into working condition.

Safety: the feature that expresses the ability of the system to avoid or prevent activities posing a threat to humans or the environment.

Security: the system protection against the use by unauthorized persons and to guarantee that authorized persons have access to the system when required.

Credibility: refers to the objective and subjective components of the believability of a source, message or system.

Measurability: quantifiability, the ability to determine the quantity or importance of the system.

Measure: numerical result of the measurement of the size, the value of a physical quantity or contractual/conventional.

1 Methodology

The methodology for carrying out the viability analysis of the ESABALT concept is proposed as follows.
The viability analysis includes the analysis of system requirements in terms of innovations, measurability, feasibility, availability, restrictions for the system, services requirements and proposed variants of the system [1, 2]. The existing systems and devices are to be considered too. This allows the comparison of the ESABALT system with systems used at sea as well as concepts of systems developed under research programmes. It is important to take into account also the costs of operating and maintaining such a system in practice (economic viability). One of the key issues for successful exploitation of the system is to ensure the sustain operation on the basis of current and projected revenues equal to or in excess of current and planned expenditures.

1.1 Assumptions

The following assumptions are considered:

1. Stakeholders and stakeholders group (Deliverables 2.1-2.3).
2. The requirements specification of projected ESABALT (Deliverables 2.4-2.5).
3. The developed system architecture, functions and services (Deliverable 4).
4. System assessment criteria (Deliverable 2.5).
5. Case scenarios are created for system testing and demonstration (deliverable 1).
6. Systems and devices used at sea as well as concepts of systems developed under research programmes which may influence the situational awareness (Deliverable 3.1).
7. The analysis and assessment of the ESABALT system carried out on the basis of a questionnaire consisting of queries related to the previously formulated assessment criteria (Deliverable 2.5).
8. Two system development phases: I) basic (key requirements); II) full (full list of requirements.

Currently they are no plans for the evaluation of the navigational situation awareness level. This is due to the fact that such an assessment is carried out mainly in the form of a survey. The evaluators are potential stakeholders which test the system or its prototype in predefined scenarios. Examples of these situation awareness assessment methods are i.e. Situational Awareness Rating Technique SART, Situation awareness global assessment technique SAGAT, Situation Awareness for SHAPE SASHA, Critical Decision Method CDM.
Therefore the test scenarios carried out in this project will be used mainly for demonstration of chosen ESABALT system functionalities or services. Further, they may be used for measurement and analysis of the situational awareness by using ESABALT system and comparison with other existing systems/devices. This, in turn, will allow to verify the hypothesis of the

situational awareness improvement with the use of proposed ESABALT system.

1.2 Navigational systems and devices

There are a number of navigational systems and devices used onboard and ashore which gather and present navigational information helpful in ship conduct process (decision making). Some of them were shortly described in Deliverable 3. The list of mentioned systems and devices is presented in table 1. The list includes additionally concepts for system prototypes developed or being developed under research programs (research projects).

Table 1. The analysed navigational systems and devices

No	The name of analysed system / device
1.	Marine VHF radio
2.	Electronic chart display and information system ECDIS
3.	Automatic identification system AIS
4.	Bridge navigational watch alarm system BNWAS
5.	Bridge alert management (BAM)
6.	Global maritime distress and safety system (GMDSS)
7.	Radar (incl. ARPA)
8.	Navigational decision support system NAVDEC
9.	Sound reception systems
10.	Thermal cameras
11.	CCTV (closed-circuit television)
12.	Vessel traffic service VTS
13.	Vessel monitoring system VMS
14.	Receiver for GNSS
15.	Long range identification and tracking system LRIT
16.	Shipborne voyage data recorder VDR
17.	ARIADNA
18.	Baltic Master I
19	Baltic Master II
20.	COSINUS
21.	EfficienSea
22.	E-Maritime EMAR
23.	Maritime Safety Information, integration of information from different sources (systems) MARNIS
24.	Mona Lisa
25.	Mona Lisa2
26.	MUNIN
27.	NAVTRONIC
28.	SAFEWIN
29.	TRITON
30.	ASSET
31.	EFFORTS
32.	MASAS-X
33.	SAFIRE
34.	SAIL
35.	MarCom
36.	TESSA
37	ESABALT

1.3 Assessment criteria

The system assessment criteria were identified, defined and described in Deliverable 2.5 (report). The next step was the formulation of detailed questions corresponding with the system assessment criteria (Table 2). Several questions were associated with more than one criterion.

Table 2. Questions and associated system assessment criteria

No	Question	Criterion
1.	To what extent functions provided by the system meet the requirements / expectations of the users?	usability
2.	What standards must be complied by the system (including user interface)? Please list the most important documents	usability
3.	How is the access to the system supervised? You can select more than one option.	security
4.	Is the system equipped with context help and/or system's manual	usability
5.	Estimate the percentage relationship between data for direct use by the user and data requiring additional analysis by the navigator (for example 40/60).	credibility, usability
6.	The amount of data requiring additional analysis by the navigator is: too large, sufficient, too small	usability
7.	What is the system's tolerance to errors?	reliability
8.	Does the system allow to create data backups used in case of failure?	reliability
9.	Are there any system response time standards for the event appearing in the system? Please list the documents containing these standards, if any.	availability
10.	What is the impact of human reaction to the response time of the system?	credibility, safety
11.	What is the failure rate of the system?	reliability
12.	Specify or estimate: mean time required to resolving the failure (mean time required to resolving the failure, the time required to resume work)	reliability, availability
13.	Is the system considered to be reliable?	reliability
14.	Does the system perform validation of operational data?	credibility
15.	What is the cost of system's acquisition?	feasibility
16.	What is the annual cost of the system's exploitation?	feasibility
17.	Does the system contain following data:	usability
18.	What is the time availability of the service?	availability
19.	Does the R&D project have novel functionality compared to other existing systems/devices? If the answer above is 'yes', please list them.	innovation, feasibility
20.	To what extent are the new technologies (for example solutions of ICT, Artificial Intelligence, image processing) used in the system /device / R&D project?	innovation, feasibility
21.	What existing systems / technologies are possible to use with the system / use in planned system / R&D project?	feasibility
22.	Kind of device / system / R&D Project.	usability
23.	What is the number of data sources? Are they multiplied (different kind of sources, the same kind of data) or redundant (the same kind of sources and data)?	credibility, accuracy, reliability
24.	Is it possible to use redundant instances of the device /	credibility, reliability,

	system?	accuracy
25.	Who receives the data transmitted from the device / system? Do the other users of system receive them?	feasibility, safety
26.	How would you rate the degree of system measurability/quantifiability – are there measures for system assessment relative to other systems? (A subjective system evaluation, based on all answers)	measurability/quantifiability

The answers were formulated by experts representing navigators, hardware, software engineers and network specialist. Because of differences in existing systems on the one side and uncertainties in case of concepts and prototypes under development on another side, some of the questions couldn't be answered. The projected ESABALT system was taken into consideration too. For this purpose ESABALT requirements specification was analysed. The same set of questions was used.
The full list of answers is presented in the Appendix.
The collected answers were used for evaluation of each analysed system as well as for their comparison.
On this basis the viability analysis for the economic and non-economic aspects associated with the introduction and operation of the proposed ESABALT system were carried out.

2 Analysis of the selected aspects of system requirements: innovation, feasibility, reliability, availability, functionality/usability, credibility, measurability (Task 6.1)

The aim of this chapter is to analyse assess and compare selected navigational systems and devices (section 1.3) on the basis of innovation, feasibility, availability and measurability. The criteria functionality/usability reliability and credibility were added for its importance for analysis and assessment purposes.
The analysis and comparison of existing an projected systems and devices allows to assess the ESABALT system according to the above mentioned criteria.
A more detailed analysis of the (ESABALT) system capability to fulfil the user requirements according to the proposed system services will be made in section 4.

2.1 Innovation

A wide spectrum and a large amount of actors in maritime industry make the identification of all individual stakeholders unpractical. The identification is instead done by listing examples of stakeholders or/and their groups. Stakeholders have been sorted after different classification criteria, e.g. performed functions or location. Four classification criteria for the extensive stakeholders analysis were used.
All systems listed 1-7 and 9-16 were innovative at the moment of introduction. Marine radio enabled to transmit voice on the distance, ECDIS integrated all

available navigation information and presents them on the electronic chart, AIS was the first automatic identification system for merchant vessels etc. However if we treat innovation literatim, innovation is a new idea, more effective device or process. Innovation can be viewed as the application of better solutions that meet new requirements, inarticulate needs, or existing market needs. This is accomplished through more effective products, processes, services, technologies, or ideas that are readily available to markets, governments and society. The term innovation can be defined as something original and more effective and, as a consequence, new, that "breaks into" the market or society, then Systems listed in positions 1-7 (Marine VHF Radio, ECDIS, AIS, BNWAS, BAM, GMDSS, radar/ARPA) and 9-16 (Sound reception system, Thermal cameras, CCTV, VTS, VMS, GNSS receiver, LRIT, VDM) are already well known and introduced on ships from many years. Only NAVDEC system listed on 8th position has some innovative and novelty functionalities like qualification of encounter situation according to COLREGs, solutions how to avoid collision with other target/targets on the presumed CPA, which were up to now not implemented in any systems.
Results or outcomes of the projects listed 17-37 are usually not implemented on board of the vessels. All of them worked out or are working out some innovative solutions or outcomes:
17 . ARIADNA – 3D domains of the vessel.
18 and 19. BALTIC MASTER I and BALTIC MASTER II – Risk analysis models on the area of the Baltic Sea , integrated model of navigational safety on the Baltic Sea , AIS for small ships.
20. COSINUS – on-board navigation systems with maritime, traffic control systems on shore.
21. EFFICIEN SEA – demonstration of e-navigation concept an testing of e-navigation solutions, dynamic risk management, virtual AtoN's.
22. EMAR – A broad range of typical e-Maritime services such as security and safety management, legislation and regulation compliance, shipping, port operations, and transport logistics.
23. MARNIS – One single window for information exchange, information sharing.
24. MONA LISA – verification system for officers certificates, dynamic & proactive route planning.
25. MONA LISA II – Ship-to-ship and ship-to-shore communication.
26. MUNIN – Collision avoidance, partially incl. Colregs, Weather routing, Track control, Rudder/engine control.
27. NAVTRONIC – A harmonised global reporting system for sea/ice state.
28. SAFEWIN – New models to predict ice conditions.
29. TRITON – Robust and trusted position-indication.
30. ASSET – road traffic monitoring.
31. EFFORDS – Specialized ports ECDIS.
32. MASAS-X – Acquisition and integration of different kind of information.
33. SAFIRE – Design of a store and forward data mule architecture for robust sensing even when networks are intermittent.
34. SAIL – The SAIL Technology uses a novel approach that includes formal logics and ontologies to represent the situation, and automated reasoning to infer logical consequences.
35. MARCOM – n/a

36. TESSA – Decisions Support Systems for complex dynamical environments.
37. ESABALT - Enhanced situational awareness to improve maritime safety in the Baltic. The system that facilitate crowdsourcing to collect, deliver, process and transmit safety related messages to stakeholders involved in maritime transport process.

2.2 Feasibility

Systems listed 1-7 and 14-16 are widely used on board the vessels. VTS and VMS (12-13) are implemented ashore. Systems 9-11 are additional equipment. Nevertheless all of them have a performance standards, which precisely described the functionality of the systems and requirements, which have to be obeyed. Performance standards for decision support systems in collision situation are currently developed. Such systems (NAVDEC, Colreg Advisor, DST) have been already presented at IMO (subcommittees NAV and NCSR). Despite there are no performance standards for such systems, NAVDEC has been successfully implemented on 12 vessels as a stand-alone system, collecting positive feedback from masters and officers.
Generally speaking all listed systems have at least TRL 7 it means are demonstrated in an operational environment.
Projects listed 17-37 are on different development level. Some of them are already completed (BALTIC MASTER I, MONA LISA, MUNIN). Nevertheless, results are not widely implemented. For example no new performance standards for navigational equipment have been developed as a result of these projects, no new equipment were introduced in the merchant fleet. This is why it is hard to estimate TRL in relation to the outcomes of these projects.
ESABALT will be on TRL 4 by March 2016. It is planned to bring the project to TRL 7 during the next 2 years.

2.3 Reliability

Reliability the ability of a system or component to perform its required functions under stated conditions for a specified period of time.
Responders pointed following systems as the most reliable: BNWAS, BAM, Sound reception system, Thermal cameras, CCTV, VMS and VDR. First two are crucial from the mariners point of view. Last one is the equivalent of aircraft black box while VMS is responsible for management of vessels traffic. It is hard to image present shipping without properly working a/m systems.
As the systems with lowest tolerance to errors, responders pointed ARPA. Although errors generated by ARPA in relation to tracking targets and reports generated for them are well known, great attention are still required by navigators during interpreting radar reports. Because of these errors, new systems, which supersedes ARPA were developed and introduced. Stable reports nowadays we can receive from AIS and NAVDEC. These systems were classified as “systems with medium tolerance to errors”, but still represents higher reliability than ARPA.
The biggest challenge for ESABALT is reliability of crowdsourced data.

Assumption that: “only you know the weather in your position” can lead to dangerous situations. This is why some level of verification should be applied.

2.4 Availability

The *Availability* is understood as a probability that a system is operational at required standard or accuracy in a given time. The value of this parameter includes such factors like the frequency of unavailability (device failure, failure of communication channels, bug causing the algorithm to generate misleading results, etc.), downtime (which consists of time from detecting the problem to determine its cause and time for re-establishment of the functionality of a device / system), and total time in which the device / system must be available – different for critical systems used non-stop and for time-to-time used systems. It is widely accepted define availability as follows:

Table 3. System availability classes

System type	Availability	Availability class
Unmanaged	90%	1
Managed	99%	2
Well Managed	99,9%	3
Fault Tolerant	99,99%	4
High-Availability	99,999%	5
Very-High-Availability	99,9999%	6
Ultra-Availability	99,99999%	7

What to look for?

- Are there any rules relating to working time device / system?
- How soon could be found the abnormalities of device / system?
- How much time does it take to restore it to work?
- Does the device / system is used constantly or occasionally?
- Is the device / system is crucial for the navigator or merely supportive?
- Is the device / system is essential for the safety of people / ship?
- What factors influence the operation of the device / system?

According answers to questions No. 3, 10, 13 and 19 (which refers to *availability*) it is possible to say that:

- For 8 of 37 (questions 3 and 10) devices / systems there are standards for response time listed in normative acts (IMO Resolutions, IEC standards), in 4 of 37 cases there are other documents specifying the response time, but in 25 of 37 cases there are no such documents or it was impossible to determine them.
- In 6 of 37 cases there was determined mean time to find and resolve the problem according to devise / system work; usually it takes from 1 to 10 minutes.
- In 8 of 37 cases there was given a time to restore the functionality of the device / system – it takes from single seconds (restart of device) to 15 minutes (the resumption of work by the GNSS receiver).

- For 8 of 37 devises / systems it is possible to determine overall time of the problem detection, resolving it and resuming of work – it takes from a single seconds to approximately 20 minutes. In 29 of 37 cases it was impossible to find such information.
- The time availability of 20 devices / systems was described as “good”, in 3 cases as “poor”, for 10 was “difficult to assess”. In 4 of 37 cases there was no such information.

It is difficult to estimate the availability of ESABALT system because of very early stage of project, but there is expected that the system should meet existed and future IMO guidelines, in accordance with e-navigation strategy. Taking into account existing technologies, it should be good available system.

2.5 Functionality / usability

Usability of the system means how it fits to the user needs. It can be expressed it as the easiness of learning and handling the system, effectiveness and efficiency of obtaining the results of the work and felt satisfaction with easily obtain the expected result. Working with high usability systems is more effective, easier, more pleasant and it causes no feelings of frustration and confusion.
The vast majority of analysed equipment and navigation systems has been characterized as a highly usable by the respondents. Some insufficiency in fulfilment of the expectations of the users were reported to the systems:

- Electronic Chart Display and Information System (ECDIS),
- Automatic Radar Plotting Aid (ARPA),
- Vessel Traffic Service,
- Vessel Monitoring System (VMS),
- Long Range Identification and Tracking (LRIT),
- Shipborne voyage data recorder (SVDR).

Most likely it can be explained by their complexity.
In the subjective assessment of the respondents, it is important to emphasize that all the analysed navigation equipment and systems must comply with the standards set by the legal regulations, where a system is required.
One of the studied traits of usability was the easiness of learning and use of the system. In this field it was found that all the analysed navigation equipment and systems have manuals. Additionally the systems:

- Electronic Chart Display and Information System (ECDIS),
- Automatic Radar Plotting Aid (ARPA),
- Global Maritime Distress and Safety System (GMDSS),
- NAVDEC.

are equipped with context-sensitive help what facilitate their use.
Another important characteristic of usability was the efficiency and effectiveness of the output data developed by the navigation system. Unfortunately, less than 40% of the worked out data is possible to directly use by the navigator, it means the majority of these require further analysis.

Comparing this to the fact that all (apart navigating decision support system NAVDEC) investigated device and systems have only informative functions it may be concluded that in this field the level of usability should strongly increase.

The tendency to transform navigational information systems to decision support systems (information and decision-making) can be seen in the context of the analysed projects, where already average more than 75% of data that can be worked out for direct use by man. This is possible because into the concerned projects, next to the data processing, there was applied also knowledge processing. Through the use of computational and knowledge representation techniques such as artificial neural networks, fuzzy logic, evolutionary algorithms, expert systems, rough sets, knowledge base, etc. (commonly known as AI – artificial intelligence), it was possible to design systems which exhibit the characteristics normally assigned to human intelligence. This is a development direction for the navigation systems that provides a higher level of usability.

The ESABALT system assumptions and build-in functionalities are based on dialog with its future users – personal interviews with experts in navigation, law and computer science and electronic surveys for other interested parties. This may result very functional and usable system.

2.6 Credibility

The concept of Credibility refers to the objective and subjective components of the believability of a source, message or system. In this sense all maritime systems must be credible – the provided information may affect the safety of people, vessels and environment. There are several factors affecting the credibility level. They can be divided into two groups:

1. technical – they may be precisely determined, for example:
   - possibility of validation and verification all data entered by user and computed by a device or system,
   - ability to determine the measurement and computing error of the processed data,
   - ability to correct data, for example the use of different or redundant data sources,
   - the complexity of used structures and algorithms,
   - probability of human error,
2. non-technical – resulting from a subjective human trust to a given device, for example:
   - trust in the applied technologies,
   - trust arising from the history of use such kind of device/systems,
   - sociological factors.

According answers to questions No. 6, 7, 11, 15, 24 and 25 (which refers to credibility) it is possible to say that:

- The most of the devices / systems requires human decision what results the possibility of making mistakes on the one hand, but on the other the experience of qualified navigator may be used. In 20 of 37 cases the human takes the most decisions, in 7 of 37 human takes only the key decisions but in 10 of 37 cases the influence of human is negligible or human takes no decisions at all – the device or system acts automatically or autonomously.

- The majority (35 of 37) of the devices / systems collect data from different sources; 12 of them gives possibility to use redundant data sources what makes possible to additional verify information.
- The data used by analyzed devices / systems are derived from measurement equipment whit a high level of confidence but also from uncertain sources such as human-made assessment.
- 24 of 37 devices / systems verify most of the entered and computed data, 3 of 37 provides partial verification and 7/37 have no possibility to verify processed data; in 4 of 37 cases there was not possible to determine this parameter.
- 30 of 37 devices / systems provide data in the form ready to use by navigator, 34 of 37 devices / systems provides data which must be analyzed by human. In 11 of 37 cases the amount of data which must be analyzed by human is equal or greater than 50%.
- In most of the cases (23 of 37) the amount of provided data which need to be analyzed by human is sufficient, in 6 of 37 cases was too small but in 13 cases was too large; there is a group of systems (7 of 37) where the amount of such data might be sufficient or too large what depends on the result of unfinished R&D project.

It can be also seen that there is a group of commonly used devices / systems which reached a medium or high level of credibility – these are all kinds of systems required for conduct the ship (AIS, ECDIS, ARPA, GNSS, etc.) – they provide reliable information used by navigator to take decisions. The algorithms implemented inside them have a limited complexity and can be easily verified.
Besides of described above group, there are also more complex systems which, although they provide valuable information in the form convenient for navigators, it may have a lower credibility level resulting from the implementation of a much more complex calculation algorithms (including decision-making algorithms), which are not possible for simple verification by navigator. For this reason, although they will indicate a high level of credibility resulting from the applied solutions and data sources, they will be treated by navigators as "less credible".
The most problematic issue according to credibility in ESABALT project is using the crowdsourced data – it is very important to implement solutions which enable evaluation, validation and verification of such data and users that provide them.

2.7 Measurability

Navigational systems, as well as other technical systems, are developed and used for defined purposes (objectives, goals). In case of navigational systems there may be generalise to the improvement of safety, security efficiency of transport processes.

The verification the achievement of the defined system objectives requires the evaluation of the results of system performance. This can be done by defining criteria for the evaluation and proposed measurements (indicators): qualitative and quantitative. The common used criteria are i.e.: functionality, availability, reliability, safety, security, credibility.
The use of the same criteria and measures for evaluating other systems allows them to compare and identify the advantages/disadvantages of individual systems. This, in turn, makes possible the improvement of the analysed system.
Additional, system specific, criteria can be used too. Assuming the main objective of ESABALT system, the criteria should concern three levels of situational awareness:

Level 1: Perception of the elements in the environment.

Level 2: Comprehension of the current situation, which is based on a synthesis of Level 1 elements.

Level 3: Projection of the future actions of the system and his elements in the environment through knowledge of the status and dynamics of the elements and a comprehension of the situation (both Level 1 and Level 2 SA).

The answers to all questions, especially question no 27, were taken into consideration for the analysis and assessment of systems measurability.
Taking into account Situational awareness levels, attention should be given to answers to questions 7, 11, 24 and 26.
Two group of systems were distinguished: existing systems and system projects or prototypes.
The existing systems were evaluate in general as good measurable, whereas prototypes and ongoing projects as poorly measurable or immeasurable.
The amount of data requiring additional analysis by the navigator was estimated as sufficient by using existing systems. In case of and system projects or prototypes, this question couldn’t be answered.
Considering the existing systems and prototypes and ongoing projects, the impact of human reaction to the response time of the system was assessed as significant because of their information character: a man takes most of the decisions. Exceptions were full automated systems - GNNS, LRIT, VDR), where the impact was estimated as negligible.
The question about the number of data sources and data redundancy corresponds with situational awareness level 1. In most cases there are different sources provided multiple and redundant data. The solutions proposed in systems projects and prototypes are strongly oriented on integration and collection of all received data.
Question no 26, concerns secondary system beneficiaries for the enhancement of their situational awareness. These User are not involved in the analysed navigational situation, but can use information about this situation, for example to project future actions (situational awareness level 3).
The most of the analysed existing systems do not transmit information to other users. Exceptions are AIS, VHF radio, VTS and VTMS. In case of projected systems and prototypes it is difficult to estimate the range of transmission.

Comprising the mentioned systems to ESABALT proposal, the last one – ESABALT – gives more opportunities for such activities because of crowdsourcing.

3 Analysis of the selected aspects of system requirements: political, economic, social, technological, safety and security domains (Task 6.2)

The feasibility study of an enterprise comprises, among others, analysis of the capability to fulfil the user requirements according to the proposed system services in political, economic, social and technological domains (PEST). This analysis gives a picture of the environment which is helpful by taking advantage of opportunities and minimize the threats of projected ESABALT system. Additionally safety and security domains were analysed.

3.1 Political domain

The Baltic Sea is a sensitive maritime area bordered by both EU and non EU countries. With about 2000 merchant ships passing each day, fishing vessels and boats, leisure boats, offshore installations, military and navy ships the Baltic is a key maritime thoroughfare. The northern climate presents natural obstacles to navigation like ice in every winter season. Transport of dangerous to environment cargoes like crude oil, chemicals, liquefied natural gases has increased year by year. ESABALT system and its exploitation plans shall take into account needs and requirements of involved countries in the Baltic Sea Region with relation to:

- international shipping,
- EU shipping,
- EU Baltic countries,
- non EU Baltic countries.

The primary goal of the ESABALT project is to study the feasibility of implementing a software platform for maritime information crowdsourcing in order to enable cross-border cross-sector cooperation, and therefore enhanced maritime safety, security, environmental monitoring and emergency response in the entire Baltic Sea region.

EU politic for Baltic Sea Region is stable with perspective of sustainable growth. It is a good perspective for implementation of ESABALT system. Full operation of ESABALT in the Baltic Region requires involvement of all maritime administrations in the region including Russian. Discussion with partners from Baltic countries which are not involved in the ESABALT consortium and particularly with Russian partners and stakeholders shall be undertaken.

Status of EU Flagship project which ESABALT obtained helps for its better recognition and impact. ESABALT can be a strong player in implementing the 'Clean and Safe Shipping', and 'Better Cooperation' action points under the EUSBSR Objective 1 'Save the Sea'. The targets and indicators for the

Priority Area PA SAFE mentions 'Increased cross-border and cross-sector cooperation and information sharing among maritime authorities and other relevant stakeholders to improve maritime safety and security' as Cooperative Objective 2, which incidentally is also an objective of ESABALT.
Furthermore, ESABALT satisfies the following EU SBSR area of special interest – 'Creation of common maritime management systems and monitoring, information and intelligence sharing environments for the Baltic Sea'.

3.2 Economic domain

Economic domain encompasses economic factors influencing the projected enterprise. There are inter alia:

- economic growth,
- interest rates,
- inflation,
- economic trends,
- sustainability and profitability of enterprises.

Because of the location of the system there should be taken into account economic factors at the international as well as national level in each of the countries in the Baltic Sea region. These affect benefits and costs of:

- system development and modifications/extensions,
- infrastructure which can be used for other purposes too,
- system maintenance,
- system exploitation.

The business potential for ESABALT comprises of all those who navigate in the Baltic, in a commercial as well as non-commercial capacity. ESABALT is planned to be free for end-users, but paid by other subscribers, such as harbors, shipping companies, and small-to-medium enterprises (SMEs) implementing innovative services and applications on top of the crowdsourced maritime data. The project will demonstrate that a trusted, independent intermediary can collect, process, and store location and other maritime data using transparent and clearly documented methods. ESABALT will also contribute towards fuel-efficient and safe shipping resulting in reduced insurance costs. Integrating pleasure boats into the data crowdsourcing will enable them to contribute to coastal surveillance and monitoring, thus reducing the burden on already resource-strapped coastal authorities. The system impact can be summarized in three categories; increased information sharing, increased number of users and aggregated information overview across national boundaries and administrative sectors.
It should be mentioned, that economic factors influence the standard of living which determines the range and scope of the use of ESABALT system.
The more complex analysis of factors affecting economic domain will be made on the basis of the tests of ESABALT system prototype.
Economics should be considered based on functionalities. Also communication as separate item is very important (eg. mobile roaming in

different countries and satellite communication in different areas and bandwidths).
The business model of the enterprise should be taken into account.

3.3 Social domain

The enhancement of situational awareness due to the development and implementation of ESABALT system will depend on the number of the stakeholders, especially system users, defined in WP2 and described in deliverables 2.1-2.3.
Therefore, it is necessary to investigate the social domain as continuation of the political domain analysis. In particular there are social, socio-economic and socio-cultural factors.
Their consideration and can lead to achieving the main objective which is the improvement of situational awareness at the sea.
It is important to take into account the specificities of stakeholders (i.e. seamen, sailors, authorities) as well as communities of Baltic region countries (EU Baltic countries and non EU Baltic countries).
The social factors specific for the analysed region are inter alia:

- demographics (age structure of the population),
- education,
- population employment,
- income distribution (change in distribution of disposable income),
- living conditions,
- attitudes to work and leisure,
- fashions and fads,
- lifestyle changes (mobiles, smartphones),
- press attitudes,
- public opinion,
- social attitudes.

Positive factors observed in the Baltic Sea region are:

- increasing education level of communities,
- continuous development of information society,
- growth of living standard,
- lifestyle changes - common use of mobiles, smartphones, Internet access,
- more time for interests and hobbies i.e. sailing, fishing,
- press attitudes, public opinion, social attitudes promoting marine environment protection,
- press attitudes, public opinion, social attitudes promoting sport and leisure activities.

The development of information society, common use of mobiles and rapid increase of social media (networks) should be underlined.
All the mentioned social factors support the implementation and use of navigational systems, which improve the situational awareness at the sea. This in turn improve the safety in commercial and leisure shipping.

This in particular relates to the developed ESABALT system, where the modern IT and ICT technologies are used, including the innovative crowdsourcing at sea.

3.4 Technological domain

The Deliverable D4.1 has provided a list of services and software modules which should fulfil the requirements specification given in the ESABALT document D2.1-2.5. There are five services provided by ESABALT Data Server:

1. System Management – aims to manage the system state, set the profile and/or parameters of the system's and authenticate the operator of the system.
2. User Management – manages information of the user/operator of the data server system.
3. Vessel Management – manages 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.
4. Environment Awareness – updates the weather and pollution reports and maps information.
5. Sensor Station Management – manages access to data from the sensor station, validates the sensor data with other data source and processes invalidated data.

Additionally there was defined a set of ESABALT Services and Functionalities understood as provided by the system:

1. Intelligent Marine Navigation and Routing – 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; the service should aim to automate the route planning functions and offer the navigators alternative routes to choose from.
2. Efficient Emergency Response – easy-to-use reporting mechanisms for different type of emergency situations.
3. Environmental Monitoring and Reporting – environmental monitoring and reporting by providing the interfaces and automatic forwarding of reports to the appropriate authorities.

There has been also defined a list of ESABALT software modules which enable it to offer the expected functionality and associated services:

1. Log-in module (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 route of nearby ship(s).
6. Report an unidentified vessel.
7. Route optimization (Route optimization request to ESABALT server and submit the selected route).

8. Route update (Make an update to vessel route and submit to ESABALT server).
9. Display situational awareness reports (weather, sea ice, pollution etc.).
10. Report to ESABALT on 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.

All system requirements developed in D2.1-2.5 have been mapped to the system services and modules provided above. All of the requirements have been taken into account into at least one service or module.
Analysing services and functionalities of the ESABALT system, there are some classes of technologies to be used:

- communication protocols,
- computations of data,
- hardware used in communication,
- hardware used in computation,
- software technologies used in programming,
- software engineering,
- databases to store data on the server and device sides.

At this moment all requirements can be fulfilled by existing technologies.
Communication between devices as well as between servers and clients are done by specified, well known protocols like IVEF or TCP/IP. There are algorithms and procedures to compute most of data and even if they are not existing, there is possibility to develop them. There is a commonly used equipment to perform communication like wide range network adapters as well as other telecommunication solutions like LTE, GPRS or satellite communication that can provide clients access to the servers. Platforms for servers and clients also exists – there is wide range of ready to use computers as well as hardware elements to develop own solution. The software development can be based on one of programming language like C++, Java or C# and may be supervised with use of one of many software engineering methodologies for example PRINCE2. All data can be stored with use of commonly used database solutions like MS-SQL Server, PostgreSQL or even NoSQL solutions like MongoDB. Linux operating system is used more and more nowadays in modern marine real time systems, so it may become main software platform for servers and desktop applications. Mobile applications running in iOS, Android and Windows Phone can be based on same software but have limited functionalities requiring less processing power and resources.
The ESABALT project is realized by the consortium of partners from Baltic Sea region countries: Finland, Sweden and Poland. These countries are technologically advanced so all partners (R&D and high-tech organizations) have good opportunities to find or develop all needed materials and technologies as well as to find good skilled specialists and companies what significantly facilitates the realization of the project. This technological

background make possible to manufacture all needed elements of the projected system to make it fully working.

3.5 Safety domain

The competitive advantage of maritime transport compared to other transport modes leads to increasingly greater volumes of seaborne cargo, which entails higher traffic intensity, vessel tonnages and speeds. This, in turn, adversely affects the safety of people, ships, cargo and marine environment. To enhance navigational safety, efficiency and competitiveness of transport services in maritime trade, ships and land-based vessel traffic centres' equipment and systems are constantly being upgraded. This is expected to bring:

- social benefits due to reduced rates of fatalities and permanent injuries of crew members and passengers of sea-going vessels,
- material benefits due to reduced losses of cargoes, ship damage and losses,
- business benefits due to reduction of general operating costs and shorter voyage times,
- marine environment protection and prevention of ecological disasters that occur as a consequence of collision of ships carrying dangerous goods.

In the most of the examined equipment and navigation systems a human must carry out a detailed analysis of the output, what is a major factor influencing the safety. All (except navigational decision support system NAVDEC) of the analysed systems have only informative functions. Noticeable is the lack of work out of solutions which could be a hint for the decision maker. The more that the case-law of marine accident investigation commissions indicates that one of the main causes of accidents on the water are human error.

The ESABALT system architecture consists of a central data and web server which will process all the crowdsourced information from the individual ESABALT terminals, and in turn cater to their service requests. Each terminal is supported by the three primary technology pillars – Navigation, Sensing and Communication. The land-based or sea-based sensor stations enable environmental monitoring, external databases provide maps, vessel information, and Sentinel-1 earth observation (EO) images, and a central control station manages administrative oversight. ESABALT also describes the concept of ‘Autonomous Vessel Data-Crowdsourcing’, which includes integration of novel sensors with the ESABALT terminals onboard the vessels or in automated sensor stations so that relevant data aggregated with other sensor/AIS information is crowdsourced to the server with minimal, if not zero human intervention. This information is available to other vessels or authorities for real-time situational awareness in the Baltic Sea Region.

Elimination or limitation of human errors and thus to ensure the highest level of navigational safety is possible thanks to an increase of situational awareness and by allowing the widest range of 'intelligent' automation, so that a human had to make only key decisions and could use a hints of solutions.

3.6 Security domain

For the purpose of this report and project ESABALT security shall be understood as the system protection against the use by unauthorized persons and to guarantee that authorized persons have access to the system when required.
It should be also understood as combination of preventing measures intended to protect the system and its users facilities against threats of unlawful acts as:

- delivery of fake information into system,
- hacking the system,
- unauthorized access to the system,
- unauthorized use of system information.

Security matters require proper identification of stockholders involved in exchange of information and involved in maritime security processes in the Baltic Region. The identification of stakeholders involved in information exchange processes in maritime transport and their needs in this respect is essential for their safety, security, efficiency and competitiveness improvement. To this end such concepts as e-maritime (EU) and e-navigation (IMO) are developed. Stockholders shall be identified by:

- levels of responsibility,
- location,
- role in the system,
- interest/responsibility.

Security matters require description of dedicated (known) and potential users of the system. Following category could be applied:

- main users,
- additional users,
- support users,
- administration users,
- other users.

Security matters require a consideration on following issues:

1. How is the access to the system supervised?
2. How the access to the system should be provided?
3. What methods are used to secure access to the system?
4. What technologies of software and data protection are planned to be used in the proposed system?
5. How system should be secured from fake information (jamming, spoofing etc.)?

Security matters require focus on technology applied in the system and system settings. System technology, data communication are critical aspects regarding the security issues. ESABALT system concept from the vessel system perspective is eNav type of application. ESABALT data communication solution must take into account same security aspects related to vessel communication and system connectivity. The transmission of information shall be encrypted due to security of transmitted information.

4 Analysis and evaluation of the system capability to fulfil the user requirements according to the proposed system services in analysed domains (Tasks 6.1 and 6.2)

The aim is to develop the ESABALT system taking into consideration two system development phases which fulfil basic and full set of requirements and to analyse them in view of the proposed system services in analysed domains.

4.1 System development phases – phase I (basic) and phase II (full)

It was assumed that the requirements defined in deliverables 2.1-2.5 as well as the identified in deliverable 4 functions and services represent the phase I of the projected ESABALT system.
Because of the system complexity two phases of the system development are proposed:

- phase where the system will be built taking into account the key (basic) requirements
- phase II where the full version of the system will be built taking into account the full list of requirements

The full list of requirements, presented in the deliverable D4.1, was analysed again to reduce them and to identify the functionalities that will be developed in phase I (basic) of ESABALT system.
The system developed in phase II, in accordance with deliverable 4, consists of 15 modules which offer the expected functionality and associated services modules:

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 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 system developed in phase I differs from that developed during phase II as follows:

- Modules 6-13 and 15: supporting and ensuring the quality of the reporting of required information to authorities, agencies, ports, carrier and others not available (SR_25).
- Module 7: route optimization not included (SR_28, SR_29).
- Module 7: interpretations of displayed information as a result of automatic inference process not available (SR_30, SR_31).
- Module 7: risk analysis, assessment and management not available (SR_33 – SR_35).
- Module 7: Detection of dangerous or irregular situations and information about them not available. (SR_36, SR_37).
- Module 7: optimisation of transport operations and vessel operations not available (SR_38, SR_39).
- Module 7: monitoring of passengers and cargo in such a way that damage and irregular or dangerous situations can be detected and if possible avoided not available (SR_40).
- Module 14: displaying of selected groups of information not possible (SR_44).
- All modules: system versions on different languages not available (only English version) (SR_53).
- All modules: client software on other than Android software platforms for mobiles not available (SR_67, SR_68).
- All modules (interface): Entering of information in languages different than English not available (SR_70).
- All modules (interface): Translation of presented information in different languages not available (SR_71).
- All modules: Full integration of client's software with ships systems/devices not available (SR_78).
- Modules 2-5: Only one type of maps (on-line or off-line) available (SR_79).

4.2 Two phases of ESABALT system – comparison in view of selected criteria

Taking into account the requirements for the system developed in two phases, the preliminary comparison of both versions is presented in Table 4.

Table 4. Comparisons of the ESABALT system developed in two phases

Phase I	Phase II
Innovation: new idea, device or process, the application of better solutions that meet new requirements. The ESABALT System can be considered as innovative because of:	
• Use of crowdsourcing to collect information	• Use of crowdsourcing to collect information

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<tr><td>

- Increase the amount of information available to non-professionals
- Gives possibility to inform authorities and other users about different kind of dangers and improper situations

</td><td>

- Increase the amount of information available to non-professionals
- Gives possibility to inform authorities and other users about different kind of dangers and improper situations
- Performs route planning and optimization and proposes a set of solutions to choose from
- Displays interpretations of information as a result of automatic inference process
- Gives possibility to determine causes, risks and provide risk control options

</td></tr>
<tr><td colspan="2">Feasibility: aims to evaluation of the project's potential for success (legal, operational, economic, technical, schedule).</td></tr>
<tr><td>System in the phase I needs less issues to solve (ex. route planning subsystem, translation of interface to different languages and solutions needed to make possible such translation, etc.) what means that this version is more feasible than final version.</td><td>Most of the requirements are feasible because of existing solutions in other working systems, devices and R&D projects. The novel functionalities looks also feasible – there are technologies which can be used during realisation as well as other domains (political, economic and sociological) brings no serious treatments.</td></tr>
<tr><td colspan="2">Usability: the degree to which system can be used to achieve specified user goals with effectiveness, efficiency and satisfaction, in a specified context of use.

The ESABALT system collects very useful information and presents it in easy to use and interpret way. Additionally gives possibility to end users add new information which can improve awareness of other users and inform authorities about danger/unusual situations. The interface is similar to other commonly known solutions what makes the system easy to use and find all important elements of interface.</td></tr>
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There are some elements that make the system in phase I less usable than final version:

- the access is realized by the client program which works under one operating system,
- interface is in English only,
- there is no decision support elements like route propositions,
- lack of organization system for presented information (choosing the groups of presented information),
- etc.

Anyway, the system is still usable in basic assumptions – the users will have access to additional information and can participate in increasing of safety by sending reports about danger and

</td><td>

System in the phase II is more useful because of:

- possibility to access the system not only by dedicated application but also via thin client, a web-based application accessed through web-browser,
- possibility to use interface in users own language as well as providing information in languages different than English – originally and automatically translated,
- provides some elements of decision support such like route planning and optimization, interpretation of information, finding causes and risks as well as provides risk control options,
- additional increasing usability

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<table>
<tr><td>unusual situations/events.</td><td>elements such like organization of information</td></tr>
<tr><td colspan="2">Availability: the probability that a system is operational at required standard or accuracy in a given time.

The level of availability is compared to system in phase II – communication skeleton and used IT solutions of both versions are the same.</td></tr>
<tr><td colspan="2">Accuracy: the closeness of the agreement between the result of a measurement and the true value of the particular quantity (or a reference value determined empirically using internationally accepted and traceable calibration materials and standard methods), taking into account both, random and systematic factors.</td></tr>
<tr><td>The accuracy of the system in phase I is affected by reduction of validation of some information sending through the system what may affect credibility also.</td><td>The accuracy of the ESABALT system depends, among others, on the quality of information provided by the users. If the institutional users (authorities, SAR, coast guard, etc.) can be considered as accurate, it can’t be said in case of information provided by ordinary users. The system in phase II provides solutions to validate and interpret entered information what improve the quality of them and the same accuracy of the system.</td></tr>
<tr><td colspan="2">Reliability: the probability that a given system will perform its intended function for a given period of time under a given set of conditions; reliability does not reflect how long it will take to get the system being serviced back into working condition.

The reliability of the system in phase I is compared to the final version.</td></tr>
<tr><td colspan="2">Safety: the feature that expresses the ability of the system to avoid or prevent activities posing a threat to humans or the environment.

The main aim of the system is to provide additional information to the user, both professionals and occasional, what may significantly improve safety. The information come from existing systems but also from other users who can posse them sooner than traditional sources (ex. authorities).</td></tr>
<tr><td>Although the system in Phase I has less option, the core of the system’s functionality is the same, so the impact to the safety should be comparable. But it might be affected by the lack of automatic validation and verification of information entered by ordinary users – imprecise and false information can influence the safety of the users.</td><td>Additionally the system in phase II has functionalities of decision support such like route planning and optimization where the dangerous area are taken into account and can be automatically avoided.</td></tr>
<tr><td colspan="2">Security: the system protection against the use by unauthorized persons and to guarantee that authorized persons have access to the system when required.

The security of the system in phase I is compared to the final version. Use of cryptography and users authorization with use of digital signatures improves the security of the system.</td></tr>
<tr><td colspan="2">Credibility: refers to the objective and subjective components of the believability of a source, message or system.</td></tr>
</table>

The information is collected by authorities as well as ordinary users, so the credibility depends on quality of information provided them as well as the interpretation and correction algorithms implemented into the system.	
Lack of implementation of some elements such like automatic interpretation of collected facts or automatic validation of information entered by users might strongly affect the credibility of the system in phase I.	The automatic interpretation of entered facts and their validation as well as possibilities to filter groups of information by the type, priority and numbers of sources can improve credibility.
Measurability: quantifiability, the ability to determine the quantity or importance of the system. There are no significant differences between both phases of the system development.	

4.3 Identification of benefits and costs in view of innovations feasibility, availability, measurability

Benefits

Taking into account the requirements for both phases of the system development, the preliminary comparison of both versions in view of benefits is presented in Table 5.

Table 5. Benefits for full and basic versions of ESABALT system

Criterion	Benefits	Phase I	Phase II
Innovation	Automated crowdsourcing	X	X
	Common software platform	X	X
	Intelligent, fuel efficient routing and berthing		X
Availability	All stakeholders in maritime process (see WP 2)	X	X
	Meteorological/ice condition observed and transmitted by drones	X	X
	Reduces the burden on public authorities	X	X
	Reduces response time	X	X
	Environmental monitoring and reporting	X	X
Reliability	Situational awareness	X	X
	Instantaneous communication	X	X
	Efficient emergency response	X	X
	Cooperation for enhanced maritime safety and security		X
Measurability	Verifiability	X	X
	Possibility to compare with other systems	X	X
	Possibility to identification of system weaknesses for system improvement.	X	X

Group of costs:

1. Feasibility study.

2. Software development.
3. Hardware designing:
   – Hardware manufacturing.
4. Testing on the simulator.
5. Testing in real condition.
6. IPR.
7. Data transmission.
8. Implementation of the system.
9. Management.
10. Marketing.
11. Distribution.
12. Service.

The costs of the system development in phase I can be estimated after the tests of the prototype. On this basis the costs of the phase II of development may be predicted.

4.4 Identification of benefits and costs in political, economic, social and technological domains

The benefits and costs of ESABALT system are analysed together for both phases of development. If differences occur, these are pointed in adequate place. This is because the differences in the analysed domains are not very strong.

Benefits:

1. Political domain:
   – mutual recognition of differences and needs of administrations and stockholders operating in the Baltic Sea Region,
   – possible harmonization of maritime law in the region,
   – increased safety of transport and international shipping in the region,
   – transfer of technology, elaborated practices and solutions in the Baltic Sea Region to other regions in EU and farther like ASEAN.
2. Economic domain:
   – lower accidents costs (human, ship, cargo and environment) because of safety at sea improvement,
   – lower operational costs (efficiency improvement) because of route optimisation.
3. Social domain:
   – the development of social networks,
   – integration of involved communities and societies.
4. Technological domain:
   - crowdsourcing technology at sea,
   - route optimization technology.

Costs:
1. Political domain:
   – none direct costs,
   – political cost could be associated with further isolation of regions and stakeholders which would not benefit from ESABALT system.
2. Economic domain (will depend on business model, which should be used):
   – system software and hardware costs,
   – infrastructure costs,
   – maintenance costs,
   – personal costs.
3. Social domain:
   – lack of communication channels in social networks,
   – misunderstanding of involved communities and societies.
4. Technological domain:
   – communication costs negligible in case of use the Internet but high in case of satellite communication,
   – maintenance costs of infrastructure
     basic version – lower costs because of lack of route optimization server and other cooperating systems and devices,
   – personal costs of operators.

4.5 The impact of developed system variants on situational awareness and on the maritime safety and security improvement in the Baltic Sea

Baltic Sea Region has got enough resources to provide assistance to all parties which seek for assistance in the Baltic. Use of these resources depends available information about particular event. Response actions and engaged resources depend on information and general situational awareness. Particularly on:
- information scope,
- information reliability,
- information actuality,
- information accuracy,
- information delivery time (delay) to/from system,
- information validity.

There are services in the Baltic Sea Region providing different types of information to the users like weather forecasts, ice conditions, winds, currents, waves, marine traffic information etc. Information in this case is obtained from remote sensors like satellites and distributed from centres in intervals.
ESABALT system will provide channels for fix communication where information could be supplied continuously without delay. On the other hand onboard users could feed the system with local information about spotted phenomena of natural (ice, sea state, visibility etc.) or artificial nature (traffic

density, spills, floating unmanned objects, threats to safety and security etc.). This social maritime information network could be organized within a ESABALT system. It will increase general situational awareness in the Baltic Sea Region and will have tremendous impact on maritime safety and security in the Baltic.
By reporting information to a central ESABALT repository, all end-users will be able to achieve a greater level of situational awareness than they would by acting independently. Therefore, the system impact can be summarized in three categories; increased information sharing, increased number of users and aggregated information overview across national boundaries and administrative sectors.

Increased information sharing
Early in the project a web based survey on feasibility and interest in crowd sourcing in the maritime was conducted. Of the 166 answers from maritime industry professionals, 86.4% answered that they would participate in crowdsourcing of maritime information if given the chance and/or technical possibility. ESABALT will provide the platform to satisfy this need.

Increased number of users
A majority of survey responses considered other ships as one of the main hazard for ships in the Baltic. Some participants explicitly answered; congested waters and pleasure crafts in summer time. The commercial fleet and relating organizations have established means for communication. Yet many small national passenger vessels or inshore pleasure boats lack such communications equipment. Harmonization, through increased availability of the system e.g. as smartphone application, will lead to a larger amount of users and hence, healthy amount of useful data.

Aggregated information overview
By gathering the information from all stakeholders to a central display, an aggregated information overview is obtained. In addition to the targeted purpose, the ESABALT system could have other unexpected effects. Big data of this type could lead to a spawning of innovative applications and therefore, business opportunities in the Baltic Sea region. For instance, statistical analysis of echo sounding data gathered through ESABALT could show a map of unchartered places ripe for a further hydrographical survey. Such analysis can provide immense possibilities for commercial exploitation, or for determining future strategy and policy directions in the Baltic Sea region.

Thus, ESABALT is strongly aligned with the objectives of the BONUS program especially, Developing improved and innovative observation and data management systems, tools and methodologies for marine information needs in the Baltic Sea region. ESABALT also contributes towards the Save the Sea objective of the European Union Strategy for the Baltic Sea Region. It directly addresses the Strategy's Policy Area Maritime Safety and Security (PA SAFE) in the part that focuses on the ‘Reduction in the number of maritime accidents’. By delivery of current, high-quality, integrated navigation-support data the project offers specific tools for situational awareness and accident prevention thus contributing to the PA Actions Develop co-operation in maritime surveillance and information exchange and Improve safety of navigation by means of e-Navigation and new technology.

5 System and services analysis with respect to functionality availability, reliability, safety, security and credibility

The aim of this chapter is to analyse system and its services in a view of availability, safety, security and credibility. The main input for this task were the ESABALT prototype tests results in a view of system requirements and system services. The analysis of tests results was performed. Additionally, selected system parameters were estimated. The AIS system data streams have been considered as a model for the communications and the mobile phones as the expected primary platform.

5.1 System prototype analysis and comparison with the architecture proposal

The system prototype analysis was performed in two steps:

1. Verification of implemented requirements.
2. Verification of implemented services.

The results of step 1 are presented in appendix III. Whereas results of step 2 in the appendix IV. Short summary regarding system prototype approval is presented in table 6.

Table 6. System prototype – services approval.

Module No.	Module name	Tests results
1	System registration and log-in	Not approved *)
2	Display vessel position and submit to ESABALT server	Approved
3	Display vessel route and submit to ESABALT server	Approved
4	Display position and information about nearby ships	Approved
5	Display route of nearby ship(s)	Partially approved **)
6	Report an unidentified vessel	Not approved *)
7	Route optimization request to ESABALT server and submit the selected route	Not approved *)
8	Make an update to vessel route and submit to ESABALT server	Partially approved **)
9	Display situational awareness reports – weather, sea ice, pollution etc.	Approved
10	Report situational awareness – sea ice, pollution, oil spill, violating ship etc.	Approved
11	Report and display ship(s) violating maritime rules	Not approved *)
12	Submit vessel radar tracks to ESABALT server	Not approved *)
13	Submit messages/warnings/alarms to ESABALT	Approved

	server	
14	Display messages/warnings/alarms from ESABALT server	Approved
15	Speed-reporting of emergency situations for pleasure craft	Approved

*) not tested
**) partially tested

Services were noted as approved when the key functionalities and accorded requirements were accepted. Partially approved services were those where only a part of key functionalities was implemented. There were some services which were not implemented and therefore not tested. This services were noted as not approved.
The presented results will be used in the further system evaluation.

5.2 System prototype evaluation in view of functionality, availability, reliability, safety, security and credibility based on system prototype tests

The evaluation was based on the system prototype services verification and the estimation of selected system parameters. The criteria mentioned in the subtitle were taken into account.

Functionality
Functionality of the system is limited. ESABALT is a laboratory prototype which means that basic technological components are integrated to establish that they will work together. This is relatively “low fidelity” compared with the eventual system. Examples include integration of “ad hoc” hardware in the laboratory.
Most of the functionality from phase I of the system were positively verified and approved. Following groups of functions will be implemented in follow up project (ESABALT II):

1. Security e.g.: restricted access to the system, verification of data collected from crowdsourcing, certification of information,
2. Optimization e.g.: automatic route optimization, optimization of the transport operation and the operation of the vessel with respect to safety, environmental protection, security and efficiency,
3. Risk determination e.g. risk control options, determination of causes,
4. Interface e.g.: multilingual interface, which giving possibilities to enter information in other than English language, access via Web browser, mobile interface, other operational systems.

Technology is presently on TRL 4. The goal is to bring it to TRL 7 in the next 3 years, which means that system prototype will be demonstrated in an operational environment. That moment all System Requirements (SR) should be implemented.

Reliability

This is a prototype of the system, which is adequate for demonstrations, not for continuous operation. The system was not implemented in real condition, this is why it is not possible to estimate its reliability. Basing on information of the general office computers reliability which is around 98%, one can assume that the maximal reliability of prototype of ESABALT system should be at the same level. Of course servers used as a basement of ESABALT will be much more reliable.

Availability

Because this is a prototype system it is not intended for continuous operations the availability will not be higher than for general office computers. On the other hand the availability should be higher than in case of unmanaged system (Availability class 1, availability in 90% of working time, referring to chapter 2.4 of this document). But in case of laboratory tests, the prototype availability is adequate for demonstration purposes and all needed functionalities were available when the tests were performed.

Credibility

Although it is not possible to say that the prototype has a high level of credibility, there may be assessed the credibility of the technologies used to prepare it. There are elements considered as highly credible like real equipment used in tests, especially the sources of navigational data (AIS, GPS, etc.) and software previously developed and published to the market (digital charts, some elements of server-side solutions, navigational algorithms, etc.).

But there are also elements newly developed and used in a new role like the use of simulation as a source of data (where simulator may be too good – meant as precise and complete source of data).

Some of the technologies are sometimes considered as potentially unsafe.

The lack of authorization and certification also affects the overall credibility.

Assuming, that at least 1% of information delivered by end users can be incorrect. This level should decrease in the longer period of time.

Safety

There are many factors influencing the safety of navigation. Existed navigation systems and devices are very helpful in supporting navigators decision making processes due to acquisition and integration of information. However a human must carry out a detailed analysis of the output, what is a major factor influencing the safety. Even though, human errors cause most of accidents in shipping. This occurs because of carrying out a detailed analysis of the output, what is a major factor influencing the safety One of the ways for enhancement of sea navigation is decision support consisting in generation of decision proposals for navigator – automation of decision making. Navigational decision support module is one of the planned ESABALT functionalities which have to be included in the phase II of the system development. An additional advantage is reduction of the amount of data requiring additional analysis by the navigator. Due to this functionality one can predict the reduction of human errors and consequently reduction of accidents at sea.

Navigational decision support system are currently under development or are introducing on ships. Therefore there are not statistical data concerning the reduction of sea accidents as result of using such systems.

Security
Security issues concern, inter alia, supervision of the access to the system, authenticity of data stored in the system as well as data to be send by the system. The corresponding services (functionalities) were not implemented in the system prototype and therefore not tested. Consequently, there were noted as not approved. This can be investigated and assessed with the use of the system full version and is planned to be performed in the future as a continuation of the current project.

6 System options taking into account political, economic, social and technological aspects of system functionalities (services)

The concept of the analysis of two system variants – basic and full versions – formulated in the work plan in the project proposal was verified.
Taking into account successfully tests of system prototype and identified small range of not implemented services, only the full version of the system was considered. This version will be developed in two phases: first one that correspond to the basic version and the second one which means the full version.
The system options were identified for the following system life cycle stages: development, implementation and exploitation.
The test results of the system prototype were used during the analysis of the system options.
Additionally, the estimated values of selected parameters (indices) were used. The estimation made by experts was done for services / functionalities / requirements not developed or not implemented in the prototype therefore not tested during prototype test.
The system prototype evaluation was performed in view of political, economic, social and technological domain. The analysis was done for two water areas of the Baltic sea: water area near Finland and Sweden and near Poland. This is because of some differences regarding, economic, political and social conditions in the mentioned regions/water areas.
Based on the current results of ESABALT development (including the mentioned system prototype evaluation) and concerned assumptions the FSA analysis [3] is proposed. This analysis may be very helpful by the system road map determination.

6.1 System development, implementation and exploitation options

Following options, listed below, were taken into account concerning ESABALT development, implementation and exploitation.

Development
It was assumed, that the development of the services, functionalities or requirements defined in previous project work packages will be done by consortium partners of ESABALT II project.

Implementation
Two options are taken into consideration:
1. ESABALT consortium performs both: server and client side.
2. ESABALT consortium performs server and private enterprises perform client side.

Exploitation
Two options are taken into consideration:
1. Public institution or state administration performs both: server and client side.
2. Public institution or state administration performs the server side and private enterprises perform client side

6.2 System prototype evaluation in view of political, economic, social and technological domain

Political domain
The main idea of ESABALT is to deliver, free of charge, information, which enhance situation awareness of the end-user. To fulfil this challenge ESABALT should be widely implemented in the Baltic States. Full operation of ESABALT in the Baltic Region requires involvement of all maritime administrations in the region.
Status of EU Flagship project which ESABALT obtained helps for its better recognition and impact. ESABALT can be a strong player in implementing the 'Clean and Safe Shipping', and 'Better Cooperation' action points under the EUSBSR Objective 1 'Save the Sea'. The targets and indicators for the Priority Area PA SAFE mentions 'Increased cross-border and cross-sector cooperation and information sharing among maritime authorities and other relevant stakeholders to improve maritime safety and security' as Cooperative Objective 2, which incidentally is also an objective of ESABALT. ESABALT satisfies the following EU SBSR area of special interest – „Creation of common maritime management systems and monitoring, information and intelligence sharing environments for the Baltic Sea".
ESABALT is in line with new BONUS call „Blue Baltic" Theme 5.3: User-driven new information and communication services for marine environment, safety and security in the Baltic Sea.
Above mentioned "fit" will help to obtain funding to bring ESABALT from TRL4 to TLR7 in the next two years. During that time it is required to convince Maritime Administration, that such system helps to improve safety of navigation. It is planned, that for final workshop of ESABALT project, representatives from all Baltic States will be invited.
EU politic for Baltic Sea Region is stable with perspective of sustainable growth. As ESABALT is in line with it, it will be much easier to contact and

convince Administration from EU countries, particularly from partner countries. The biggest challenge is to involve partners from Baltic countries which are not involved in the ESABALT consortium and particularly with Russian partners and stakeholders. Discussion shall be undertaken.
Such action helps to increase number of countries implementing the system.
Next step for consortium is to fulfil of IMO and EU requirements for such system. The way to reach it goes through IMO subcommittee e.g. NCSR, where appropriate Performance Standards should be adopted. Recognition of the system by IMO and EU will be crucial in mutual recognition of differences and needs of administrations and stakeholders operating in the Baltic Sea Region as well as harmonization of maritime law in the region.

It should be noticed that there are very important additional political threats: strained international relations and concerns regarding terrorism. The first one can lead to the failure of the project in all the project lifecycle phases. The second one can discourage users from use of the system because it can be seen as a potential weapon in hands of terrorists or source of information for them.

Economic domain

Economic point of view consisting of cost-benefit analysis is very important for decision makers and causes set-up of the project or his abandonment.
An attempt was done to estimate the costs of the development, implementation and operation of the ESABALT. Only a coarse estimation of benefits (incomes) was conducted because of their hard measurable character. More visible benefits will be primarily in terms of political, social and technological domains.
The business potential for ESABALT comprises of all those who navigate in the Baltic, in a commercial as well as non-commercial capacity. ESABALT is planned to be free for end-users, but paid by other subscribers, such as harbors, shipping companies, and small-to-medium enterprises (SMEs) implementing innovative services and applications on top of the crowdsourced maritime data.
Total cost of implementation consists of following categories:

- system software costs,
- hardware costs,
- infrastructure maintenance costs,
- operational costs,
- personal costs.

The ESABALT software should be provided at no cost. ESABALT functionality may be included as additional features in other software which may have cost e.g. NAVDEC.
Cost of developing software will be more or less equal to the total budget of project ESABALT and ESABALT II.
Regarding hardware we assume the use of any existing general-purpose device: smartphone, tablet, computer, which are already in end-user’s possession.
ESABALT will use existing infrastructure i.e. communication infrastructure like WiFi hotspots, GSM/HSDPA network, Inmarsat, V-sat and wired connection

particularly on the administration side. Data will be stored in cloud servers. In this case monthly or yearly fees will appear. At the moment of this report creation, the year cost of virtual server is less than 8000 USD if it will be implemented with use Amazon Web Services. The server was defined as a one virtual instance using 500GB SSD storage place connected to the Internet via dedicated 300Mb/s connection with one public IP address and 10 cryptography keys. The transfer was estimated on 15GB of monthly outcome transfer what was calculated for regular and extraordinary communication of 100 users connected all the time, with monthly software update in size of 25MB for all of them.
Despite the system itself will be free of charge, critical for end users are operational costs like data transmission. It is most likely that the popularity will be in line with availability, and mobile phones are the most available of these systems, but there should be also some other option particularly on the open sea. Part of transmission will be also conducted by wired connection (we assume 10 %). This method will be used by administrators of the system. Another 5 % of whole capacity will go through Wi-Fi. This method will be used in ports and harbors. The rest will be split between satellite communication e.g. via Inmarsat (5 %) and via mobile phone networks (80 %). First two methods are usually free of charge or are paid as lump sum, so additional transmission will not generate extra cost.
Unfortunately transmission via mobile network usually generates additional cost for the subscriber, particularly in roaming. Presently it is around 0.25EUR per 1MB, but European Commission announced, that in two years roaming in EU will "disappear", so we can assume that there will be no extra cost for end-user. The only roaming which lasts at Baltic Sea is in Russia. It costs now around 8EUR per 1MB. Basing on the length of Russian coast in the Baltic Sea, we assume, that time spend in area covered by Russian roaming should be less than 3 % of all time spend by vessel/pleasure craft in the Baltic Sea.
The lowest cost for satellite communication is around 13EUR per 1 MB (Inmarsat Fleet 77) basing on monthly airtime. While average cost reaches 35EUR. It is possible to transfer 10MB for around 75EUR (Thuraya GmPRS) or 100MB for 500EUR (ThurayaIP).
Basing on the assumption that size of the message will be 200bytes and optimum frequency rate is 10 times per minute, the average quantity of data is around 2.5MB per day, which is 75MB per month. This is already high cost for pleasure crafts and significant for commercial vessels.
To summarize. 2.5MB per days, 15 % of which is via cost free connection. Remaining 85 % is divided between mobile and satellite network. 80% of 2.5MB i.e. 2MB will be transmitted via mobile. 3 % of 2MB in Russian roaming zone i.e. 0.06MB*8EUR=0.48EUR. 5 % of 2.5MB via satellite i.e. 0.125*13EUR=1.63EUR.
Daily cost for end-user is around 2EUR.

Personnel costs

The back end of the system should not require continuous operation. The curation of data gathered is guessed to consume 20% of the time of a coast guard/VTS traffic monitoring person for some geographical area. This is very dependent on the volume of traffic in a given area.

During the first year of system implementation it is expected to employ one person in each Baltic countries, which gives 9 additional employees with total budget of 250.000EUR per year.
Basing on assumption that there is no cost of software, hardware and infrastructure for the users, the total cost during the first year is 250.000EUR (authorities side) and 2EUR*365days*100 users= 73.000EUR (data transmission).
This is much less that cost of one collision at sea, which in average is equal to 1 million EUR (excluding loss of life, loss of cargo and environmental issues)

Social domain
Following the analysis in subchapter 3.3, selected social, socio-economic and socio-cultural factors investigated in Baltic Sea regions planned as ESABALT system testbeds. Therefore Finland, Sweden, Estonia, Russian Federation and Poland were taken into account. For this purpose OECD statistics were used [4].
Parameters describung are presented in tables 7 and 8.

Table 7. Selected demographic and social statistics in analysed countries of the Baltic Sea region

Factors	Finland	Sweden	Estonia	Russian Federation	Poland
population	5,4 mil	9,5 mil.	1,3 mil.	142,5 mil.	38,5 mil.
education - adults aged 25-64 having completed upper secondary education	85%	88%	90%	94%	90%
people aged 15 to 64 having a paid job	69%	74%	68%	69%	60%
the average household net-adjusted disposable income per year (in USD	27 927	29 185	15 167	19 292	>25 908*)

*) less than OECD average

Table 8. Selected social statistics in analysed countries in Baltic Sea region. Scale 0 ÷ 10

Factors	Finland	Sweden	Estonia	Russian Federation	Poland
Housing	6,2	6,3	4,3	3,3	4,1
Income	3,3	5,0	0,7	1,3	1,3
Jobs	7,0	7,6	5,7	6,3	4,9
Community	9,4	8,3	7,1	7,4	7,9
Education	9,1	7,9	7,9	6,2	8,3
Environment	8,8	9,6	7,8	4,3	4,5
Civic Engagement	5,9	8,8	2,3	2,1	5,3
Health	6,9	8,7	4,4	0,6	5,0

Life Satisfaction	9,6	9.0	2,9	4,7	3,6
Safety	9,3	8,3	7,3	6,5	9,8
Work-Life Balance	7,4	8,1	7,4	7,9	5,6

Legend:
Housing – housing conditions and spendings
Income – Househod income and financial wealth
Jobs – earnings,job security and unemployment
Community – quality of social support network
Education – education benefits
Environment – quality of environment
Civic Engagement – involvement in democracy
Health – tate of the health
Life Satisfaction – ”happyness” level
Safety – murder and assault rates
Work-Life Balance – comparision work-play

The number of potential users is important. One can assume, that leisure boats users wll play an important role because of croudsourcing. In Europe alone are in use (estimation) 6 million leisure motor boats and yachts [5]. Because of selected Baltic Sea regions planned as ESABALT system testbeds the estimation of leisure boats users can be made on the basis of sea yacht in previously mentioned countries. There are for example in Poland around 15 000.

Positive trends observed in the Baltic Sea region, mentioned in the subchapter 3.2, are inter alia increasing education level of communities, continuous development of information society, growth of living standard, lifestyle changes, more time for interests and hobbies i.e. sailing, fishing, press attitudes, public opinion, social attitudes promoting marine environment protection as well as sport and leisure activities.
However, some factors may influence the range of system users, especially sailors (leisure). There are:

- social awareness, in this context aware of the availability of the ESABALT system,
- social level life standard, incomes, preferences regarding leisure and hobbies,
- reluctance to crowdsourcing – distrust, piracy, terrorism.

Technological domain
The analysis of ESABALT system prototype in point of view of technological domain has been focused on existing and future technologies which has been used in the prototype and may be used in fully implemented system. Individual modules / functionalities of the ESABALT system have been evaluated and issues that need additional development in science, infrastructure and user access to the system have been pointed.
The modules “Display vessel position and submit to system server” and “Display vessel route and submit to system server“ are presented in prototype and approved. The information provided to this modules are collected from wide range of on-board devises such like GPS receivers, log or radar. In final version different sensors build into smartphones, tablets or dedicated devices

(like Thingsee One) also might be used. The vessel position and route will be presented on electronic chart which may be any of commercial or free charts (like OpenSeaMap or even Google map). The free of charge maps have open programming interface which can be used by any of software developer. The publishers of commercial maps usually are also interested in using their solutions in software products. The transmission of own vessel position and route will be done via any kind of internet connection which is usually provided by manufacturer of hardware device (computer, tablet or smartphone).

The module “display position and information about nearby ships” is presented in prototype and approved. The information used in this module is collected from different kind of own sources (AIS, radar) and from ESABALT servers. The connected with this one is the module “display route of nearby ship(s)” which was partially approved during prototype tests. The information used in this module can be get from ESABALT servers or computed with use of information collected from ship systems (AIS, radar) and sensors. For modules described in this paragraph will be used the same technologies like for previous modules.

Modules for displaying and reporting situational awareness information and messages / warnings / alarms from and to ESABALT server have been presented in prototype, tested and approved. The technologies needed to develop them exist and can be used in final solution. There are three modules that have not been approved during prototype tests but the way they will be act is very similar to the approved modules. These are modules for reporting unidentified vessels, reporting and displaying ships violating maritime rules and submitting vessel radar tracks to ESABALT server.

The module “Speed-reporting of emergency situations for pleasure craft” was implemented in prototype and approved during tests. The solution is based on quickly accessible point-to-select menu but different kind of triggering can be also possible e.g. automatic sending of message in case of detecting specific situation.

The log-in module was not evaluated during prototype tests. This module is essential for secure use of whole ready to work ESABALT system – it provides identification and authorisation of every user using the system. The appropriate technologies that provide such functionalities already exist and are widely used. Very important issue that should be solved here is a problem of communication security e.g. detecting intentional introduction of erroneous information or prevention against intentional changing correct data into false data.

One functionality – the route optimization – was not accessible in the prototype and must be developed. The module “Route optimization request to ESABALT server and submit the selected route“ was not approved (not tested) and the module “Make an update to vessel route and submit to ESABALT server” was partially approved. There are commercial solutions that provide such functionalities but it is possible to develop own solution for ESABALT project – there are methods and technologies that are used in decision supporting systems development. Communication facilities associated with this part was tested and approved.

During prototype tests all mentioned above modules / functionalities have used LAN network to communicate to the ESABALT server. The server was a stand-alone Linux based machine with proprietary software developed by

FURUNO Finland. The final version of the system will require a dedicated infrastructure for rapid collecting, processing the information from multiple sources and sending them back to multiple users. There will be required a highly scalable solution, such like a virtual server in computing cloud connected to the Internet with use of high bandwidth links. Such kind of solutions are supplied by many commercial providers e.g. Amazon.
Concluding, most of the technologies needed to develop and implement final version of the system already exists and even if the functionality was not fully approved in prototype tests, there is no significant obstacles to develop it. There is one issue that needs development of new solution in automatic route planning. Additionally, there is also need to implement highly scalable infrastructure for ESABALT server which will provide fast access to the information and their processing.
The main cost is amount of time and work needed to choose appropriate technologies and develop all elements of the system. The main technological benefits are: a new solution for automatic route planning and methods of communication security.

6.3 The Formal Safety Assessment methodology in risk analysis and management

The assessment of the designed system was performed with the use of the criteria listed in chapter 4.4.. The risk analysis and management of the ESABALT was performed with the use of the Formal Safety Assessment (FSA) methodology. The analysis included:

- threats,
- risk analysis,
- risk reduction measures,
- risk control options,
- risk monitoring.
- profitability analysis for each proposed system option:
- the system implementation costs (hardware, software, outsourced services),
- the benefits of using the system, taking into account the risk control options.

The assessment concerned three processes:

- development,
- implementation and
- operation (exploitation).

The FSA methodology [3] consist of five steps:

1. Identification of hazards - a list of all relevant accident scenarios with potential causes and outcomes (what might going wrong?);
2. Assessment of risks - evaluation of risk factors (how bad and how likely?);
3. Risk control options - devising regulatory measures to control and reduce the identified risks (can matters be improved?);
4. Cost benefit assessment - determining cost effectiveness of each risk control option (what would it cost and how matters can be?);

5. Recommendations for decision-making - information about the hazards, their associated risks and the cost effectiveness of alternative risk control options is provided (what actions should be taken?).

Threats result from technology, human factor, organisation, tools and requirements.
Step 1 of FSA. Threats in ESABALT system development, implementation and operation (exploitation) processes were identified and are presented in the table 9.

Table 9. Identified threats in selected system lifecycle phases.

		System lifecycle – selected phases		
		Development	Implementation	Exploitation
Domains	Political	• strained international relations • changes in law of Baltic Sea Region states	• strained international relations • changes in law of Baltic Sea Region states	• strained international relations • passive attitude of authorities • passive attitude of commercial ships • concerns regarding terrorism • changes in law of Baltic Sea Region states
	Economic	• inability to finance the system development • need to buy commercial solutions	• inability to finance the system implementation	• underestimated data flows and higher costs for users • underestimated data flows and higher costs for provider • underestimated costs of hadrware and software maintenance • underestimated personel costs
	Social		• insufficient promotion	• insufficient promotion • a small number of users • a small number of active users • insufficient credibility of data from crowdsourcing • intentional introduction of erroneous information by users • lowering the standards of living • reluctance to use the system even if there are visible benefits • significantly more than expected users resulting in a decrease of system performance • reluctance to spend money on data transmission
	Technological	• difficulties in implementation of functionalities based on ship manouver optimisation and intelligent supporting, • insufficient progress of	• insufficient progress of implementation • difficulties with connection to existing systems/devices that were not used during development	• insufficient computing power due to increasing number of users • insufficient links • delay in access to information • crowdsourcing range (coverage) limited to the scope of mobile telephony • new standards in maritime and ICT technologies that were unknown during development

	development • selection of impropper technology

Step 2 of FSA. Risk assessment based on estimation of probability and consequences of threats was performed and are presented in the table 10.

Table 10. Probability and consequences of identified threats.

	Threat	Probability	Consequences
Development	strained international relations	very small	serious
	changes in law of Baltic Sea Region states	very small	serious
	inability to finance the system development	small	catastrophic
	need to buy commercial solutions	very small	little
	difficulties in implementation of functionalities based on ship manouver optimisation and intelligent supporting,	moderate	moderate
	insufficient progress of development	small	serious
	selection of improper technology	small	moderate
Implementation	strained international relations	very small	serious
	changes in law of Baltic Sea Region states	very small	serious
	inability to finance the system implementation	small	catastrophic
	insufficient promotion	large	serious
	insufficient progress of implementation	small	moderate
	difficulties with connection to existing systems/devices that were not used during development	moderate	moderate
Operation (exploitation)	passive attitude of authorities	moderate	serious
	passive attitude of commercial ships	moderate	moderate
	concerns regarding terrorism	large	serious
	underestimated data flows and higher costs for users	small	serious
	underestimated data flows and higher costs for provider	small	moderate
	underestimated costs of hardware and software maintenance	moderate	moderate
	underestimated personel costs	moderate	moderate
	insufficient promotion	large	serious
	a small number of users	large	serious
	a small number of active users	very large	serious
	insufficient credibility of data from crowdsourcing	large	serious
	intentional introduction of erroneous information by users	very small	serious / catastrophic
	lowering the standards of living	very small	moderate
	reluctance to use the system even if there	very small	minimal / little

	are visible benefits		
	significantly more than expected users resulting in a decrease of system performance	very small	little
	reluctance to spend money on data transmission	large	moderate
	insufficient computing power due to increasing number of users	very small	moderate
	insufficient links	small	serious
	delay in access to information	moderate	moderate
	crowdsourcing range (coverage) limited to the scope of mobile telephony	large	serious
	new standards in maritime and ICT technologies that were unknown during development	very small	moderate

6.4 System control options and recommendations

This chapter indicates the existence of the threats that may affect the development, implementation or exploitation of the system. The threats were estimated and the risk control options for selected threats were proposed. All significant threats will be defined in more detailed document developed during the development of the system final version.
This analysis is a one of the bases to roadmap (WP7) document.

Step 3 of FSA. Risk control options as regulatory measures to control and reduce the identified risks were proposed.

Table 11. Threats and threats prevention

	Threat	Risk control option
Development	strained international relations	-
Development	changes in law of Baltic Sea Region states	Adaptation of system functionalities to new law
Development	inability to finance the system development	Searching for new finance sources
Development	need to buy commercial solutions	Searching for new finance sources
Development	difficulties in implementation of functionalities based on ship manouver optimisation and intelligent supporting,	Additional consultations
Development	insufficient progress of development	Motivation of existing developers and searching for new developers
Development	selection of improper technology	Searching for proper technology
Implementation	strained international relations	-
Implementation	changes in law of Baltic Sea Region states	Adaptation of system functionalities to new law
Implementation	inability to finance the system implementation	Searching for new finance sources
Implementation	insufficient promotion	Increasing budget for promotion - searching for new finance sources
Implementation	insufficient progress of implementation	Motivation of existing developers

		and searching for new developers
	difficulties with connection to existing systems/devices that were not used during development	Development of new plug-ins and adapters
Exploitati	passive attitude of authorities	Motivation made by EU
	passive attitude of commercial ships	Additional promotion and workshops
	concerns regarding terrorism	Additional confirmation regarding information credibility
	underestimated data flows and higher costs for users	Reducing the frequency of data transmission
	underestimated data flows and higher costs for provider	Reducing the frequency of data transmission
	underestimated costs of hardware and software maintenance	Searching for new finance sources
	underestimated personnel costs	Searching for new finance sources
	insufficient promotion	Additional promotion and workshops Searching for new finance sources
	a small number of users	Additional promotion and workshops
	a small number of active users	Additional promotion and workshops Motivation through “hall of fame”
	insufficient credibility of data from crowdsourcing	Authenticity check/verification Verification by operator
	intentional introduction of erroneous information by users	Authenticity check/verification Verification by operator
	lowering the standards of living	Reducing costs of transmission
	reluctance to use the system even if there are visible benefits	Additional promotion and workshops
	significantly more than expected users resulting in a decrease of system performance	Enhancement of system availability (server side)
	reluctance to spend money on data transmission	Reducing costs of transmission
	insufficient computing power due to increasing number of users	Enhancement of computing power Searching for new finance sources
	insufficient links	Enhancement of bandwidth
	delay in access to information	Enhancement of computing power Enhancement of bandwidth
	crowdsourcing range (coverage) limited to the scope of mobile telephony	Off-line collecting of crowdsourcing data and sending them when connection is set Use communication infrastructure set-up on off-shore constructions like oil-rigs or windmills
	new standards in maritime and ICT technologies that were unknown during development	Development of new plug-ins and adapters according to e-Navigation solutions

Step 4 of FSA. Costs and benefits of the risk control options were estimated and are presented in table 12.

Table 12. Costs and benefits of risk control options

Risk control option	Costs	Benefits
Adaptation of system functionalities to new law	Depend on range and scope of adaptation	Compliance with law Increased number of users
Searching for new finance sources in case of inability to finance the system development	Man power	Continuation of system development
Searching for new finance sources in case of need to buy commercial solutions	Man power	System services development
Additional consultations	Consultation and business trips' costs	Implementation of required functionalities
Motivation of existing developers in case of insufficient progress of development	-	Expected progress of system development
searching for new developers in case of insufficient progress of development	Man power	Expected progress of system development
Searching for proper technology	Man power	Expected progress of system development
Adaptation of system functionalities to new law	Depend on range and scope of adaptation costs	Compliance with law Increased number of users
Searching for new finance sources in case of inability to finance the system implementation	Man power	Continuation of system implementation
Increasing budget for promotion	Decreasing budget for other activities	Additional promotion
Searching for new finance sources in case of insufficient promotion	Man power	Additional promotion
Motivation of existing implementers	-	Expected progress of system implementation
Searching for new implementers	Man power	Expected progress of system implementation
Development of new plug-ins and adapters	Additional work for developers	System cooperates with new devices
Motivation made by EU	No costs	Activation of authorities in ESABALT sourcing
Additional promotion and workshops	Man power Organizing costs of workshops	Activation of commercial ships in crowdsourcing
Additional confirmation regarding information credibility	Man power Development of additional security	Credibility improvement

		code	
	Reducing the frequency of data transmission (user side)	Data accuracy decreasing	Reduced costs of data transmission
	Reducing the frequency of data transmission (provider side)	Data accuracy decreasing	Reduced costs of data transmission
	Searching for new finance sources in case of underestimated costs of hardware and software maintenance	Man power In critical circumstances costs of system reactivation	Ensuring of system availability
	Searching for new finance sources in case of underestimated personnel costs	Man power; In critical circumstances costs of system reactivation	Ensuring of system availability
	Additional promotion and workshops about ESABALT system	Man power; Organizing costs of workshops	Better system recognition
	Searching for new finance sources in case of insufficient promotion	Man power	Better system recognition
	Additional promotion and workshops to encourage potential users to use ESABALT system	Man power; Organizing costs of workshops	More users of the system
	Additional promotion and workshops to encourage users of the system to enter situational awareness information	Man power; Organizing costs of workshops	More active users of the system
	Motivation through “hall of fame”	Costs of development of a small piece of code	More active users of the system
	Authenticity check/verification	Additional security code development	higher credibility
	Verification by operator	deploying extra personnel	higher credibility
	Reducing costs of transmission	No costs	Reduced user exploitation costs
	Additional promotion and workshops to reduce reluctance to use the system	Man power Organizing costs of workshops	More active users of the system
	Enhancement of system availability (server side)	Server extension	Ensuring of system availability
	Reducing costs of transmission	No costs	Reduced user exploitation costs
	Enhancement of computing power	Server extension	Ensuring of system availability
	Searching for new finance sources in case of insufficient computing power	Man power	Ensuring of system availability
	Enhancement of bandwidth	Bandwidth extension	Ensuring of system availability
	Enhancement of computing power	Server extension	Ensuring of system availability
	Enhancement of bandwidth	Bandwidth extension	Ensuring of system availability

Off-line collecting of crowdsourcing data and sending them when connection is set	Additional code development	Ensuring of system availability
Use communication infrastructure set-up on off-shore constructions like oil-rigs or windmills	Man power	Ensuring of system availability
Development of new plug-ins and adapters according to e-Navigation solutions	Additional code development	System cooperates with new devices and fulfil with standards

Step 5 of FSA: recommendations for decision making. Assuming that the risk control options presented in table 11 cover the measures to control and reduce the identified risks for each threat, it is proposed to use these control options as recommendations for decision-making.
Detailed risk control options and recommendations should be indicated in the initial stage of the planned project ESABALT II.

7 Conclusions

This report summarizes different issues which are important regarding development, implementation and exploitation of ESABALT system.
Baltic Sea is a sensitive area because of natural conditions and geopolitical localization. The reason is the countries have different political, economic and social perspective and interest.
The presented analysis focuses on different aspects of ESABALT system. Based on this potential threats were identified. The FSA analysis was performed to obtain control options and recommendations regarding prevention of previously identified threats. One can assume that the presented report will be the basement for Roadmap (WP7) formulation as well as for detailed FSA analysis in project ESABALT II.
Besides the mentioned perspectives the report focuses also on innovations, technical constrains and opportunities for the ESABALT project including discussion on safety and security matters which are critical for Authorities operating in the Baltic. They will be encouraged to monitor and verify information supplied by users and also contribute to the information. Flow of information in the system has to be monitored and secured in order to protect it against fake information, hacking and other threats.

8 References

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