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Analysis and Identification of Requirements for a System to Enhance Situational Awareness at Sea

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ABSTRACT: This paper presents the research results of identifying and analyzing key requirements for the ESABALT system based on pre-defined user profile groups. These requirements have been identified through multiple sources, which include an electronic survey of potential users of the system, interviews with specialists in navigation, law and computer science, analysis of state-of-the-art in maritime safety procedures, and study of past R&D projects in this field. Finally, these requirements are classified into user level, domain level and system level requirements for easy interpretation while designing the system architecture and its function-al specifications. The presented system specification is discussed.

1 INTRODUCTION

In 2010 the European Union launched a new re-search and development program to protect the Bal-tic Sea worth EUR 100 million over the period 2010-2017, called Baltic Organizations Network for Funding Sciences EEIG (BONUS). BONUS is considered as the first model case for the development of science-based management of the European regional seas by bringing together the research com-munities of marine, maritime, economical and societal research to address the major challenges faced by the Baltic Sea region (Bonus Portal, 2014).

The European Union e-Maritime initiative aims to promote the use of advanced information technologies for working and doing business in the maritime transport sector. The ESABALT is a research and development joined (Finnish Geodetic Institute, FURUNO Finland, SSPA Sweden and Maritime University of Szczecin, 2014) project studying the feasibility of a novel system for enhancing maritime safety. The aim of this paper is to present results of identification and analysis of key requirements for the potential ESABALT system.

2 SITUATIONAL AWARENESS

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

situational awareness is an important concept for Vessel Traffic Services (VTS) and Search and Rescue (SAR) centers, who must maintain good situational awareness in order to fulfill their missions.

ESABALT aims to increase the safety of all vessels operating in the Baltic Sea by providing tools and services which enhance situational awareness. This is achieved using the latest technological advances in sensing, positioning, e-Navigation, Earth observation systems, and multi-channel cooperative communications. In addition, ESABALT aims to facilitate crowdsourcing of relevant information from a multitude of users. That is, by reporting information to a central repository, all end-users will be able to achieve a greater level of situational awareness than they would by acting independently. A guiding tenet of the ESABALT concept is that all maritime users in the Baltic Sea can operate more safely by collaboratively building and maintaining situational awareness.

According to a web-based survey conducted by the ESABALT project, the vast majority of maritime actors are already familiar with the concept of situational awareness (84.9% of respondents to the survey). Furthermore, maritime actors consider situational awareness to be an important factor in maintaining safe maritime operations. The average rating of the importance of situational awareness was 4.4 on a scale of one to five with five being the highest level of importance. These initial results suggest that systems capable of enhancing situational awareness at sea would have a strong possibility to improve overall safety of maritime operations.

At the same time, however, it was noted in the survey results that a new system introduced to the maritime operating environment should not require significant additional interaction or sustained attention of the crew. Traditional methods of situational awareness include monitoring the situation by visual means or through established electronic means (radar, AIS). Thus, an additional system introduced by ESABALT should not detract from the time available for the crew to monitor the situation using these traditional methods. In particular, any new system should exhibit a high level of autonomy and, if possible, it should be integrated into existing systems.

3 REQUIREMENTS IDENTIFICATION

The identification of key requirements for the system was divided into following steps:

1 identification of stakeholders,
2 identification of potential system users and groups of potential users,
3 preparation and conduct the survey for potential users to provide user requirements,
4 interviews with specialists in navigation, law and computer science to provide system and domain requirements,
5 analysis of ESABALT project assumptions and output of previous stages of the project,
6 review of maritime safety approaches and analysis of different R&D projects in the field of maritime safety, navigation, communication and situational awareness.

The steps 1, 2 and 6 are presented in different papers.

3.1 *User requirements*

In the case of ESABALT project, the list of user requirements specifies the expectations of potential users of the potential system. To find them, the electronic survey in the form of web-based questionnaires was prepared. The survey contained 38 questions focusing on the issues of maritime safety, situational awareness, crowdsourcing and preferences in IT solutions such as user interface and integration with other on-board systems. The answers for example question are presented in table 1.

Table 1. The answers to example question: "What kind of difficulty in the work due to the following characteristics of previously used systems are the most important?".

Item	Score[1]	Overall Rank
interface much different from interfaces in use	291	1
excessive quantity of information	229	2
the complexity of the information provided by the system	209	3
lack of manual	209	4
inability to adapt systems to personal needs	193	5
obligatory registration/login in the system	189	6
lack of system help	187	7
on-line work only	175	8
delays in the system	172	9

[1] Score is a weighted calculation. Items ranked first are valued higher than the following ranks, the score is the sum of all weighted rank counts.

There was 83 responses and 52 of them were complete. The analysis of the survey's output combined with the results of previous stages of the project and interviews with experts gave the list of 28 user requirements. The examples of defined user requirements are presented in table 2.

Table 2. The examples of user requirement got from the web survey.

No.	User requirements
1	The user interface and working manner of the system should meet the standards for navigational information systems (ex. ECDIS, ARPA, AIS).
2	The user interface should be as simple as possible in order to prevent information overload – only the basic information should be presented, detailed information should be available on demand only.

3.2 *System requirements*

Designing any IT or ITC system there should be determined its architecture and functionality as well as its requirements for hardware and software. These information is placed in a list of system requirements.

In the case of ESABALT project, its assumptions, outcome of previous stages, results of R&D projects and existing systems analysis and interviews with

experts were used. The list of 53 system requirements was formulated. Some of them are presented in table 3.

Table 3. The examples of system requirement got from the interviews with experts.

No.	System requirements
1	The system should provide continuous access to data residing on the server.
2	Information transmitted in the system should be made available to users immediately after their introduction/approval.
3	Information should be certified with use of digital signatures associated to individual users (account).
4	The transmission of information should be encrypted.

3.3 *Domain driven requirements*

As every specialized system, the potential ESABALT solution should meet the requirements in the specific field. These so called domain driven requirements are specified in the documents relating to the maritime field (such as IMO or IHO norms) but also arise from less formal rules and customs. The interviews with experts in navigation gave the set of such domain driven requirements. The example of domain driven requirements are presented in table 4.

Table 4. The examples of system requirement got from the interviews with experts.

No.	Domain driven requirements
1	The system shall fulfill as many as possible requirements listed in IEC 60945 norm: Navigation and marine radio communication equipment and systems - general requirements,
2	The system shall fulfill as many as possible requirements listed in IEC 60936 norm: Guidance of for using AIS information display on radar screen,
3	The system shall fulfill as many as possible requirements listed in IEC 62288 norm: Navigation and marine radiocommunications equipment and systems – Presentation of navigation-related information on shipboard displays - requirements for handling and operation, methods and performance.

4 REQUIREMENTS ANALYSIS

On the basis of identified user, system and domain requirements functional and nonfunctional system requirements are specified. Functional requirements define the expected functionality of a system and its components whereas non-functional requirements specify criteria that can be used to judge the operation of a system, rather than to specify system behavior.

To simplify the process of system requirement analysis and assessment, the lists of functional and non-functional requirements are integrated and reordered focusing on system analysis, design, implementation and testing. The identification of the significance of particular requirements from the user point of view is done. This allows the determination of the requirements hierarchy. On this basis key requirements are specified. The key requirements represent the core of the system and facilitate the development of the system architecture. The summarized list of final system requirements is shown in Table 5.

Table 5. The examples of final requirement for the ESABALT system to enhance situational awareness at sea.

Module	Domain driven requirements
Access to the system	Authorized users in the Baltic Sea region can be assigned to one or more categories which define the access rights to enter and/or read specified types of information.
Information in the system	The system should have at least the following categories of information: - weather information, - navigational information, - navigational warnings, - traffic information, - detailed information about the nearest vessels.
Computations and Algorithms	The system should have the capability to propose solutions to a present navigational situation based on historical data of hazards, risk assessment, and prior working solutions.
User interface	The user interface and working manner of the system should meet the standards for navigational information systems (ex. ECDIS, ARPA, AIS). Also, the presentation of information should comply with navigational standards and guidelines The user interface should be as simple as possible in order to prevent information overload – only the basic information should be presented, detailed information should be available on demand.
Data transmission	Information should be certified with use of digital signatures associated to individual users (account). The transmission of information should be encrypted to maintain integrity.
Client module	The ESABALT terminal should be a software program installed on a computer or an application within a mobile device. The system should also be available using a thin client (accessible via web browser).
Norms and standards	The system shall be aligned with: - (IEC 60945) - (IEC 62388) - (IEC 62288)
Other technical guidelines	ESABALT should complement and not compete with the existing ship systems. The system should display Virtual Aids to Navigation. A user manual and context help should be developed.

The full list of system requirements provide guidelines for next stages of system design. The results of web survey gave the opinion of potential users. The analysis of existing systems and R&D projects gave the overview of the solutions used in maritime systems. The of domain driven requirements showed the law guidelines that the projected system should fulfil. And finally, the interview with specialists in navigation and computer science gave the requirements for internal system architecture.

5 CONCLUSIONS

In this paper the research results of identifying and analyzing key requirements for the ESABALT system based on pre-defined user profile groups was presented. The multiple sources for requirements identification ware used: electronic survey for potential users of the system, interviews with experts in navigation, law and computer science, analysis of state-of-the-art in maritime safety procedures, and study of past R&D projects in this field. All found requirements ware classified into user, domain and system levels what should provide easier interpretation while the system architecture and its functional specifications will be designed.

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