The use of Bluetooth Beacons in Maritime Emergencies

Mobile safety and security - DigLogs pilot project by University of Trieste

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Abstract— **The aim of this paper is to research and describe how the use of mobile technologies can help in reducing the time required for the ship evacuation and abandonment procedures, as it was identified within the scope of 2014 - 2020 Interreg V-A Italy - Croatia CBC Programme "Digitalising Logistics processes – DIGLOGS" project. Furthermore, main findings and opportunities for proving technical feasibility will be identified and presented along with a carefully selected and envisaged test scenario chosen to compare the standard evacuation time with the one related to the adoption of the mobile technologies, the final goal being the streamlined evacuation procedures, and the increase of the ship's security and target group stakeholders' satisfaction.**

Keywords: ***ship security and safety; maritime emergencies; ship evacuation; mobile application; Bluetooth beacons; DigLogs project***

I. INTRODUCTION

2014-2020 Interreg V-A Italy - Croatia CBC Programme Digitalising Logistics processes - DIGLOGS project aims to create the necessary concepts, technological solutions, models and plans to establish the most advanced digitalized logistic processes for multimodal freight transport and passengers' services in the Programme Area. This requires coordination among players supporting networking activities and overcoming barriers and constraints. Among possible constraints, the digital ones are the most urgent to be faced [1-2]. The integration of digital tools supports the collection and analyses of data and smooth decision-making processes [3]. To this end, the DIGLOGS project includes seven pilot projects affecting both the passenger and freight sector.

Among the others, the pilot project carried out by the University of Trieste (UNITS) is hereinafter discussed. In detail, the main project goal is to assess the effectiveness of the application of mobile technologies to enhance safety and security on passenger vessels, which has been proven to be a very critical aspect [4]. The UNITS pilot project will be mainly focused on ship evacuation, which is a very complex and critical operation [5] during the ship design [6-8] and even more in the operative environment, when it could be strongly affected by the emergency scenarios [7]. In fact, as a consequence of a fire or flooding emergency, ship abandonment could be required [10]. The spread of fire [11] and floodwater [12-13] can be simulated onboard to provide decision support to the crew, however, only limited passengers guidance means are available and an experimental test involving mobile devices is lacking [14].

Such a test can foster the deployment of mobile technologies for onboard safety and security purposes in the long term. The achievement of a reduction of the evacuation time is essential to raise the interest of shipping companies and, thus, to enable further development of the solutions tested during the pilot action. Besides, the experience gained during the pilot, from a technical point of view is expected to ease the development of onboard positioning systems and their scalability. Furthermore, reliable onboard localization service may enable the development of more complex solutions compared to the pilot one. Additional tools are already foreseen to increase the ship safety and security, ranging from the access to restricted area control to the persons tracking in case of onboard infections, passing through the enhancement of crew situational awareness and the improvement of communication/data collection during an emergency. Besides, localization can be extremely useful for commercial purposes too. The development of combined systems (also including the commercial functionalities) can, even more, encourage the application of mobile technologies for safety/security, fostering their development and widespread diffusion.

Focusing on the UNITS pilot project, a mobile guidance system will be developed and tested aiming to reduce the evacuation time on passenger vessels in a real emergency scenario. The system will be composed by an application (APP) to be installed on mobile devices and a backend program capable to collect data from mobile devices for monitoring and analysis purposes. The APP will exploit Bluetooth beacons [15] to locate the users inside ship public spaces and thus guide them to the ship muster stations through the shortest route while considering the available escape routes, which could be blocked due to fire, flooding or overcrowding. As mentioned, the pilot scope is to measure the benefits coming from the adoption of mobile technologies to enhance ship safety in terms of reduction of the evacuation time. To this end, an experimental campaign will be performed in a real environment consisting of a passenger vessel. The present work presents the methodology, the selected test environment and the expected outcomes of the UNITS pilot project, which is currently still in a preparatory phase.

II. PROJECT PREPARATIONS AND METHODOLOGY

Aiming to fulfil the pilot project objectives, it is necessary to design the technical specifications of the system that will be adopted during the experimental campaign. The technical specification will be the base for a tendering procedure devoted to developing services provider selection. In the following, the key points of the tender technical specification are summarized.

As mentioned, the system, which will be the durable output of the pilot project, will be composed of two applications: the APP and the backend. The APP will be developed for the Android environment and installed on 30 mobile devices (smartphones/smartwatches) and will perform the device positioning based on a Bluetooth beacons net. In detail, based on the signal intensity of three or more beacons, the APP will triangulate the position of the device within the test environment. The backend application will be installed on a Windows 10 laptop and will show and record the localization data and perform some basic analysis including import/export functionalities. The communication between the Backend and the mobile devices equipped with the APP will be assured by the ship Wi-Fi, provided that the solution will be proved to be feasible in the test environment.

The pilot system will be required to operate in two modes:

1. Standard: normal condition, the APP locates the user.
2. Emergency: the APP guides the user to the muster station through the shortest escape route.

In both modes, the APP transmits the device position to the Backend, which shows the location of the connected devices on the ship general arrangement. Both the APP and the Backend will record the data in a log file. The function mode will be selected using the backend application and automatically transmitted to all connected devices. Schematic view of the pilot and its components is shown in Figure 1.

Figure 1: Schematic view of the pilot arrangement and communication between components

In the selected test environment, multiple escape route scenarios will be prepared. They will include design conditions (all escape routes available) and additional scenarios, where one or more paths are blocked. Using the backend, the active scenario will be selected to consider the actual condition of rooms, corridors or staircases that might be blocked by fire, water or smoke [16]. The selection of the actual scenario will be automatically transmitted to the mobile devices where the APP is installed. This basic solution has been considered satisfactory to fulfil the pilot project objectives and can be easily improved by adding an automatic generation of the escape route scenarios after pilot completion. Based on the active escape route scenarios, the APP shall provide guidance information to the user.

Identified pilot project prerequisites are:

1. Selection of a proper test environment (limited area of a passenger ship),
2. Selection of a developing service provider to design and develop the APP and the Backend,
3. Installation of a beacon net in the test environment to enable localization,
4. Installation of the APP on test mobile devices, and
5. Installation of the Backend on a laptop.

III. DESIGN, DEVELOPMENT AND PILOT ENVIRONMENT

Detailed pilot design will be performed by the developing service provider selected with the already mentioned tendering procedure. The design shall satisfy the technical specification and it is subject to UNITS approval. In particular, the developing team will be in charge of defining:

a) The type of mobile devices (smartphone/smartwatch/both);
b) The system architecture, including the application's breakdown into modules;
c) The communication protocols between the APP and the backend;

d) The data logging functionalities, including a dedicated database, if required;
e) The localization algorithm, which shall ensure a 0.5 m maximum error;
f) The guidance mode, which shall be as user friendly as possible considering the chosen device type and might be combined including video, audio and/or device vibration;
g) The installation and testing procedures;
h) The procedures to optimize Bluetooth beacons position to enable accurate localization within the test environment.

The pilot project will be divided into four main tasks:

1. T1 After the detailed design of the system has been agreed with the developer, the planning of the experimental campaign will be carried out;
2. T2 System developer: in this phase, the system (APP and Backend) will be developed and tested in-house by the developer. The guidelines for the deployment of the beacon net will be also defined;
3. T3 Configuration and testing: in this phase, the system will be installed and configured in the test environment. In particular, the location of the Bluetooth beacons will be optimized to assure accurate localization of mobile devices; and
4. T4 Experimental campaign: in this phase, the system will be tested with a small sample population. Then the experimental data will be analyzed to finalize pilot project outcomes.

The pilot application will be tested on a medium-size passenger ferry which is currently under construction at Visentini shipyard in Porto Viro. UNITS will sign an agreement with the shipyard, which will put the ship and its Wi-Fi network at disposal free of charge l. The ship is 203 m long overall, has 151 passenger cabins and 32 crew cabins on four decks, and can carry 400-1000 passengers depending on the length of the voyage, along with 260 cars. A sample of similar sized ROROPAX vessel is shown in Figure 2.

Figure 2: Comparable medium sized ROROPAX vessel

UNITS will select a development service provider through the tendering procedure. The developer will be also in charge to provide all the required hardware to carry out the experimental campaign in the test environment, including the beacons and the mobile devices where the application will be installed.

IV. DISCUSSION OF THE EXPECTED RESULTS

The test environment shown in Figure 3. will be limited to the two main corridors on Deck 6, the ship main lounge on Deck 7 and the three staircases connecting the two decks. The area has been selected as a test environment since the presence of multiple staircases makes it easy to define alternative evacuation routes from cabins (start point) to the main lounge (assembly point). Hence, by blocking one or more staircases, it will be possible to test the effectiveness of mobile technology in guiding persons along available escape routes during the evacuation.

Figure 3: Test environment for experimental campaign

All areas within the selected test environment will be properly fitted with Bluetooth beacons to cover all the spaces with the signal from at least three devices. This should enable the localization of mobile devices in the test area. The location of beacons will be optimized to ensure good localization accuracy.

During the experimental campaign, the backend program will run on the laptop connected to the ship Wi-Fi network to monitor and record the mobile devices' positioning data, switch evacuation scenario and start/stop emergency mode. The APP will be installed on 30 smartphones and/or smartwatches to carry out the experimental campaign. The experimental campaign will include evacuation trials performed with a small sample population. The experimental campaign will be carried out in 1-2 days at Visentini shipyard (Porto Viro), where the ship is currently under construction or at Arsenale San Marco (Trieste), where the hull maintenance will be performed after launching. UNITS personnel will be flanked by the developer's personnel during the experimental tests to prevent/correct any possible technical issues. The experimental campaign aims to prove the efficiency of the deployed technology in reducing the evacuation time. To this end, the sample population will first perform the standard safety training regarding evacuation procedures in the test environment [3]. Then, multiple evacuation trials will be performed and recorded starting from cabins' corridors (Deck 7) to the main lounge (Deck 6), which

is the muster station for the applicable evacuation zone. The trials will include multiple scenarios, where one or more staircases are blocked and cannot be used by the passengers. Trials will be performed with and without the active mobile APP guidance in order to measure the evacuation time reduction obtained by deploying the mobile technology. The scenarios will be randomly scheduled to prevent persons from knowing available escape routes at the beginning of each evacuation trial.

Due to the expected small scale of the pilot project, some limitations are envisaged. In detail, the experimental campaign involving a small sample population will be carried out in a limited area of a passenger vessel. This can be sufficient to reach the project goal (check technical feasibility and measure the evacuation time) which is the most important prerequisite to enable widespread adoption of the tested technology. Due to the limited area and the limited number of users, the APP and the Backend could require to be scaled and applied in wider environments. Besides, during the pilot, the ship Wi-Fi will be utilized to enable the communication between the APP and the backend. In a real application, this solution would be viable provided that the Wi-Fi is powered by the emergency grid. Otherwise, it would be necessary to adopt other connection means (or to adapt existing) to assure the functionality during an emergency. If the pilot project will succeed, these issues will be addressed and the installation in all common spaces of several passenger vessels is already envisaged.

V. CONCLUSIONS

The EU has been focused on the digitalization and cross-border regional cooperation as means of closing the technological gap in identified geographical areas. Interreg DigLogs project has been identified as a funding source to close the digital gap posed by a lack of a modern streamlined digital system used to enhance ship safety and security procedures by utilization of widely available low energy protocols.

Localization data can also be useful during normal operation, e.g. for early detection of unauthorized access to restricted areas, allowing fast reaction of the onboard security team. Moreover, in case of onboard infections, the localization records, normally not accessible to protect passengers' privacy, could be put at disposal of medical officers. The movements of infected passengers can be analyzed to identify the persons that came in contact with them, of course without storing the personal data for other purposes. Then, through the adoption of test and quarantine, it will be easier to contain the infection onboard. Finally, localization also can be useful for commercial purposes, such as allowing big data analysis, providing push notifications related to the passenger position and providing guidance onboard to reach the desired destinations, provided the consent from the passengers is obtained.

Before the development of this promising technology, the technical feasibility of a system based on Bluetooth beacons on a ship has to be proven. Besides, the effect on the evacuation time due to the usage of mobile technology should also be studied to prove the benefit of the system. For such a reason, a test on a small test population is required to compare the standard evacuation time with the one related to the adoption of mobile technology. This will be the main objective of the pilot action carried out by UNITS within the framework of the DigLogs project, contributing to more safe and secure shipping operations.

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