PARADA: Control Support System for Parades

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Abstract: The parade of "Festas in honor of Nossa Senhora D'Agonia", which is celebrated every year in the city of Viana do Castelo, it is one of the highlights of the traditional festival, that gathers hundreds of people in one giant parade throughout the city streets, this event attracts thousands of spectators. Due to its big dimension, it presents some difficulties regarding its organization. The lack of cohesion of the parade during its course is one of the issues observed that originates several and large empty spaces, which end up to discredit the parade. This paper presents the study the issue related with the Parade's organization/planning, by proposing a solution based on low-cost technologies. In this work we intend to study the problem of empty spaces, proposing a solution based on low cost technologies and evaluating the performance of this solution with its potential users. In this way, a process of collect information was initiated through the observation of the Parade, an interview with the organization and an inquiry of the collaborators and another one for the drivers. Based on the collected information, it is proposed a solution that uses smartphones to interconnect through a mobile application and also a web management application, in order to monitor the Parade and help in suppressing empty spaces. The proposal was evaluated to its potential users through a functional prototype. Usability and User Experience tests were performed and the results were promising. It is intended to validate the proposed solution in the field and extend the proposal to other Parade.

1 INTRODUCTION

Every year, in the city of Viana do Castelo, there is a parade of "Festas in honor of Nossa Senhora D'Agonia", with the goal of presenting to everyone the traditions of the city and the surrounding villages. The event gathers 3.000 participants and dozens of floats, in an extension of 2300 meters, throughout the streets of Viana do Castelo, where thousands of people watch this parade (Viana Festas, 2017).

The parade has been having a serious issue for several years regarding its extension, i.e., throughout the parade there are many empty spaces, resulting in several breaks of the cohesion and fluidity of the course. This study proposes to research about these issues by suggesting some solutions based on low cost technologies and evaluating the performance of this solution amongst its potential users.

On the literature searched it was not possible to find any kind of system that could solve this issue. Thus, information was collected by observing the parade of Sr.ª D'Agonia and by contacting with the staff, including the floats drivers and their collaborators, with the help of an interview and two queries. This process helped to identify the main difficulties which every person involved on the parade faces.

In order to project a solution based on the gathered information, a proposal was developed, named PARADA. The PARADA uses smartphones which interconnect through a mobile application for Android and iOS devices (APPARADA) and, also, a web management application, with the ability of monitoring the parade and helping the suppression of empty spaces.

Finally, a prototype was designed to be validated by its potential users, by simulating a micro parade. To evaluate the usability and users experience, regarding APPARADA and GESPARADA, there were used the SUS test – System Usability Scale and UEQ test – User Experience Questionnaire, respectively.

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2 RELATED WORK

The technological advances of smartphones, in terms of processing capacity, sensor integration and data communication, has motivated a massive use by users around the world. In particular, the fact that smartphones integrate different types of sensors, e.g., location, environmental variables, user activity, facilitate the acquisition of information about what surround us. Based on these data, it is possible to develop applications and provide services geared to user needs (Rafael, et al., 2016).

Conventional, low-cost GPS devices that are integrated in various devices, e.g. smartphones, have an error that, depending on the purpose of their use, may or may not meet the necessary requirements. In the case of the monitoring of the geographical position of vehicles, this error can be an obstacle to the safety of users. In order to increase location accuracy, even using non-professional GPS sensors, there are algorithm-based solutions that allow you to present more accurate data.

Han Kim propose an algorithm to increase the accuracy in positioning the data collected by a low-cost GPS sensor. This method uses the information collected by the GPS sensor associated with the vehicle in progress, places that data in a buffer and, after the buffer is complete, matches the vehicle's trajectory with a predefined map (Kim, et al., 2016). Based on the determined error, rotations and translations are applied to correct the trajectory of the vehicle.

Based on the location of the vehicles through the GPS coordinates and later calculation of their travel path, it is possible to monitor the traffic at a certain location. For this, it is only necessary to count vehicles and contextualize the route on a map. By knowing the number of vehicles that circulate in a certain street and adding the vehicles that follow the same route, it is possible to anticipate a forecast of the traffic.

What D'Andrea e Marcelloni presents is a system to detect congestion and traffic incidents, from GPS data collected in real time. This system aims to be an useful tool for countries and cities in the management of traffic density. Therefore, it uses the GPS sensors present in vehicles and mobile devices to acquire the necessary data for the system, e.g., smartphones or tablets (D'Ándrea and Marcelloni, 2017).

Adaptative Cruise Control (ACC) is a system that keeps the speed of a vehicle constant and safe for the user, taking into account the distance of the vehicle in front of you. This system uses "LiDAR" (Light Detection And Ranging) sensors to measure distance and cause accelerations and decelerations as needed (Noei, et al., 2016). However, the response of the sensors to the changes has a large delay. In addition, they are also susceptible to interference from the environment, e.g., in the case of vegetation, their physiognomy may induce the result of the reflection in error. A solution to increase the response speed of the ACC system is to use wireless communication between vehicles-to-vehicles (V2V) and vehicles-to-infrastructures (V2I) (Noei, et al., 2016). This paradigm is called the Cooperative Adaptive Cruise Control (CACC). Considering, then, the scheme in Figure 1 composed of three vehicles, a leader and two precedents: each vehicle sends via V2V communications its current state that includes its position, speed and acceleration or deceleration. This same data is received by other vehicles traveling in the same range (Noei, et al., 2016).

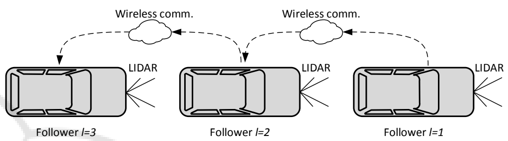

Figure 1: Representation of CACC system based in (Noei, et al., 2016).

However, as it happens with the GPS signal, both are susceptible to electronic interference. These interferences may arise from natural causes, e.g., electromagnetic noise or, hence, structured attacks by hackers (Carson, et al., 2016). To keep the system robust, both systems should be used together, i.e. "Drive" sensors for distance control and V2V or V2I communication to increase the speed response.

3 METHODOLOGY

The parade of Sr. ª D'Agonia is organized by sections, in which each section is composed of participants and/or floats (*Carros Alegóricos*). During the parade the distance between the sections should be considered uniform, for example, between the participants and the float of section 1 and section 2 there should be a range of 10 meters. An empty space happens when this distance is not respected and does not allow the spectacle to be able to see two consecutive sections in a row, as Figure 2 shows. Thus, a break in the flow of the parade is generated.

During the parade there are people, called collaborators and organizers, who are responsible for keeping the parade together and organized, avoiding the existence of empty spaces. These people are

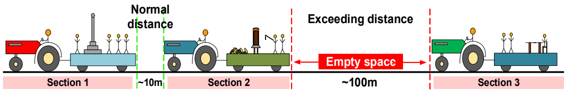

Figure 2: Representation of a parade end the empty space issue.

distributed throughout the length of the parade and they help to keep its flow, from beginning to end, in order to keep it as constant as possible. The floats' drivers, by driving vehicles with low acceleration, play an important role in the cohesion of the parade, due to limiting its progress and consequently its flow.

3.1 Observation and Analysis of 2017 Parade

Observing the parade allows, in addition to establishing the problems that cause empty spaces, to have a realistic overview of the whole process in order to develop a proposal for an effective solution. The point of observation in the parade that took most interest was the southern top of Avenida dos Combatentes. This location allows you to observe the parade along the avenue (from a south to north perspective), in the curve at the bottom of the avenue and following the Gil Eanes (west), which are points where is more troublesome.

During the analysis of the flow of the 2017 Parade, at the chosen point, information was collected about stops, particularly their duration, and photographs, which depicted breaks or empty spaces.

In Figure 3 it is possible to verify a distance between two sections that begins to be noticeable. At this point it is known that there is a separation of about 30 meters and, if the horses move faster or the tractor advances more slowly, an empty space is created. In the case of a curve, it is known that the public at the knee of the curve, either on the side of the avenue (right side of the figure) or on the side of Gil Eanes (left side of the figure), cannot have visual perception in order to observe the parade in a long

Figure 3: 2017 evidence of large distance between two sections of the parade.

stretch, as can be seen in the photograph. At this moment a subliminal idea is transmitted to the audience that the parade may have ended.

3.2 Requirements Assessment

The current panorama of the Parade, regarding the problem of empty spaces, was obtained using the observation of the 2017 Parade, as presented in the previous point, and an interview with the person in charge of planning and organizing the Parade, Hermenegildo Viana. With this interview, we verified the methodology that has been implemented in order to minimize this problem. Hermenegildo says that when there are empty spaces throughout the parade, it is communicated through a radio system. However, due to the city's geography and architecture, this system becomes obsolete and only works properly in straight line. This way, it would be ideal if there was a possibility to avoid this problem or to be able to readjust it. In order to do this, the front of the Parade would have to be informed of the existence of the various spaces, as well as the collaborators themselves, who, with this knowledge, would be able to fill the empty areas.

Groups of people who have a direct connection to the problem of empty spaces in the Parade, in order to identify and minimize them in real time, are the organizers, collaborators and drivers. In order to collect information from the collaborators and drivers, it was decided to carry out a survey for each group instead of an interview. Due to similar tasks performed by organizers and collaborators, only the collaborators were questioned.

The survey directed to collaborators consists of four parts, the first part of which is intended to characterize the sample, and the next three focus on aspects of the parade. Regarding the characterization of the participants, six questions were defined: age, gender, number of collaborators, which area of the parade was responsible, whether the mobile phone is used and which operating system the mobile phone performs. In terms of the three parts related to the parade, the first part of the question was about the problems that occur in the parade and what are the main difficulties. Then, in the second part, eleven statements were asked about the degree of agreement on a 7-level Likert scale, and finally the third part questioned the type of information that a system should provide to drivers, collaborators and organizers, respectively.

The questionnaire for drivers is composed of three open-ended questions, where one intends to perceive the difficulties they face during the parade.

3.3 Requirements Analysis

The interview to the person in charge of the organization and the surveys to collaborators and drivers were based on the 2017 Parade.

In the case of collaborators, a total of 43 participants in the 2017 parade, 20 were randomly selected. All of them responded to the survey. The average age of the collaborators who responded was 49 years, being in the middle age group. 60% were female and 40% male. The responses obtained from the survey led to the following conclusions:

- They have experience as collaborators in the parade, around 90% have done so more than once;
- All have mobile phones, mostly with Android® system (70%), 20% refer to iOS®;
- The main difficulties affecting the flow of courtship are uncoordinated stops;
- They consider communication with the organization efficient, although between collaborators and floats' drivers it is ineffective;
- It is difficult to perceive the state of the parade in areas far from where they are;
- It is very important to have an application-based system that provides real-time information on the status of the parade to be sent to organizers, collaborators and drivers;
- It is very relevant, in terms of organization, to have a system that allows viewing the parade in real time;
- It is useful for an application to provide information to collaborators about the status of the parade, stops and allow contact with the organization;
- For drivers an application should convey information about stops and fluidity; however, because they should drive, they should only receive this information by collaborators;
- For the organization, an application must provide all the information useful to the parade, highlighting fluency, stops, information messages, among others.

In the case of the drivers' survey, of the 33 who participated in the 2017 parade, 14 were randomly selected, of whom 11 responded to the survey. The respondents were all males with an average age of 46 years. The responses obtained through the survey drivers, after a qualitative analysis, allowed to draw the following conclusions:

- The main difficulties found during the parade by the drivers are related to the disrespect by the public about the circulation of floats and the improper stops in places such as the avenue.
- As to the classification of communication among the participants, one of the problems is related to the fact that the information that the collaborators/ organization pass on to the drivers are contradictory to each other.
- Regarding the possibility of a system that helps the organization is said to be useful, especially for collaborators and organization.

3.4 Definition of Requirements

The information obtained from the members of the parade, namely the Organization, Collaborators and Drivers allowed, after processing the data, to draw conclusions about the main needs that an auxiliary system to the parade's organization should respond to. Based on this information, the following requirements were defined:

- Allow real-time communication between collaborators, organizers and drivers;
- Receive / send information in real time about events related to the parade (stoppages, breaks, participants, among others);
- Make it possible to display the status of the parade in real time at any point in the route on a map (mainly for the organization);
- Transmit information to drivers about stoppages and the fluidity of the parade.

3.5 Proposal for a Solution

The main requirement on which the whole solution proposal is based is related to the need for interconnection of Organizers, Collaborators and Drivers. It is essential that the system is networked and allows the exchange of information in real time between these elements. It should also enable the organization to visualize, in real time, the status of the Parade and allow its monitoring.

After a first approach to the problem, smartphones presented themselves as a tool with the ideal capabilities to integrate the proposed solution. In addition to its network connectivity capabilities, it is possible to develop applications and the incorporation of several sensors.

The proposed solution to solve the problem of empty spaces, shown in Figure 4, supposes the use of a smartphone by Organizers, Collaborators and

Drivers, on which a certain application is executed. This application provides relevant information about the Parade, in real time, according to the type of user, i.e. Organizer, Collaborator and Driver. It also enables communication between Collaborators and Organizers.

Moreover, it proposes a web application (optimized for computers) for the Organization that does not accompany the Parade on the ground.

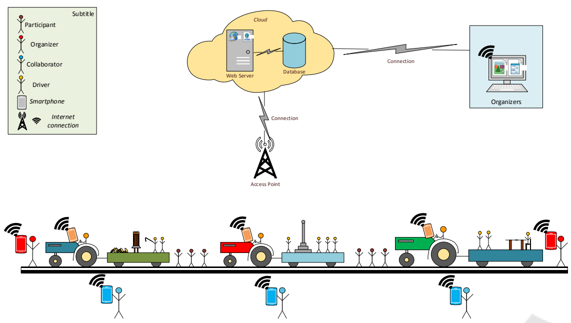

Figure 4: Schema of the proposed solution.

4 PARADA

The PARADA is composed by a mobile application, APPARADA, which has an interface adaptive to the type of user and by a management Web application, GESPARADA, which incorporates a set of functions for configuration and organization of the Procession.

The characteristics of the architecture of PARADA presuppose the creation of a set of heterogeneous applications to access at the same back-end, i.e., database and computational logic. It was decided, due to integration issues, to provide all the functions of operation with this backend, through a layer of services. This way, it is possible to create a level of abstraction large enough to be easier to implement applications on several platforms, extend or add components or new operations to these applications in a relatively simple way. It should be noted that because some of these operations are security-sensitive, security solutions have been implemented over these services.

The RESTful architecture, Figure 6, was used to allow access to resources through URIs (addresses) and to use the HTTP protocol, namely the GET, POST, PUT and DELETE verbs, to perform operations. The data exchange is done in JSON notation. The storage of this data is done using a MongoDB database, type NoSQL, which stores them in the same format. This data model substantially facilitates the implementation and use of CRUD (Create, Read, Update, Delete) services as it does not require conversions.

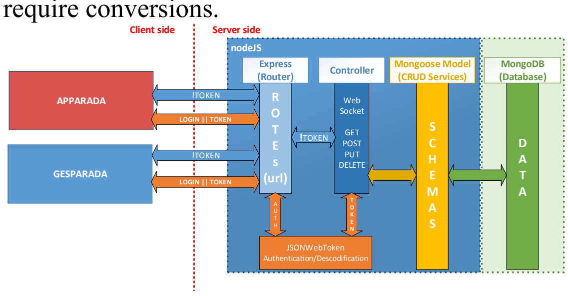

Figure 5: Architecture of the proposed solution.

4.1 GESPARADA

GESPARADA is a web application, with an interface adapted to the theme Ace Admin®, supported by the RESTful architecture that allows the user to define, configure and monitor the Process. Each page responds to at least one requirement, e.g., viewing parade status in real time. Only Organizer users have access to all features. This system was developed to be generalist, i.e. support the management of several parades and for each of them it is possible to associate floats, their drivers and collaborators. It can be divided into three parts for a better understanding:

- Creation of the Parade (and floats and users).
- Parade Setup:
    - Allocation of floats;
    - The Association of Floats to drivers;
    - Association of collaborators and organizers.
- Parade Monitoring:
    - See the parade in real-time on a map;
    - Send / receive information messages.

4.2 APPARADA

The mobile app, APPARADA, is intended for Android® and iOS® mobile phones. This requirement was one of the conclusions of the collaborators survey since, based on the answers, collaborators were using smartphones with both systems. In order to facilitate the development of the application, a study was made on hybrid development platforms that support both systems (Latif, et al., 2017) (Martinez and Lecomte, 2017) (Biswas, et al., 2013). It was decided, based onthe development capabilities, support for both systems and the documentation available, for a development with React Native. React Native allows you to develop the application for smartphones using JavaScript and the React architecture. This tool enables the creation of applications that use real components as if they were programmed in Objective-C / Swift or Java.

The APPARADA is used in two strands, the first focuses on the acquisition of data and the second on the presentation of data. It can be summarized in the following functionalities:

- Monitor the GPS position (drivers using APPARADA send their geographic position to the server).
- Monitor the Parade (based on the geographic position, it is shown to drivers, collaborators and organizers the distance between floats, namely for what follows immediately in front of and behind).
- View of the Parade on a map (any user can see the geographic position of the floats on a map).

The user, when opening the application, may choose to see the parade on the map, which does not require authentication, or else, being a Driver, Collaborator or Organizer, can authenticate and access the other functions dedicated to monitoring the Parade.

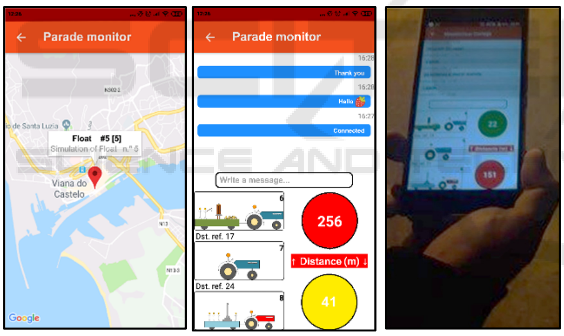

Figure 6: The main interface of the APPARADA.

GPS position monitoring is a feature of the mobile application that is only available to Driver type users. This feature supports the parade monitoring because it is based on the GPS coordinates acquired that the distance calculations are carried out, through the Distance Matrix API of Google Maps, between Floats and what you can see of the parade on a map.

In this case, the Driver type user, after authentication, is identified in GESPARADA as the driver of a particular float. From that moment, it starts to acquire GPS coordinates of the place where it is and sends them remotely. In response, the distance in meters from the float that follows in front of you is shown on the screen as shown in Figure 7.

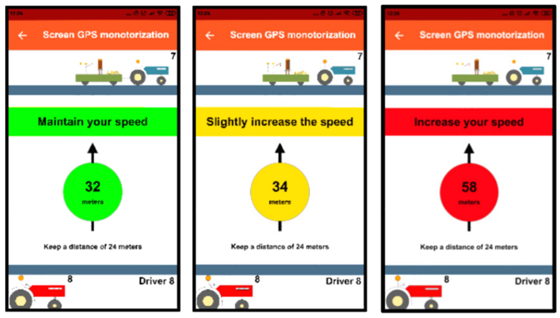

Figure 7: The interface for the Drivers user.

Inside the red circle of Figure 7 written the current distance that the car 7 has towards the car 6. At the bottom appears a message indicating which distance should be maintained, in this case 24 meters. At the top (after the arrow) messages are generated with suggestions that help the driver make a decision. Both the circle and the rectangle with suggestions change colour according to whether or not the distance to the car that follows is met. In particular, this functionality is sensitive to both positive and negative distances, i.e. if the Driver is at a lower distance than the recommended (reference) distance it is suggested to slow down. If you are at a greater distance than recommended, you are advised to increase the speed.

Finally, it should be noted that this functionality should not interfere with driving, so the interface is only expositive. In the case of the interface (Figure 7 – middle image) for the Collaborators or Organizers the aspect changes slightly since the use of a chat is already foreseen for sending and receiving information.

5 TESTS AND RESULTS

A test scenario was created for the solution proposal, in order to obtain information on the Usability of the System and on the User Experience.

Twelve volunteers gathered in Viana do Castelo to walk a portion of the parade of Sr. ª D'Agonia on foot from the start (next to the Eiffel bridge) to the end of the avenue using the mobile application. Eight of the volunteers have already participated in the parade as participants and one of them has already collaborated. The rest were spectators only. The system's functionalities were explained and assignments were assigned to each one.

Thus, of the twelve people, seven took the position of user of the type driver and four of the type Collaborator, using APPARADA. The rest was an organizer and used the GESPARADA. In order to evaluate the PARADA on the part of the participants, the System Usability Scale (Brooke and others, 1996) and UEQ - User Experience Questionnaire (Cota, et al., 2014) were used.

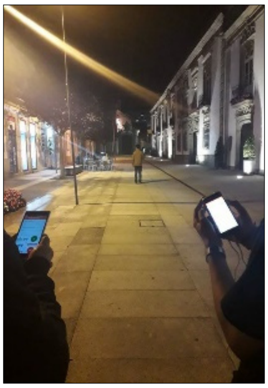

Figure 8: Photograph collected during the conducted test.

5.1 System Usability Scale (SUS)

In this case, the SUS test was used with a 5-level Likert scale, from totally disagreeing to fully agreeing. The PARADA Score resulting from the evaluation, based on the responses to the SUS survey, is 69.4. The SUS Score predicts a ranking above the average for values greater than 68. Thus, PARADA is considered good in terms of usability (Bangor et al., 2009).

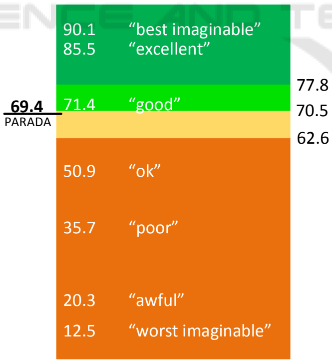

Figure 9: SUS evaluation score levels.

5.2 User Experience Questionnaire (UEQ)

To classify the PARADA through the UEQ test, the Portuguese version (Cota, et al., 2014) was used with a questionnaire composed of twenty-six items grouped into six characteristics. In the graphic of Figure 10 it is possible to see the classification of the application, based on the obtained answers.

In this evaluation it is possible to verify that the efficiency has a level almost below the average that is identified with the failures in the acquisition of the GPS coordinates. Moreover, at the interface level all functions performed without any problem, both at the level of APPARADA and at the level of GESPARADA.

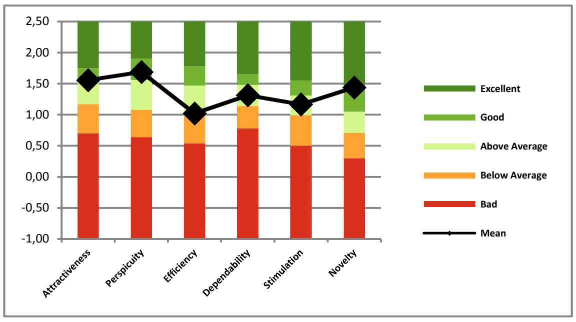

Figure 10: UEQ evaluation graphic.

6 CONCLUSIONS

The proposed solution, known as PARADA, has the main goal of helping the organization of the parade and its organizers, Drivers and collaborators, to carry out their tasks in a more assertive and easy way.

Drivers, using APPARADA, can consult the mobile application to check if they are complying with the distance between vehicles. At the same time, Collaborators can control this distance and receive or send information to other Collaborators and Organization through a chat. With this communication model it is possible, at any point in the parade, to have the information exchanged in real time. This factor is crucial to keep the parade orderly and also to give a quick response when unforeseen events occur. In addition, the application allows you to see the positioning of all Floats on the map, including the description of each one, which also allows anyone to identify the float and where it is.

At GESPARADA, the organization has at its disposal a detailed information panel on each float, including a map with the positioning along the route. With this information it is possible that the organizers anticipate possible empty spaces even before they happen.

Finally, it should be noticed that this system serves as support to the organizers and not as a complete automation substitute of the human component of the organization, as the event has a huge complexity and there is vast amount of existing distributed knowledge that will be bewildering to model. Thus, the intended developed system -

PARADA should be used to support decision making regarding control and coordination, i.e. as a control support system.

This work was always developed with close proximity to the users, and a survey was carried out based on queries and an interview that allowed the identification of the main problems and the main expectations of the various collaborators. The developed system was tested, namely through the simulation of a mini parade, after which it was verified the fulfilment of the requirements of functionality as well as usability and user experience. The results are very promising, however, some interface situations have to be corrected, as well as to perfect any problems of precision in obtaining coordinates that, if they occur, can have a negative impact on the usefulness of the proposed solution.

The use of Bluetooth devices to improve position accuracy and robustness to GPS errors/faults is being considered in the future developments. Our intention is to validate the presented system by using it in a real parade (namely the Nossa Senhora D'Agonia Parade) and measuring the impact and its benefits with respect to the existing organizational model and tools.

REFERENCES

Biswas, A., Pilla, G. and Tamma, B. R., 2013. Microsegmenting: An approach for precise distance calculation for GPS based its applications. s.l., s.n., pp. 327-332.

Brooke, J. and others, 1996. SUS-A quick and dirty usability scale. *Usability evaluation in industry, Volume 189, pp. 4-7.*

Bangor, A., Kortum, P., and Miller, J., 2009. Determining what individual SUS scores mean: adding an adjective rating scale. *J. Usability Studies 4 (3), 114-123.*

Carson, N., Martin, S. M., Starling, J. and Bevly, D. M., 2016. GPS spoofing detection and mitigation using Cooperative Adaptive Cruise Control system. s.l., s.n., pp. 1091-1096.

Cota, M. P., Thomaschewski, J., Schrepp, M. and Gonçalves, R., 2014. Efficient measurement of the user experience. A Portuguese version. *Procedia Computer Science, Volume 27, pp. 491-498.*

D'Ándrea, E. and Marcelloni, F., 2017. Detection of traffic congestion and incidents from GPS trace analysis. *Expert Systems with Applications, Volume 73, pp. 43-56.*

Kim, H. S., Park, J. B. and Joo, Y. H., 2016. A position accuracy enhancement algorithm for a low-cost GPS receiver under distance boundary consideration. *2016 International Conference on Robotics and Automation Engineering (ICRAE), p. 83.*

Latif, M., Lakhrissi, Y., Es-Sbai, N. and Nfaoui, E. H., 2017. Review of mobile cross platform and research orientations. *(1) ERSI Laboratory, Sidi Mohamed Ben Abdelah University, s.n.*

Martinez, M. and Lecomte, S., 2017. Towards the quality improvement of cross-platform mobile applications. *2017 IEEE/ACM 4th International Conference on Mobile Software Engineering and Systems (MOBILESoft), p. 184.*

Noei, S., Sargolzaei, A., Abbaspour, A. and Yen, K., 2016. A Decision Support System for Improving Resiliency of Cooperative Adaptive Cruise Control Systems. *Procedia Computer Science, Volume 95, pp. 489-496.*

Rafael, P. T., César, T. H. and Hiram, G. Z., 2016. Full On-Device Stay Points Detection in Smartphones for Location-Based Mobile Applications. *Sensors, Vol 16, Iss 10, p 1693 (2016), p. 1693.*

Viana Festas, 2017. VianaFestas - Associação Promotora das Festas da Cidade de Viana do Castelo. [Online] Available at: http://www.vianafestas.com [Acedido em 08 julho 2018].