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Contributions to the improvement of emergency situation management by implementing an integrated system using mobile alerts

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INTRODUCTION

The purpose of this research is to design a mobile emergency system that uses the smartphone to announce emergencies. The system aims to reduce the rescue response, thus contributing to the reduction of deaths by providing two-way communication and ensuring equivalent access to all emergency services.

By developing an integrated emergency system, the individuals involved in an emergency situation can be helpful by rapidly transmitting critical information to emergency dispatches. Information is transmitted more quickly and clearly through text instead of verbal communication, which can be interrupted due to emotions, noises, or language barriers.

The **main goal of the developed system is to provide support in large emergency crisis where multiple alerts are sent from the same location** and the PSAP operator can deduce the extent of the event and act before things degenerate. The **system also provides support in sending silent notifications**. This functionality is especially useful for circumstances where sounds might endanger the safety of the caller, or in situations where the caller does not speak the language of the country in which he/she is located.

The system proposed for development consists of two parts: *a mobile application designed for victims* and *a web application designed for dispatchers*, and the main objective of the system is to provide complementary functionalities such as:

- the possibility to **request multidisciplinary help** simultaneously through a single notification;
- the possibility **of selecting the appropriate response provider according to the reported situation**;
- the possibility **of creating an alert within a short time with a concise textual description (predefined keywords)**;
- the possibility to **inform** PSAP operators about a **major event involving more than one person**, and/or for about events in which phone calls are ineffective to describe the extent of the event;
- the possibility of **creating silent emergency alerts** necessary in situations such as terrorist attacks, deprivation of liberty, etc., where a phone call could endanger the caller's security;
- collecting and sharing the user's personal details in a very short time.

The main purpose of this research is to support emergency mobile app developers. Thus, due to the literature analysis carried out in ***PART I - Current State of Emergency Communication Research****, the experience gained in* ***PART II - Theoretical Contributions Regarding the Development of a Mobile Emergency Systems***, the results obtained from the evaluation phase and from interviews with academic experts, several findings were highlighted to improve the design and functions needed to make the emergency mobile applications more efficient. Therefore, in ***PART III - Experimental Research and Case Studies on Mobile Emergency Communication Systems*** is presented the emergency alert system - SASU composed of an emergency mobile application for designed for victims and a web application designed for dispatchers. In order to understand the real usefulness

and the limitations it faces; the system has been analysed and tested with the goal to assess the benefits and disadvantages of using a mobile emergency system in a real environment.

After analysing the needs, the emergency alert system - SASU was developed. As a principle of use, in order to send an emergency alert via the victim's mobile app, the user must first log in to the mobile application, create an emergency notification, and then validate the notification.

As soon as the user has completed the previous steps, the alert created together with all the identification data and the user's location are sent to the database of emergency dispatches; the alert is then subsequently redirected to the nearest emergency dispatcher (PSAP). Thus, in the case of large-scale tragedies (e.g., fires, terrorist attacks), the response time of the authorities can be shortened by at least 1 minute. According to the research, the ideal duration of an emergency voice (call to the emergency number "112") is 30 to 40 seconds, while the average of a call exceeds 2 minutes in the case of tragedies [GHI19].

The results of the research reflect the need to develop an innovative integrated emergency management system at global level, indicating the necessary steps to be taken to improve the potential of digital emergency assistance solutions.

PART I - CURRENT STATE OF EMERGENCY COMMUNICATION RESEARCH

CHAPTER 1. General framework for emergency communication

According to Ordonnance No. 21 from 15 April 2004 regarding the National Emergency Management System, an emergency situation is an "exceptional, non-military event that threatens the life and health of the population, the environment, important material and cultural values, and in order to restore the state of normality it is necessary to adopt urgent measures and actions, the allocation of additional emergency-response resources" [OUG04].

The response time of the intervention teams is a major issue in the event of a disaster or large-scale accident. Therefore, to minimise the number of victims, but also for an easier post-disaster recovery, it is necessary to develop a modern solution to provide a quick and effective response to an emergency [MUS13]. The response of the intervention teams is closely linked to the information provided by the public during the emergency calls. Therefore, the communication with the emergency dispatcher is considered to be the most important part of the emergency response phase. Currently, PSAP is the only entity capable of obtaining accurate and useful information about the emergency event, but also of providing the necessary data for a prompt and efficient rescue response-time [MUS12].

Research and case studies on emergency-response demonstrate that the speed of response and interaction with rescue forces is crucial. Reducing the time from the onset of the incident to the rescuers' intervention is the most important feature.

CHAPTER 2. The current state of research on mobile emergency systems

The definition of an 'emergency' covers a multitude of critical situations, from events involving a single participant, such as health problems (e.g., heart attacks, strokes), murders, robberies, or threats of personal safety, to events involving more than one person, such as fires, road accidents, plane accidents, natural disasters, terrorist attacks or other similar situations.

A "smartphone" is defined as a multifunctional mobile phone with smart features similar to those of a computer. Thus, in addition to the basic functionalities of a regular phone, it offers different functionalities: Internet, e-mail, GPS navigation, computer, agenda, camera and video, music, games, dedicated mobile applications.

Connected to a GSM network and equipped with powerful processors, these devices incorporate a range of sensors (e.g.: compass, accelerometer, gyroscope, GPS, etc.) that allow them to run dedicated mobile applications for: physical activity, navigation, support, email, chat, games, etc. [BAT17].

For this reason, emergency authorities quickly realised that through mobile applications, PSAP dispatchers can quickly obtain additional details regarding an emergency event, such as the user's personal data, short description of the scene, images, recorded sounds or any other important information [WIN15].

2.1 Mobile applications for emergency communication

In recent years, emergency mobile applications have been mainly used in the transmission of alerts and emergency notifications. Thus, in the event of an imminent disaster, users receive notifications of what is going to happen through mobile apps. Moreover, in the event of a catastrophe, survivors can immediately transmit their condition (e.g., via Facebook Safety Care), providing real-time information to families and/or to rescue crews.

With the spread of state-of-the-art mobile devices equipped with cameras, microphones and a multitude of sensors capable of detecting movement, orientation or location of the user, the data collected can be used to find out what is happening in a particular place at a certain time and can also be used in real time for disaster communication and emergency response dispatch alert purposes. Thus, in order to improve post-disaster communication in crisis situations, several systems and mobile applications for emergency management have been developed.

Although the mobile app market is growing fast, mobile emergency solutions face significant barriers that prevent their improvement and adoption on a larger scale. These obstacles include:

- Low awareness of emergency mobile applications;
- Lack of regulations in the field;
- Lack of literature;
- Data privacy and security issues.

However, despite the current limitations, mobile emergency solutions have the major potential to improve the emergency management system. Future developments in the field include:

- defining international standards and regulations;
- integration of mobile solutions into the emergency system;
- promoting emergency mobile applications.

2.2. Critical analysis of existing emergency mobile applications on the market

In recent years, mobile emergency market is rapidly growing, and mobile emergency applications provide support to users in various situations such as road accidents, natural disasters, health problems, or dangerous circumstances. The results show that emergency mobile applications are excellent, providing accurate and accurate information to operators in PSAP dispatches [SKO17].

However, existing emergency mobile applications are only accessible in the region where they were created, which can discourage both citizens and competent authorities. According to the European Emergency Number Association (EENA), an emergency mobile application should be available throughout the entire European Union (EU). This is the main reason why EENA advocates that all emergency mobile applications operate in a standardised way across the EU and comply with a pan-European standard [CAS15].

The European Emergency Number Association (EENA) has started implementing a policy for emergency mobile applications: Pan-European Mobile Emergency Apps (PEMEA).

At present, several adjacent, non-accredited mobile platforms are available to support disaster and emergency-response teams. All of these platforms are specifically designed to support medium and long-term actions, especially in the context of natural disasters, where the response process can take several days or weeks.

Moreover, the agencies providing emergency services together with mobile app developers have worked hard to provide the necessary mobile solutions trying to preserve the features present on social networks. Currently, several mobile apps are available in the major mobile app stores to help people involved in disasters, as well as emergency services. It should be noted, however, that these applications are currently not accredited by emergency services.

2.3. Conclusions

In emergency situations, the information transmitted is the key to resolving the crisis, and the intervention of rescue teams. Emergency communications is a type of communication in which the information required by the PSAP is transmitted through both phone call and text messaging (SMS) communications services, or by using other types of communications such as video calls or real-time text applications.

The spread of smartphones is considered to be the biggest technological change, even when compared to the advent of the Internet. The multifunctionality of mobile devices allows users to fully configure their device to meet daily needs by adding different mobile applications. Recent studies by EENA show that mobile devices can be a powerful tool to facilitate emergency response, helping both citizens involved in an unpleasant event and rescue teams.

CHAPTER 3. Scientometric methods for literature review

The first concerns for the statistical analysis of scientific production arose in the first part of the 20th century, consisting of comparing the scientific productivity of different countries based on the number of published works.

The bibliographic data downloaded from the Web of Science database were analysed using VOS Viewer, a software program designed to construct and visualise bibliometric data. This data may include scientific journals, scientific research, or individual scientific publications [VOS1]. Thus, the

Web of Science database was downloaded as a.txt file, and then exported to VOS Viewer to get bibliographic connections. By analysing only the title and abstract of the 819 selected scientific papers, it can be seen that the most commonly used keywords are:

- Application;
- Technology;
- Paper;
- Device;
- Network;
- Service;
- Mobile device;
- Sensor;
- User

The density of keywords used in the title and abstract is shown in Figure 3.1 [ENF1].

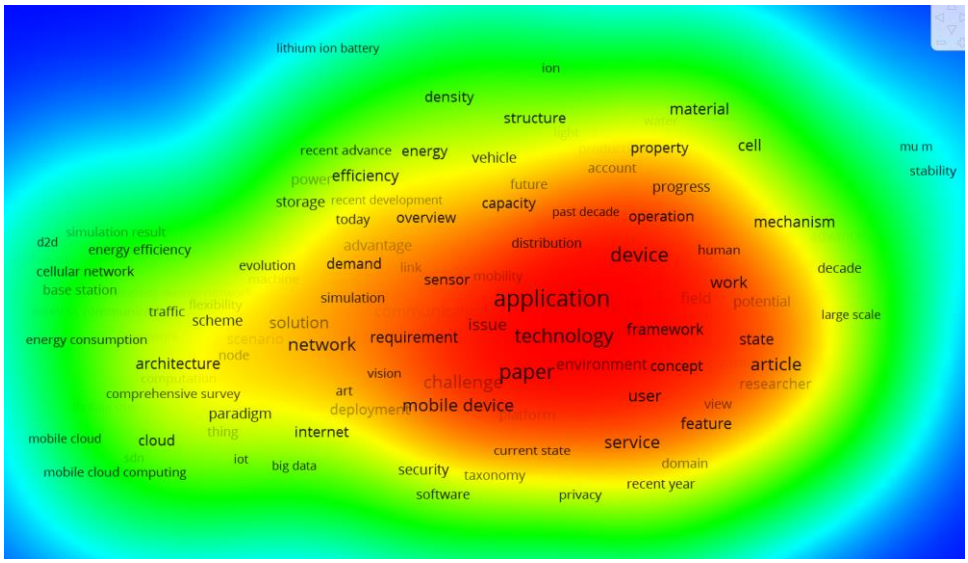

Figure 3.1: The density of keywords used in the title and abstract

Subsequently, in order to measure the impact of scientific publications on knowledge generation, a bibliometric research was carried out for the period 2008-2017. The method of researching literature in the fields of emergency situations, mobile technology, alerts and artificial intelligence was done by using search strategies based on Boolean operators [POW1].

Further, the most influential documents, the most cited, the collaborative networks created, and the intellectual structure used in the field of mobile emergency alerts have been identified.

The scientometric research aims to provide information about the authors and the most influential works, but also about the future development directions. The main questions to which an answer has been identified through this scientometric research are:

- What are the most influential documents in the field of mobile emergency alerts?

- What is the intellectual structure in the field of mobile emergency alerts and how has the field evolved?

CHAPTER 4. Objectives of the PhD Thesis

Critical analysis of existing emergency mobile applications reveals that mobile emergency alerts can reduce the total call time between an end-user and the operator in the emergency dispatch. Studies led by the European Emergency Number Association (EENA) have concluded that emergency-specific mobile applications are necessary and should operate in the same way as the phone call to "112". Moreover, the European Commission published a directive calling on all EU member states to guarantee an equivalent access to emergency services for all citizens. The research carried out reflects the need for innovation of the current emergency management system, indicating the steps to be taken [ECR16].

Thus, considering the scope of the research, the analysis of the fatal cases produced in the case of large-scale tragedies, the critical analysis of the research in the field and the existing technical solutions, the premises were created to build the theoretical bases and applied research studies in the field of mobile emergency management.

In accordance with the title of the doctoral thesis "Contributions to the improvement of emergency situation management by implementing an integrated system using mobile alerts", the general objective of this research is to **develop an innovative approach for emergency reporting using smartphones and improve the emergency communication in order to reduce the response time of rescue teams**, thus contributing to the reduction of deaths.

The Specific Objectives (SO) of the work are based on:

1. **OS1: Identifying the current state of research in the field**

   Following the study of the literature, the key points for improving the emergency management system were highlighted by implementing a mobile alert system. This involved the following research directions:

   - Consultation of definitions and general notions specific to emergency situations.
   - Analysis of human behaviour during crisis situations.
   - Consultation of definitions of emergency communications.
   - Analysis of methods used for communication during emergency situations.
   - Identification of the most relevant scientific papers in the field of mobile emergency communication published in the literature, as well as the most significant trends in the field through a scientometric analysis.
   - Analysis of the importance and the necessity of implementing an integrated mobile system to improve the emergency management system.

- **OS2: Critical analysis of existing solutions in the field of emergency communication**

In order to achieve this objective, the means of communication available in emergency situations have been assessed. For this purpose, the multicriteria analysis (MCA) has been used:

- Identification of alternative communication means used in emergency situations.
- Establishing the criteria for their comparison: eight criteria for comparison have been established.
- Determining the weights of each criterion.
- Classification of alternatives.

- **OS3: Critical analysis of existing mobile emergency systems and applications**

  After analysing the trends in the emergency management system, a critical analysis of existing emergency mobile applications was carried out on the market. Barriers and development potential have been identified.

- **OS4: Designing an integrated emergency and response alert system**

  To achieve this objective, the technical needs of the two applications were analysed: the emergency mobile application - designed to enable users to alert emergency dispatchers, and the web application - designed to enable PSAP operators to manage reported events.

  Subsequently, the use cases necessary for the implementation of such a system were defined and the use flow was defined for the two applications.

- **OS5: Development of the mobile emergency alert and response system - SASU**

  To achieve the experimental model, an integrated mobile system has been designed to reduce the intervention time of rescue teams:

  - an *emergency mobile application designed for victims* in various emergency situations requiring the intervention of rescue teams;
  - a *web application designed for dispatchers* in emergency centres that facilitate the analysis of emergency alerts sent by users via the mobile application.

- **OS6: Validation of the mobile emergency alert and response system - SASU**

  In order to achieve this objective, an emergency scenario has been established in advance. The experimental testing of the system took place between June and July 2022, at Transilvania University of Brașov in which 44 respondents participated.

  Testing the experimental model involved the following steps:

  - The emergency mobile application was installed on participants' phones.
  - After setting up the requested permissions, participants created a user account to use the mobile application.
  - Participants were presented with an emergency scenario: the fire alarm was triggered, and they were asked to alert the emergency dispatcher via the mobile app installed on their phones.

Subsequently, in order to assess the level of satisfaction among end-users, a satisfaction questionnaire was carried out on the two applications.

The systematic representation of specific objectives in relation to the chapters is presented in Figure 4.1.

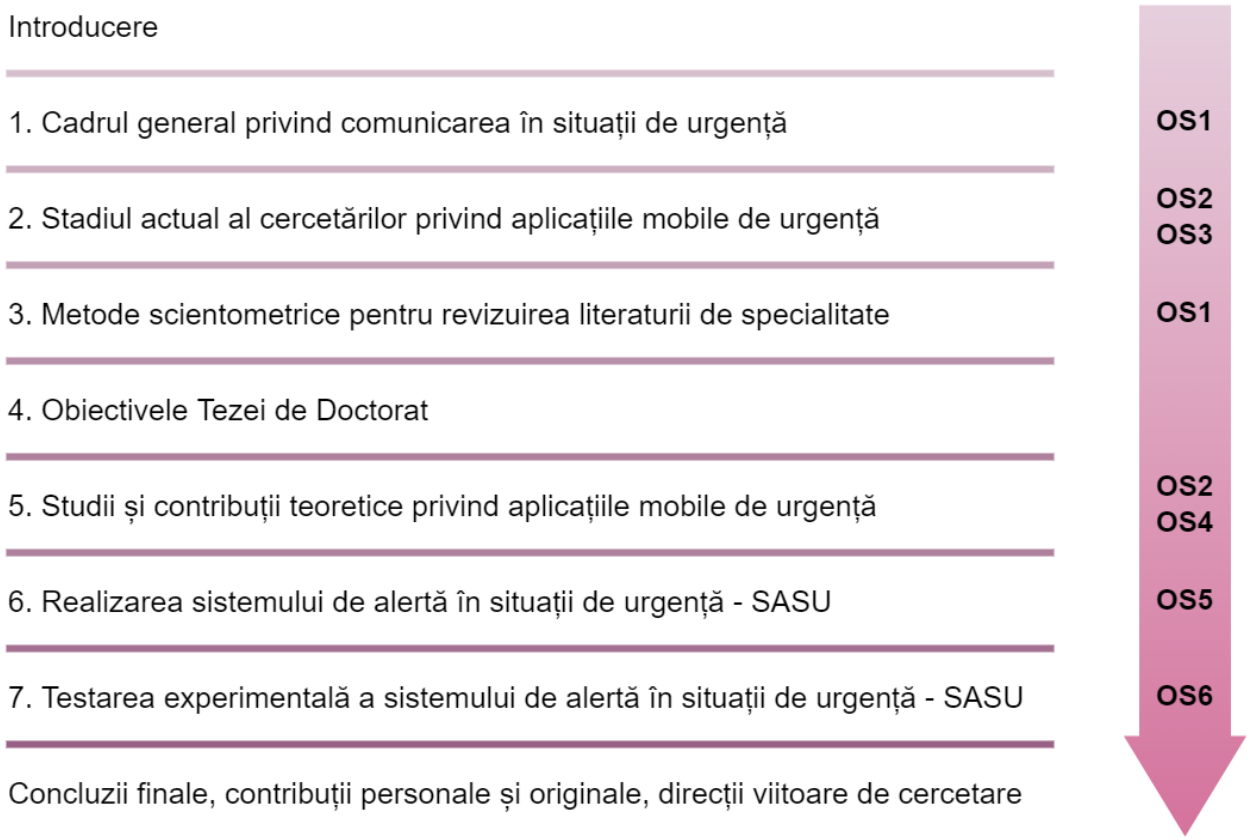

Figure 4.11: Logic of the doctoral thesis

PART II - THEORETICAL CONTRIBUTIONS REGARDING THE DEVELOPMENT OF A MOBILE EMERGENCY SYSTEMS

CHAPTER 5. Studies and theoretical contributions regarding the mobile emergency systems

Scientific studies demonstrate that developments in information and communication technology offer new opportunities for offering emergency response in a short time. When discussing emergency communication, state-of-the-art technologies facilitate the collaboration between law-enabled institutions to act in case of emergency in mitigating efforts, identifying potential risks and coordinating activities to alert the public about imminent disasters [FIS98].

5.1. Communication during emergency situations

PSAP operators often face errors and communication problems leading to mismatches. These misunderstandings between the caller and the emergency operator can prolong the intervention time and even lead to the loss of human lives [ITS10]. According to the authorities of the Single National Emergency Call System (SNUAU), the method of processing an emergency call is shown in Figure 5.1 [STS1].

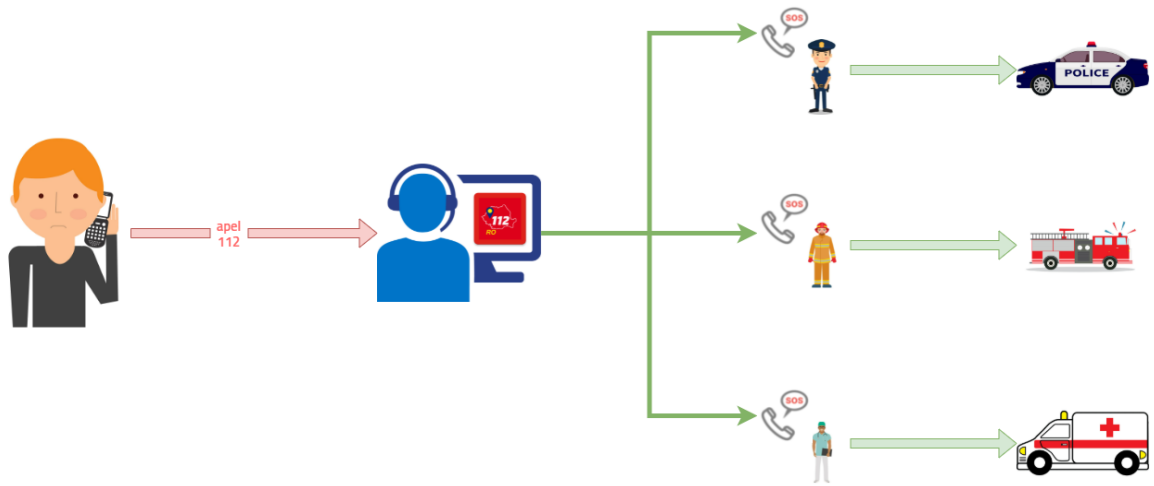

Figure 5.1: How is processed an emergency call

According to EENA, there are currently three ways in which citizens in danger can contact and send alerts to emergency call dispatches, often also called Public Safety Access Points (PSAPs) [VIV19]:

- Phone call to "112": available worldwide
- Emergency SMS: available only in certain states
- Mobile app: available only in certain states

In order to identify the optimal communication solution in emergency situations, Multicriterial Analysis (MCA) was used. The key element of the MCA is the selection of experts in the field analysed who must set the performance targets and criteria, estimate the relative weights of importance for each criterion, and determine the performance of each alternative according to each predefined criterion. The multicriteria analysis can be used to identify the best alternative, to classify selected solutions, or simply to determine the usefulness of the analysed solutions. The fundamental steps of the MCA are [DCL09] [BOB15]:

1. Identification of alternatives
2. Establishing the decision-making criteria
3. Determining the weights of each criterion
4. Classification of alternatives.

The three alternative solutions were examined and the characteristics of each solution as well as their comparison is illustrated in Table 5.1 [EENA2][LUM14][ECR20].

Table 5.1: Emergency alerts alternatives - comparison

Features		**Phone call**	**SMS**	**Mobile app**
Call time		5-10′	> 10′	5-10′
Call response time		~10′″	0′″	0′″
Time to obtain address details	Automatic	10-261′	-b	0′″
	Manual	30′ [a]	0′′ [c]	-
Location accuracy (automatically)		0.5-40 km	-	& 100 m
Time to obtain event description		30-278.	0′″	0′″
Total duration of the call		30-278.	0′″	0′″
Pre-registration of the user in the system		No	Yes [D]	Yes
Accessibility	All situations	Yes	Yes	Yes
	People with communication disabilities	No	Yes	Yes
	Silent emergency situations	No	Yes	Yes

[a] *Time can be extended by about 3 minutes depending on the situation*
[B] *Not available in most cases*
[C] *Available only if the user provides the information in the text message*
[D] *Obligatory only in certain regions*

Eight criteria have been established for the assessment of the identified alternatives:

A. Cost of manufacturing and maintenance

B. Utility

C. Quantity of information

D. Accuracy of information

E. Usefulness of information

F. User perception

G. Ease of use

H. Response time

To quantify the criteria weights, the specialists established the importance of each criterion and then calculated the weighting coefficients. The table illustrated in Table 5.2 contains three additional columns:

- p: the total number of points obtained by each criterion;
- hierarchy: the hierarchy level of each criterion;
- Yi: weighting coefficients calculation.

Table 5.2: Criteria weightings calculated with FRISCO formula

	A	B	C	D	E	F	G	H	p	lerarhie	γ_i
A	**0.5**	0	0	0	0	0	0.5	0	1	8	0.17
B	1	**0.5**	1	0.5	0.5	1	0.5	0.5	5.5	2.5	3.44
C	1	0	**0.5**	0	0.5	1	0	0	3	6	1.07
D	1	0.5	1	**0.5**	0.5	1	0.5	0.5	5.5	2.5	3.44
E	1	0.5	0.5	0.5	**0.5**	1	0	0	4	5	1.75
F	1	0	0	0	0	**0.5**	0.5	0	2	7	0.56
G	0.5	0.5	1	0.5	1	0.5	**0.5**	0.5	5	4	2.7
H	1	0.5	1	0.5	1	1	0.5	**0.5**	6	1	4.63

Once the table has been completed and the ranking of the criteria has been established, the FRISCO formula (1) is used to calculate the weighting coefficients γ_i:

$$\gamma_i = \frac{p + \Delta p + m + 0.5}{-\Delta p' + {}^{N_{crt}}/_{2}} \qquad (1)$$

$$\gamma_A = \frac{1+0+0+0.5}{5+4} = 0.17 \qquad \gamma_E = \frac{4+3+3+0.5}{2+4} = 1.75$$

$$\gamma_B = \frac{5.5+4.5+5+0.5}{0.5+4} = 3.44 \qquad \gamma_F = \frac{2+1+1+0.5}{4+4} = 0.56$$

$$\gamma_C = \frac{3+2+2+0.5}{3+4} = 1.07 \qquad \gamma_G = \frac{5+4+4+0.5}{1+4} = 2.7$$

$$\gamma_D = \frac{5.5+4.5+5+0.5}{0.5+4} = 3.44 \qquad \gamma_H = \frac{6+5+7+0.5}{0+4} = 4.63$$

The result of the analysis is determined by the objective and comparison of the relative importance of the criteria considered. The weight (γi) of each criterion is shown in Table 5.2. The results of the analysis show that the most significant criterion in the assessment of alternative solutions is criterion H, followed by criteria B and D, which are placed at the same level.

The next step of the MCA is to analyse the three alternatives against each criterion. Therefore, to each alternative it will be given a note of importance, Ni, from 1 to 10. The score awarded is determined by specialists in relation to each criterion analysed [DCL09]. Subsequently, to determine the final hierarchy of the three alternatives, the performance index, Fi, is be calculated by using the relationship (2). Fi shall be calculated for each alternative in relation to each criterion.

$$F_i = N_a \, x \, \gamma_i \qquad (2)$$

The final ranking shall be determined on the basis of the values of the Fi performance index. Finally, the classification is established, and the results are shown in Table 5.3.

Table 5.3: Means of communication - classification using MCA

Criterion		γi	Phone call		SMS		Mobile app	
			Ni	Be	Ni	Be	Ni	Be
A	Cost of manufacturing and maintenance	0.17	10	1.7	10	1.7	8	1.36
B	Utility	3.44	8	27.52	6	20.64	9	30.96
C	Quantity of information	1.07	10	10.7	6	6.42	9	9.63
D	Accuracy of information	3.44	10	34.4	7	24.08	10	34.4
E	Usefulness of information	1.75	10	17.5	9	15.75	10	17.5
F	User perception	0.56	10	5.6	7	3.92	10	5.6
G	Ease of use	2.7	10	27	8	21.6	10	27
H	Response time	4.63	9	41.67	7	32.41	10	46.3
Final Score			-	**166.09**	-	**126.52**	-	**172.75**
Final Ranking				**II**		**III**		**I**

In MCA, the alternative solution ranked at the top of the hierarchy is considered to be the ideal solution. Therefore, the following conclusions were drawn from this study:

- **The ideal solution** for communication during an emergency is alternative 3, the **mobile app**, with a final score of **172.75** points.
- The lowest score (126.52 points), considered to be the least feasible solution, is alternative number 2, the text message.

5.2. Designing a mobile response system for emergency situations

As shown in the previous section, the lack of immediate assistance in an emergency situation may increase the risk of death. This can be caused due to the fact that the PSAP dispatchers do not receive vital information in a timely manner. The analysis shows that if the response time of the emergency-response teams decreases by 1 minute, the chances of saving an individual's life increase by up to 6 % [EVA96]. The aim of this research is to design an integrated emergency alert and response system that uses the smartphone to create emergency notifications.

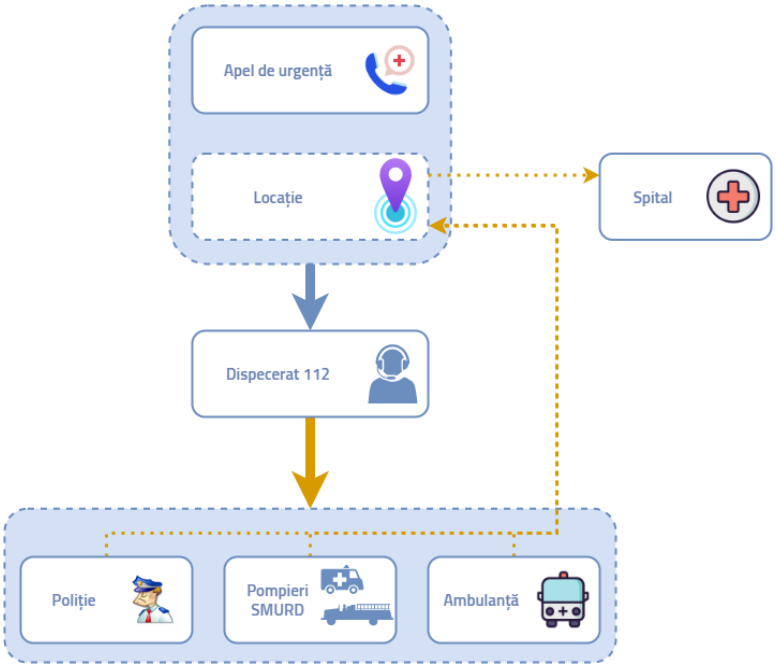

Figure 5.2: Emergency call processing

The current emergency alerting process is shown in Figure 5.2.

As a result of the investigations, the usage flow of the *mobile emergency application designed for victims and/or witnesses* illustrated in Figure 5.3 was established. Furthermore, Figure 5.4 illustrates the user interaction with the *web application designed for dispatchers.*

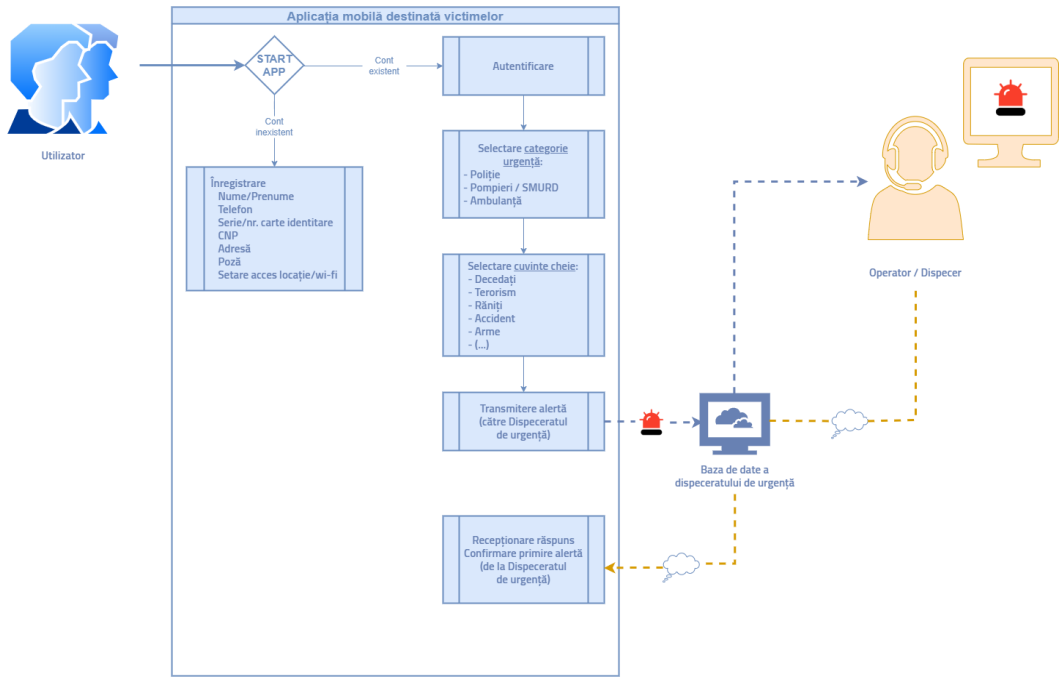

Figure 5.3: Emergency mobile application - Flow of use

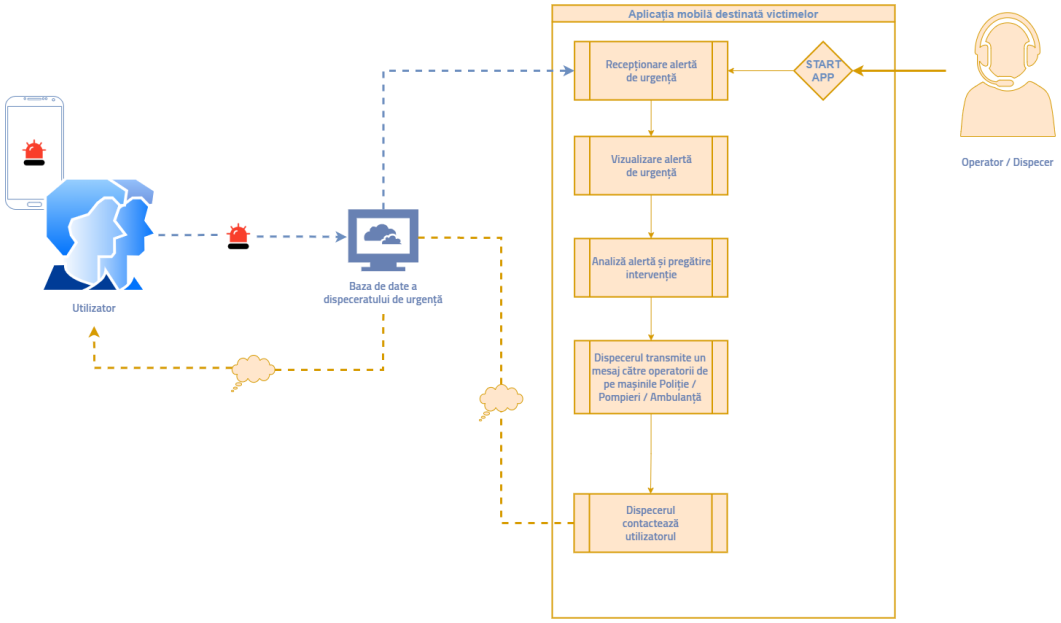

Figure 5.4: Emergency web application - Flow of use

5.3. Conclusions

The response time is vital in emergency situations such as terrorist attacks, natural disasters, or accidents. The analysis shows that if the response time of the rescue teams decreases by 1 minute, the chances of saving the life of individuals involved in a crisis situation can increase by up to 6% [EVA96]. To achieve alert correlation different algorithms were studied: Pouget [POU03] carried out an in-depth review of the published works and the available tools in order to explain the differences between them, and Sadodin [SAD06] provided a mapping of them.

PART III - EXPERIMENTAL RESEARCH AND CASE STUDIES ON MOBILE EMERGENCY COMMUNICATION SYSTEMS

CHAPTER 6. Development of the mobile emergency notification system - SASU

6.1. Introduction

In the previous sections, the potential of a mobile emergency alert and response system has been analysed, and the results of the research have shown that such an application is useful as information technology evolves from year to year and users use more and more mobile applications and mobile services.

The mobile emergency system designed and proposed for development in **Chapter 5: Studies and theoretical contributions regarding the mobile emergency system** shall consist of the following functionalities:

- The *mobile emergency application designed for victims and/or witnesses* involved in emergency situations requiring immediate help and/or assistance. The mobile app will provide users with the ability to alert the nearest emergency dispatches, providing the exact location of the users, as well as other related-information of interest (location, user data, description of emergency crisis).
- The *web application designed for dispatchers* (the emergency operators in PSAP) facilitates the analysis of emergency alerts sent by mobile users via the mobile emergency application. The mobile notification will inform emergency dispatchers about incidents occurring near them and will provide dispatchers with the opportunity to view the location of victims on the map, have a concise description of the event and an overview of the reported situation.

In case of an emergency, the user will be able to generate an alert via the mobile app. In case of an accidental alert, the user also has the possibility to cancel the new created alert before it is processed by the operator in the emergency dispatcher. The mobile app gets the victim's location using the Google Location API and sends it to the nearest emergency dispatcher (PSAP). As soon as the operator in the emergency dispatch admits the request sent by the victim, the mobile application will display the estimated time in which the intervention teams can reach the location of the reported event.

The system designed mainly targets large-scale emergency categories, where multiple alerts are sent from the same location and the PSAP operator can deduce the extent of the event and act before things degenerate. However, although the app does not target emergencies with a single victim, words such as "raped" have been added to the keyword list to cover such events in which the victims cannot alert the emergency dispatch by a voice call because any noise could jeopardise their safety.

The language selected for the development of the two applications, the mobile application, and the web application, was English, as it was considered that the results of the experimental testing could be disseminated later in a scientific article for international validation.

According to the research carried out and taking into account the results of the testing, it has been found that this approach can help rescue teams intervene as quickly as possible at the place of emergency crisis to rescue victims in a shorter time.

6.2. Emergency mobile application for victims

As a result of the analysis carried out, for *the mobile application designed for victims*, a total of ten use cases (UC) were identified. Out of these, six use cases are primarily used, and four are secondary use cases:

- **UC01:** Application Launch
- **UC02:** New user registration
- **UC03:** Login
- **UC04:** View profile data
    - **UC041:** Editing profile
- **UC05:** Create an emergency alert
    - **UC051:** Send an emergency alert
    - **UC052:** Cancel the emergency alert
    - **UC053:** View the emergency alert status
- **UC06:** Sign out

In order to access the services provided by the mobile emergency application, the user must first install the application on his device, create a user account and give access to all required data (e.g. device location).

In order to send an emergency alert via the emergency mobile application, the user must follow the next steps:

1. Login
2. Create Notification:
    a. identification of the appropriate response provider (Police / Ambulance / Fire brigade);
    b. selecting incident-specific keywords (e.g., dead, terrorism, injured, accident, crowd, rape, weapons, kidnapping, avalanche);
3. Validate the notification

As soon as the user has completed the previous steps, the alert created together with all the identification data and the user's location are sent to the database of emergency dispatchers, the alert being subsequently redirected to the nearest PASP.

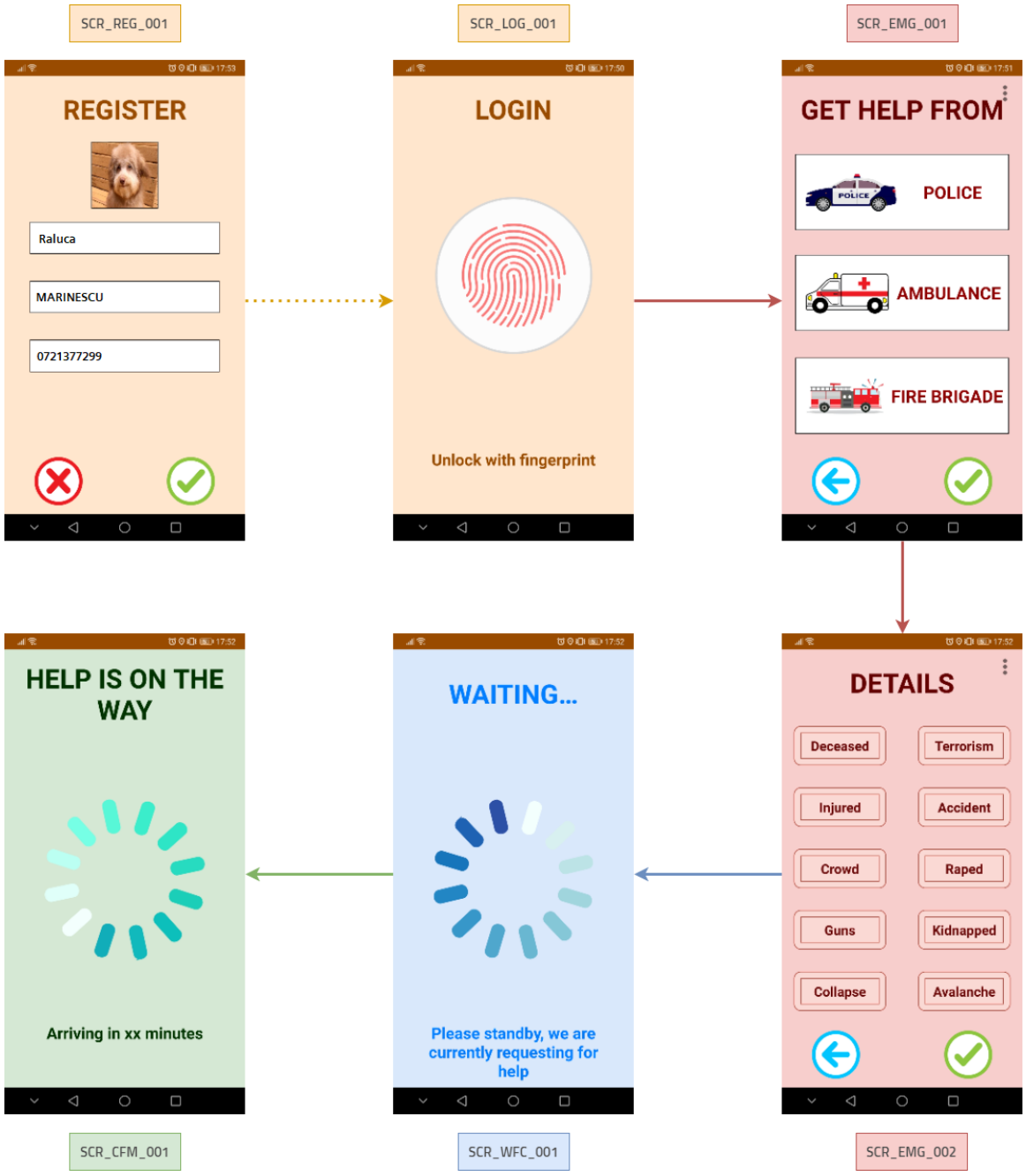

Figure 6.1: Emergency mobile application for victims - Flow of use

The emergency mobile application flow is illustrated in Figure 6.1. Based on the results obtained in the preliminary usability test, the following six screens have been designed:

- SCR_REG_001 - Register screen
- SCR_LOG_001 - Login screen
- SCR_EMG_001 - Emergency response provider selection screen
- SCR_EMG_002 - Emergency keyword selection screen

- SCR_WFC_001 - PSAP confirmation waiting screen
- EMG_CFM_001 - Emergency Alert Confirmation Screen

The mobile emergency system developed under this project is not subject to use in the context of a real emergency situation. Therefore, in order to carry out usability tests on the emergency mobile application designed for victims and witnesses and the web application designed for dispatchers, users do not have access to a dedicated app in the app store offered by Google. That's why, for installing the mobile app on a smart mobile device, users need to copy the apk file of the app to the device's "Downloads" folder and launch the installation.

6.3. Web application for dispatchers

Being developed exclusively for experimental purposes, the web application for dispatchers is not available on a public web-address. Thus, in order to access the services offered by the web application designed for dispatchers, the user must launch the web application on a laptop or computer with internet access, accessing the localhost port: 70.34.207.151:3000.

The web application was developed in order to receive alerts sent by victims via the mobile application. Therefore, it has been developed simplistically, consisting of 3 screens where users in the emergency dispatch can view the location from which the emergency alerts were sent, the total number of alerts received from the same location, but also the user details (name, phone).

Subsequently, after analysing an alert, the PSAP operator may select the appropriate response provider for the reported situation and send the rescue team to the alert's location. A random, pre-registered location was used to test the system, which was considered to be the PSAP's location. To calculate the appropriate route and the estimated arrival time of the rescue vehicles at the emergency's location, the web application uses the Google Directions API.

Given the fact that the web application was developed exclusively for experimental testing of the system, it was not designed to be used simultaneously by several users. Therefore, functionalities such as user profile creation, user registration, log-in/log-out, profile editing, accessibility, system administration, have not been implemented at this point.

As a result of the analysis carried out, a total of four use cases (UCs) were identified for the web application designed for dispatchers:

- **UC01:** Launch of the app
- **UC02:** Emergency alert reception
- **UC03:** Analysis of emergency alert
- **UC04:** Start of rescue operation

In order to access the services offered by the web application, the user must launch the application on a laptop or computer with internet access by accessing the localhost port: 70.34.207.151:3000.

Based on the results obtained in the preliminary usability test, the following three screens, illustrated in Figure 6.2, have been designed:

- SCR_WEB_001 - Main screen
- SCR_WEB_002 - New Emergency Alert screen
- SCR_WEB_003 - Emergency Alert Analysis Screen

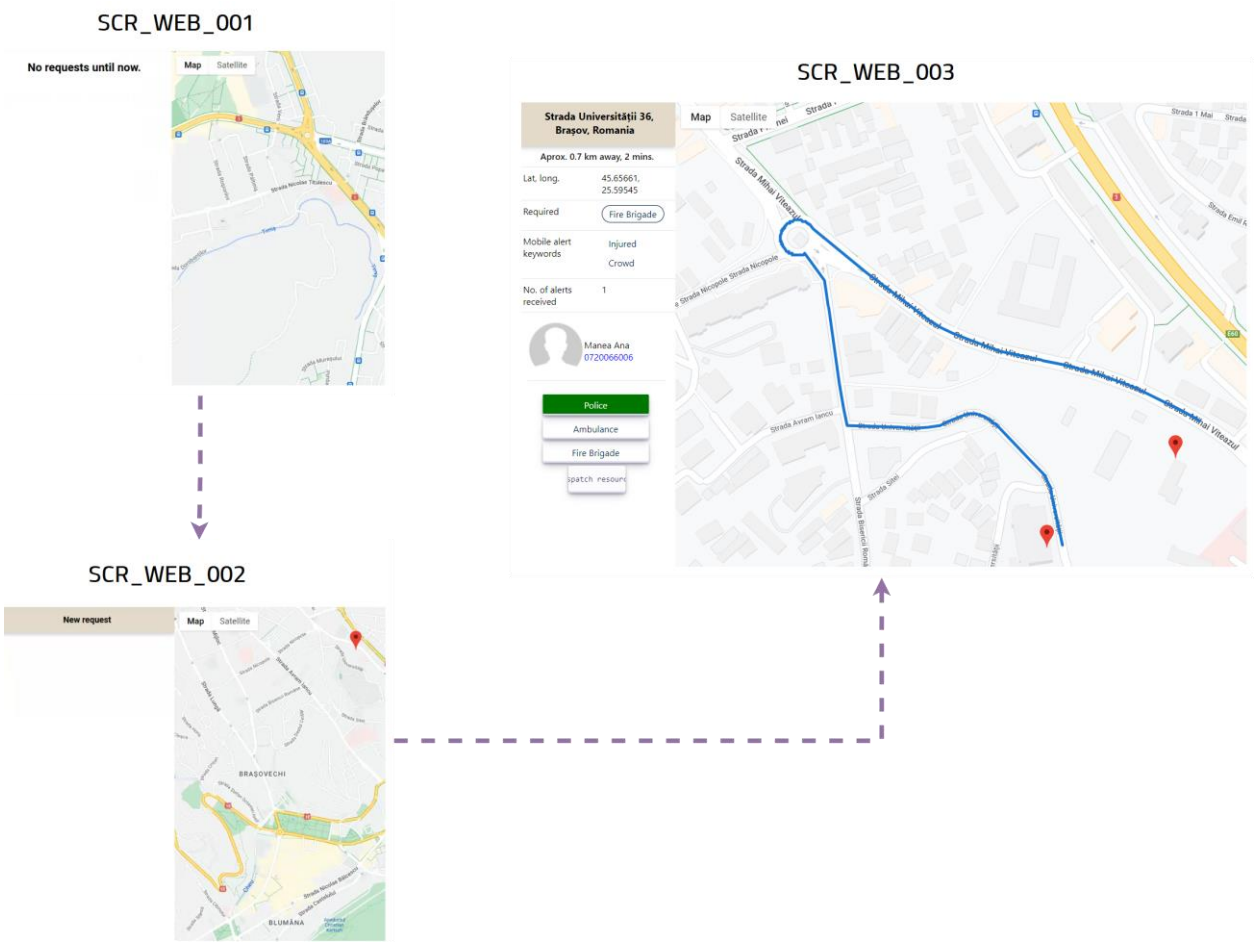

Figure 6.2: Web application for dispatchers - Flow of use

6.4. Conclusions

Using the Design Science Research - DSR methodology [HEV10], a study was carried out, and following this practical approach, the integrated mobile emergency alert and response system - SASU was developed:

- The *mobile emergency mobile designed for victims* reports user alerts to the nearest emergency dispatches, providing the exact location of the victims, as well as other information of interest in emergencies;
- The *web application designed for dispatchers* facilitates the analysis of emergency alerts sent by users via the mobile application. The web app quickly informs emergency dispatchers of

incidents occurring near the PSAP and provide them with the opportunity to view the location of the victims on the map.

The system developed mainly targets large-scale emergency categories, where multiple alerts are sent simultaneously from the same location and the PSAP operator can deduce the extent of the event and act before things degenerate. The language selected for the development of the system was English, as it was considered that the results could be disseminated for international validation.

In regards with the minimum information needed to create an emergency alert, it has been considered that a mobile notification shall consist of:

- data automatically retrieved from the mobile application:
  - user profile (pre-configured): name, surname, phone number
  - user position, automatically retrieved at the moment of triggering the emergency alert
- manual data provided by the user manually:
  - response provider requested by the user: Police, Fire brigade, Ambulance
  - keywords associated with the emergency event.

According to the research carried out and taking into account the results of the pilot-testing, it has been found that this approach can help rescue teams intervene as quickly as possible at the emergency site to rescue victims.

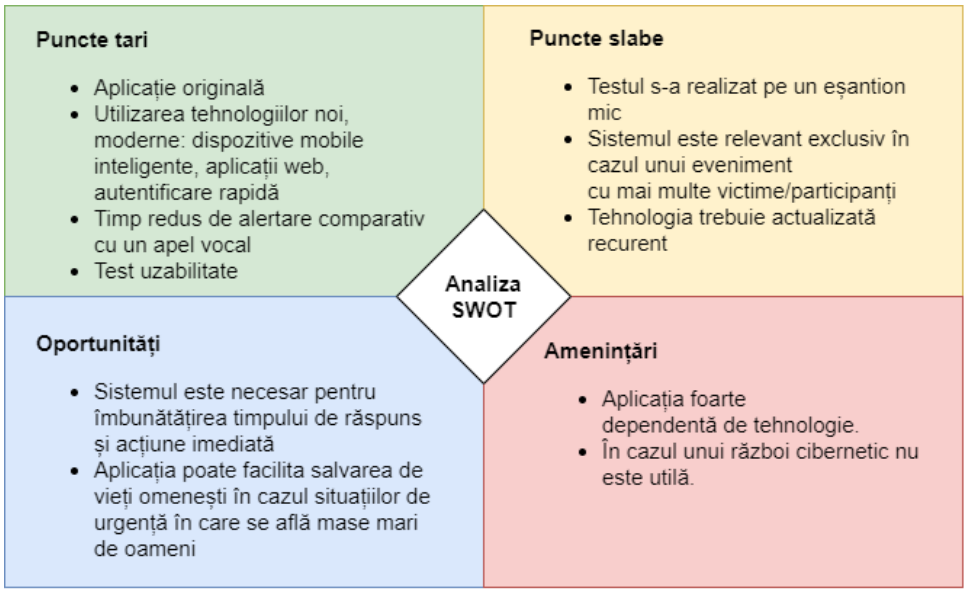

Figure 6.3: SASU - SWOT Analysis

In order to send an emergency alert via mobile app, the user must follow the following steps:

1. Login
2. Create Notification:
   a. identification of the appropriate response provider (Police / Ambulance / Fire brigade);

b. selecting specific keywords (e.g., dead, terrorism, injured, accident, crowd, rape, weapons, kidnapping, avalanche);

3. Validate the emergency notification

As soon as the user has completed the previous steps, the alert created together with all the identification data, the request for the response provider, the keywords associated to the event and the user's location are transmitted to the nearest emergency dispatcher where an operator can view them using the web application.

Figure 6.3 illustrates the SWOT analysis of the developed system.

CHAPTER 7. Validation of the mobile emergency notification system - SASU

7.1. Introduction

The objective of the experimental testing is to analyse the mobile emergency alert and response system presented in the previous sections in order to understand its actual usefulness and its limitations. The developed system consists of an *emergency mobile application developed for victims and witnesses* and a *web application developed for dispatchers*. The ultimate goal of the test was to assess the benefits and disadvantages of using the two applications in a real emergency situation.

The research process adopted to propose a solution to this problem is based on the Design-Knowledge-Research methodology (DSR) [HEV10] which allows researchers to develop innovative artifacts that they subsequently test at a later in real-world conditions. The results obtained through this methodology can clarify potential design problems by allowing researchers to learn from the experiment in order to develop a product as close as possible to the needs of end-users.

7.2. Usability test: Simulating an emergency situation

The experimental testing of the mobile emergency alert system - SASU took place between June and July 2022. The experiment was conducted at Transilvania University of Brașov - Faculty of Sociology and Communication, in two stages, at the following specialisations: Digital media, and Communication and public relations.
Thus, two groups of participants participated in the testing and validation phase of the SASU system, as follows:

- Group I: 22 students, 2 university professors, 1 university assistant.
- Group II: 22 students, 2 university professors, 1 university assistant

Each test session lasted about 25 minutes in which participants were presented with the developed system. Later, the mobile app was installed on their mobile phones. Users interacted with the

application at the time of the simulated emergency event, and then they replied to a usability questionnaire, the results being presented in the following sections.

The experiment began without preliminary preparation, the main purpose being to observe users' understanding of the mobile app, screens, as well as the projected usage flow.

Subsequently, participants were presented with an emergency scenario: the fire alarm was triggered, and they were asked to alert the emergency dispatcher via the mobile app installed on their phones.

Research has revealed that alerting an emergency incident via a voice call to the European emergency number "112" lasts between 30 and 278 seconds, with an overall average of 90 seconds [EENA2][LUM14][ECR20]. In comparison, the total average time needed to send a mobile emergency alert via the mobile application was about 30 seconds, during which users selected the appropriate response provider and the keywords associated with the crisis event.

During the experiment, users demonstrated that the mobile app screens are intuitive and user-friendly, being able to select both the appropriate response provider for the reported situation (e.g., fire), as well as several keywords to accurately describe the crisis event. As depicted in Figure 7.1 out of the available options offered by the mobile application, the users have chosen the following options for creating the emergency mobile notification:

- Response provider:
    - Ambulance
    - Fire Brigade
- Keywords:
    - Injured
    - Crowd
    - Accident

The analysis shows that the benefits of the mobile emergency application developed for victims and/or witnesses are obvious. In the case of simultaneous calls coming from the same location, the emergency dispatcher needs one operator for each caller, and if they are not available, the call response time is extended, and victims have to wait in order to be able to communicate the problems they are facing. By using the mobile application, the information can be automatically aggregated and monitored, requiring a single PSAP operator that manages data from the same location.

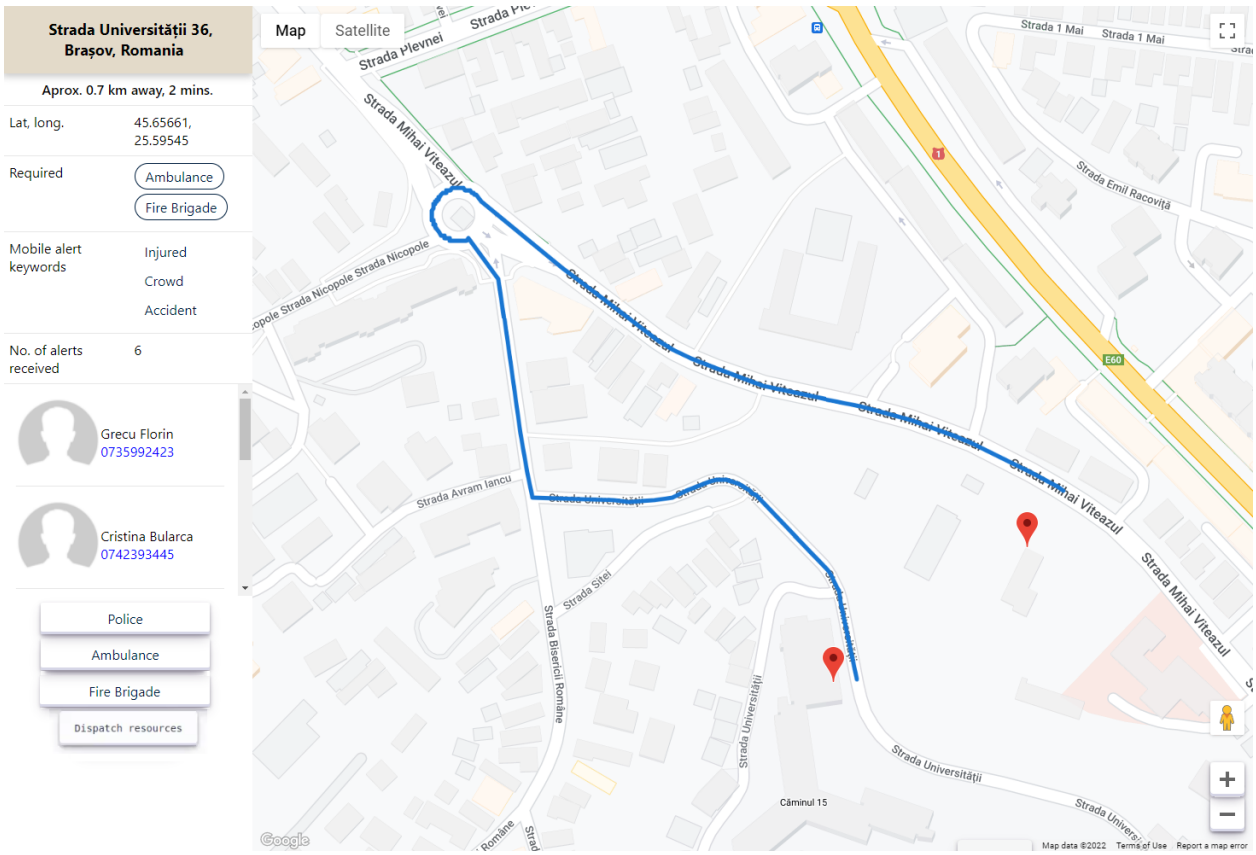

Figure 7.1: Mobile Emergency Alert - Fire at UnitBV

7.3. Simulation exercise results

After the development of the emergency alert system - SASU, in order to assess the level of satisfaction among end-users, a satisfaction questionnaire was carried out on the two emergency applications developed: the mobile application developed for victims and the web application developed for dispatchers.

To measure user satisfaction regarding the *emergency mobile application for victims*, a group of 49 students and teachers from Transilvania University of Brașov was selected. The responses collected from the three groups of respondents were merged, with Figure 7.2 representing the results of the satisfaction questionnaire using a random sampling technique.

In order to measure user satisfaction regarding the emergency web application designed for dispatchers, a group of 5 teachers and university assistants at Transilvania University of Brașov was selected. Figure 7.3 shows the results of the satisfaction questionnaire using a random sampling technique.

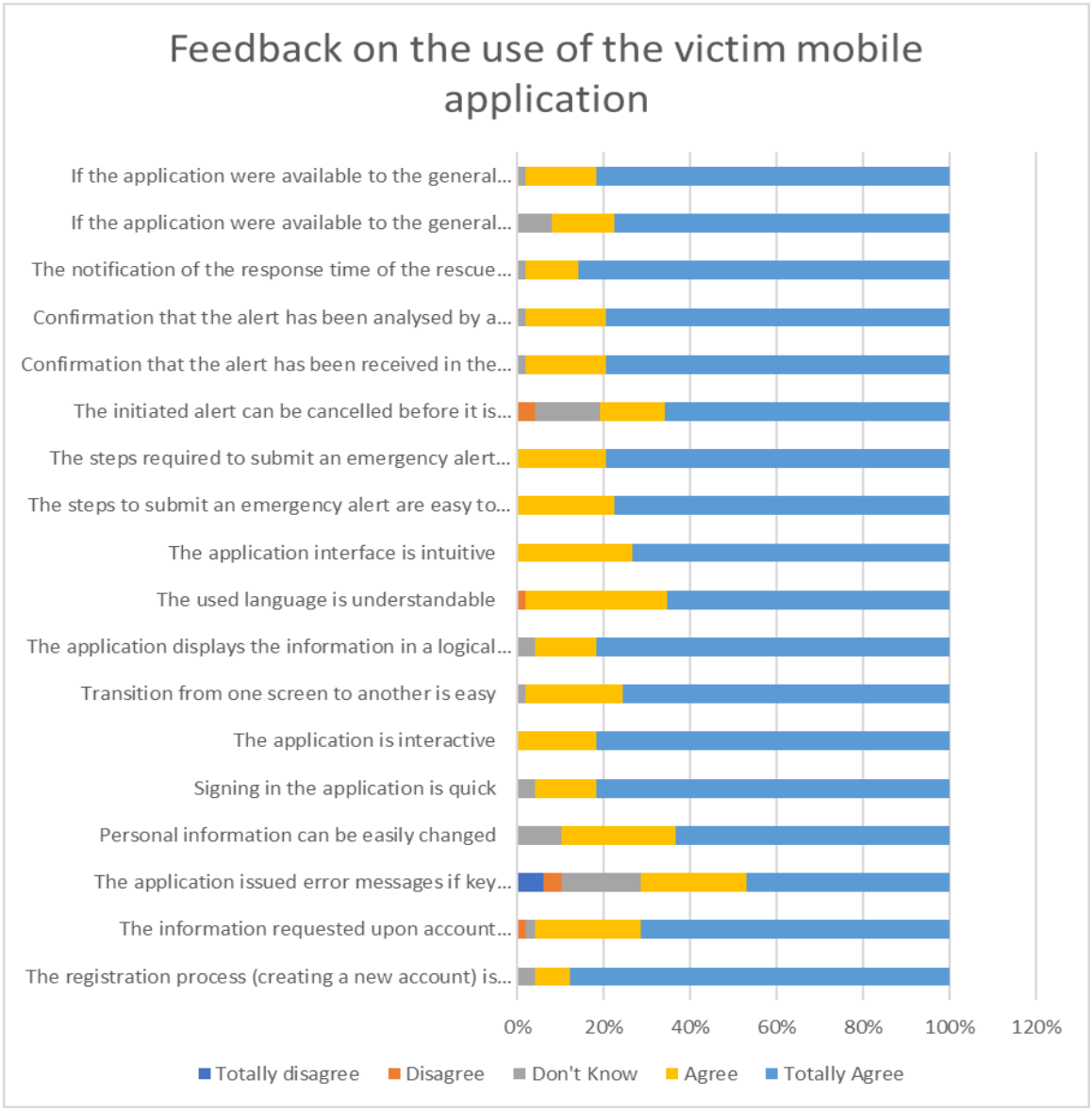

Figure 7.2: Mobile application - Satisfaction questionnaire results

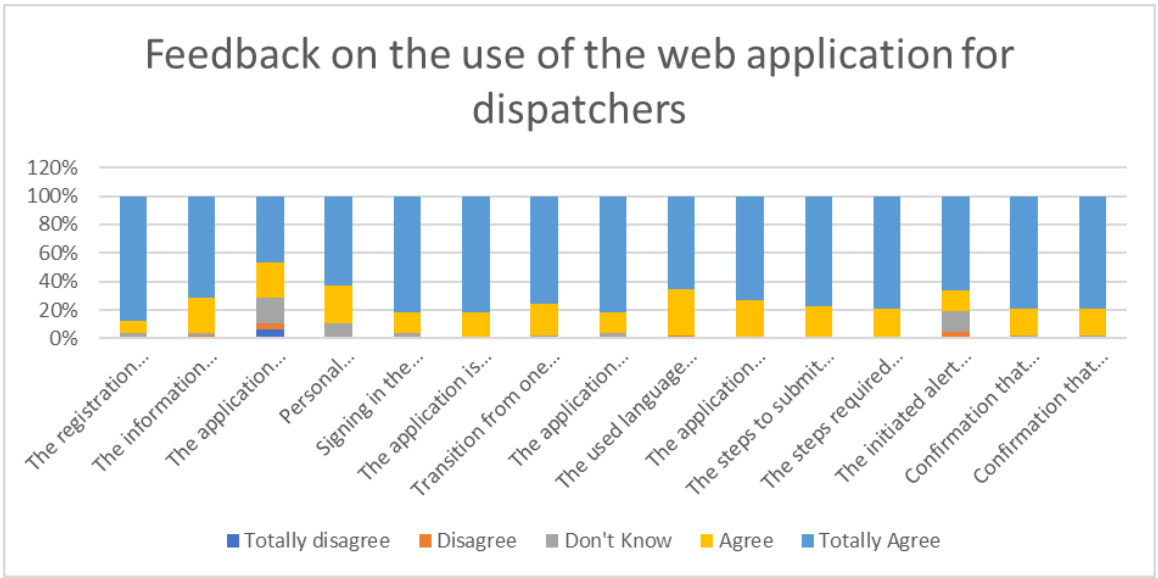

Figure 7.3: Web application - Satisfaction questionnaire results

7.4. Conclusions

Experimental testing of the mobile emergency alert system - SASU highlighted some interesting elements regarding the usefulness of the system and its acceptance among end-users, namely the ability to use the emergency mobile application in crisis situations.

- First, it was found that the emergency mobile application for victims can have a positive impact on the current mechanisms used to notify exceptional events. Although the average time for sending a message via the app is significantly lower than a voice call to 112, the real utility is that an operator in the emergency dispatcher can handle multiple notifications at the same time. In addition, the content of the notification is accurate, and the information provided is sufficient to handle the crisis event.
- Secondly, it has been shown that the mobile app is supported by potential users. The vast majority of respondents said they would use this app to the detriment of a 112-voice call. However, the developed application is not intended to replace traditional phone calls, but only to provide citizens with an official alternative channel.
- From usability point of view, the experiment has shown that the mobile application is easy to use and the responses from the questionnaires carried out show that the level of acceptance is good. Moreover, the experiment revealed that participants showed no hesitation in managing the phone and collecting the necessary information, demonstrating that the app is intuitive.
- The level of accuracy of the GPS embedded in smart mobile devices is considered appropriate by both experts and users. Automatic location pickup avoids further interactions, such as using a map or describing a difficult address.
- Regarding the minimum information required to create an emergency alert, the user's position combined with the user profile (e.g., phone number and full name) and the selection of the appropriate response provider together with the associated keywords have proved to be sufficient. Storing personal information and automatically picking up the device's position allows users to send an emergency notification in just two steps, by selecting only the response provider (Police, Fire brigade, Ambulance) and the keywords associated with the emergency event.
- Short and direct interactions were also found to be appropriate and preferred by users over voice calls. Moreover, the language used and short descriptions in the keywords were easy to be interpreted, giving participants the opportunity to establish a communication channel with the emergency dispatcher in a short time.
- Finally, the confirmation that the mobile emergency alert was received and analysed by the emergency dispatcher quieted the users of the mobile application. It was therefore found that an emergency mobile application must be able to provide a confirmation message as soon as the mobile alert has been received in the emergency dispatch, i.e. a confirmation message that the request has been assessed and rescue teams sent to the scene of the incident.

Part IV - GENERAL CONCLUSIONS AND ORIGINAL CONTRIBUTIONS

CHAPTER 8. Original contributions

In accordance with the title of the doctoral thesis, the general objective of this research is to **develop an innovative approach for emergency reporting using smartphones and improve the emergency communication in order to reduce the response time of rescue teams**, thus contributing to the reduction of deaths. The original contribution to the development of scientific knowledge can be assessed by the author's contribution from different perspectives of scientific research. These can be translated into:

A. Summary contributions

- Identifying the current state of research in the field of mobile emergency communication:
    - Analysis of human behaviour during crisis situations;
    - Analysis of the methods currently used for communication during emergency situations;
    - Identifying the most relevant scientific papers in the field of mobile emergency communication published in the literature through scientometric analyses carried out in the Web of Science and Dimensions databases.
- Analysis of the importance and necessity of implementing an integrated mobile system to improve the emergency management system.
- Analysis of trends and needs to develop an integrated mobile emergency alert and response system.
- Analysis of existing standards and procedures for the development of an emergency mobile application.
- Critical analysis of existing solutions and developments in emergency alert management using MCA analysis:
    - Identification of emergency communication alternatives;
    - Establishing the criteria for their comparison;
    - Determining the weights of each criterion;
    - Classification of alternatives by assessing performance levels.
- Critical analysis of existing mobile emergency systems and applications.

B. Theoretical and experimental contributions

- Selecting appropriate standards and procedures for the development of an integrated mobile emergency alert and response system.

- Analysis of trends and technical needs to develop an integrated mobile emergency alert and response system.
- Defining the use cases necessary for the implementation of an integrated mobile emergency alert and response system.
- Design of the usage flow for the two applications.
- Design and development of an integrated mobile system aimed at reducing the intervention time of rescue teams. The **main goal of the developed system is to provide support in large emergency crisis where multiple alerts are sent from the same location** and the PSAP operator can deduce the extent of the event and act before things degenerate. The **system also provides support in sending silent notifications**. This functionality is especially useful for circumstances where sounds might endanger the safety of the caller, or in situations where the caller does not speak the language of the country in which he/she is located. The developed system consists of two parts:
    - an *emergency mobile application designed for victims and/or witnesses* in emergency situations requiring the intervention of rescue teams: designed to allow users to alert emergency dispatches in just 4 steps, which last on average 10 seconds:
        - login
        - selection of the appropriate response provider
        - selection of selecting predefined keywords specific to the situation
        - send the emergency alert
    - a *web application designed for dispatchers* in emergency centres that facilitates the analysis of emergency alerts sent by users via the mobile application: designed to enable PSAP operators to quickly manage the reported events.
- Testing and validation of the mobile emergency alert system - SASU in a simulated emergency situation with 49 participants.
- Analysing the results obtained and highlighting the innovative elements.

C. **Contributions of a curricular scientific nature**

- The current state of research in the field of emergency communication.
- Elaboration of scientific research reports within the research program at PhD.
- Completion of the doctoral thesis.

D. **Novelty of the doctoral thesis**

The novelty of the doctoral thesis consists of:

- The subject of theoretical investigations.
- A comparative analysis of the technical and functional characteristics of existing mobile systems and applications on the market designed for emergency communication.

- The definition and design of an integrated mobile system aimed at reducing the time of rescue teams' intervention.
- The development of an integrated mobile emergency alert and response system composed of a *mobile emergency application*, and a *web application*. **The novelty of the system is that** the **mobile application user** (victim or witness) **can notify the emergency dispatcher in just four steps, which take an average of 10 seconds**. **This was made possible by implementing a new approach consisting of developing specific screens with predefined information in which users can select**:
    - SCR_EMG_001: **the appropriate response provider** to the situation (Police, Ambulance, or Fire brigade / SMURD);
    - SCR_EMG_002: specific **keywords** describing the crisis situation (Death, Terrorism, Injury, Accident, Crowd, Violence, Weapons, Rapture, Avalanche, Fall)
- Testing and validation of the mobile emergency alert system - SASU in a simulated critical situation with 49 participants.

E. Usefulness of research results

The results of the research are revealed both by the contributions made and by the following aspects:

- From a scientific point of view, the studies carried out make a particular contribution in the field of fundamental knowledge, by developing and deepening research on mobile emergency alert and response systems.
- From a didactic point of view, both the results themselves and the applied research methods and procedures are of interest and usefulness.
- From an applicative point of view, the research brings on one hand a scientific substantiation of the knowledge gained through practical experience, and on the other hand offers a product, namely an integrated mobile emergency alert and response system composed of:
    - a *mobile emergency application designed for victims and or witnesses*: designed to enable mobile users to quickly alert emergency dispatches;
    - a *web application designed for dispatchers*: designed to enable PSAP operators to quickly manage the reported events;

F. Valuing and disseminating research results in scientific academia

The exploitation and dissemination of research results in the scientific academic environment was achieved through:

- Publication of 7 scientific papers and articles as a first and co-author, in the results of international and national scientific events, of which 3 papers presented at international conferences indexed ISI, 1 chapter book published in Springer International Publishing House, 1 paper presented at an international conference and published in the journal of the IOP conference, 2 papers presented at an international symposium, published in the

volume of the symposium, indexed in the national digital repository of the Republic of Moldova in open access:

- ISI proceeding
    1. Repanovici R. *Multi-criteria analysis of wearable activity-fitness trackers and 3D concept models of smart jewellery*. MATEC Web Conf. 178, 05017 (2018). WOS:000570197900075
    2. Repanovici R., Nedelcu A. *3D printing new direction and collaboration in scientific research. A scientometric study using Web of Science, Clarivate Analytics database*. MATEC Web Conf. 178, 07009 (2018). WOS:000570197900110
    3. Marinescu R., Nedelcu A. *Smartphone application for heart rate monitoring*. 2017 E-Health and Bioengineering Conference (EHB), 141-144 (2017). WOS:000445457500036
- BDI and B+
    1. Repanovici R., Nedelcu A. *Alerts in Emergency Situations Using Mobile Technology, Scientometric Visualization Analysis*. SIM 2019. Springer Proceedings in Business and Economics (2019). Springer, Cham. https://doi.org/10.1007/978-3-030-44711-3_2
    2. Repanovici R., Coman E. The recipe for success in the era of knowledge economy : motivating employees to become brand ambassadors. IbnIdsiMd, 179-184 (2018). ISBN 978-9975-75-926-7.
    3. Repanovici R., Coman E. mHealth Applications: Current State, Barriers and Future Potential. IbnIdsiMd, 81-90 (2018). ISBN 978-9975-75-926-7.
    4. Repanovici R., Nedelcu A. *Mobile emergency notification apps: current state, barriers and future potential*. IOP Conf. Ser.: Mater. Sci. Eng. 1009 012049 (2021).

- Production of scientific research reports within the scientific training programme
- Completion of the doctoral thesis

CHAPTER 9. General conclusions

The aim of this research is to develop an integrated mobile system that uses the smartphone to announce emergency situations in order to reduce the response time of rescue teams. By developing an integrated emergency system, the individuals involved in a crisis can be helpful by quickly transmitting relevant information to emergency dispatches.

The **main goal of the developed system is to provide support in large emergency crisis where multiple alerts are sent from the same location** and the PSAP operator can deduce the extent of the event and act before things degenerate. The **system also provides support in sending silent notifications**. This

functionality is especially useful for circumstances where sounds might endanger the safety of the caller, or in situations where the caller does not speak the language of the country in which he/she is located.

CHAPTER 10. Future research avenues

Taking into account the analysis of the fatal cases of large-scale tragedies, the critical analysis of the research in the field and the existing technical solutions, the following general premises for further development directions have been created:

- continuation of experimental research;
- testing the developed system on a larger sample in which all social groups are represented: women and men of all age groups, ethnic groups, and social classes;
- adapting the mobile emergency alert system - SASU to emergencies with a single victim to cover situations where the victims cannot alert the emergency dispatcher with a voice call because any noise could jeopardise their safety.

Specific development directions have also been identified as follows:

- The mobile emergency application designed for victims:
    - Language of use: The mobile application should integrate several languages of international circulation so that all citizens of the European Union can use it. The default language of the application should also be updated according to the language in which the operating system of the device is set.
    - Mode of transmission of data: If there is no internet access, the application should be able to use the text message (SMS) for the transmission of data to emergency dispatchers.
    - Emergency notification: When the user validates the emergency notification, the mobile app could open an audio communication channel with the emergency dispatcher through which the sounds captured around the user can be transmitted to the operator in the emergency dispatcher. In this way, a broader view of the situation faced by the victim can be created.
    - Automatic activation of the communication channel between the emergency mobile application and the web application for dispatchers: Given the fact that currently all smart mobile devices are equipped with voice support programs ("Hey Siri" for devices running iOS and "OK Google" for those running Android), the mobile emergency mobile app could use the keywords defined in the SCR_EMG_002 screen to automatically trigger an emergency alert. Thus, when the user pronounces, for example, "OK Google terrorist attack", the application should automatically send an emergency notification contain the relevant information to the nearest PSAP dispatcher.
- The web application designed for dispatchers:

- Language of use: the web application should integrate several languages of international circulation so that all emergency operators in the European Union can use it. Also, if mobile alerts are transmitted in a different language, the system should automatically translate their content in accordance with the language in which the dispatcher web application operates. Thus, language barriers can be removed, giving EU citizens equivalent and unlimited access to emergency services across the European Union.
- Implement algorithms capable of automatically removing false alerts and detecting normal emergency behaviours for more efficient manual monitoring.
- Implement algorithms capable of automating the response process in case of large-scale tragedies. In such situations, the number of emergency alerts is so high that manual analysis becomes impossible. Therefore, the implementation of algorithms to analyse data and make automated decisions should become a priority. For example, in the case of an event similar to Colectiv when a high number of emergency alerts come from the same location, the system should automatically send on-site intervention crews composed of ambulance cars, firefighters and police. The number of crews should also be linked to both the number of alerts sent and the location from which they were sent.

BIBLIOGRAPHY

[BAT17] B. Bathelot, Définitions marketing, *Définition : Application mobile*, **2017**
Disponibil la: https://www.definitions-marketing.com/definition/application-mobile/
Accesat la: 12 August 2021

[BOB15] Ș. Bobancu, *Creativitate și Inventică*, Brașov, Editura Universității Transilvania, **2015**

[CAS15] B. Casse, I. Gomez, J. Winterbottom, *112 Apps Strategy - Pan European Mobile Emergency*, EENA Operations Document, **2015**

[DCL09] Department for Communities and Local Government, *Multi-Criteria Analysis: A Manual*, London, Communities and Local Government Publications, **2009**

[ECR16] European Commission Report, *Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL establishing the European Electronic Communications Code* (Recast), **2016**

[ECR20] European Commission Report, *2020 Report on the on the effectiveness of the implementation of the European emergency number '112'*, **2020**

[EENA2] EENA, *SMS communication with PSAPs and EROs*, EENA Operations Document, **2015**

[ENF1] Enformation, Profil Access
Disponibil la: http://apps.webofknowledge.com.am.e-nformation.ro/Search.do?product=WOS&SID=C4YeBq7S3ns9iuWbeK7&search_mode=GeneralSearch&prID=6f092f57-8546-4990-851f-2ec1e65b0bb5
Accesat la: 5 August 2021

[EVA96] W.M. Evanco, *The Impact of Rapid Incident Detection on Freeway Accident Fatalities*, Mitretek Center for Information System, McLean, Virginia, USA, WN 96W0000071, **1996**

[FIS98] H.W. Fischer, *The Role of the New Information Technologies in Emergency Mitigation, Planning, Response and Recovery*, Disaster Prevention and Management 7 (1): 28-37, **1998**

[GHI19] C. Ghibuțiu, *De vorbă cu Emilia, operator la 112*, Unica, **2019**
Disponibil la: https://www.unica.ro/diverse/vocea-care-salveaza-vieti-de-vorba-cu-emilia-operator-la-112-143237
Accesat la: 6 Octombrie 2020

[HEV10] A. Hevner, S. Chatterjee, *Design Science Research in Information Systems,* Springer US: New York, NY, USA, pp. 9–12, **2010**

[LUM14] C. Lumbreras, G. Machado, *112 Caller Location & GNSS*, EENA Operations Document, **2014**

[MUS12] A.A. Mustaffa, K. Kazunori, *The effectiveness of emergency response system's service providers for road accidents*, Johor Bahru, Malaysia. Civil Engineering Dimension, 14(2):77–83, **2012**

[MUS13] A.A. Mustaffa, K. Hokoa, M.M. Rohani, M.Y. Aman, M.B. Saifullizan, *Integrated Road Traffic Accident Systems (IRTAS) for Emergency Service Providers*, World Conference on Integration of Knowledge, Langkawi, Malaysia, p. 1–10, **2013**

[OUG04] Ordonanță de Urgență Nr. 21/15.04.2004 privind *Sistemul Național de Management al Situațiilor de Urgență*, **2004**

[POU03] F. Pouget, M. Dacier, *Alert Correlation: Review of the state of the art*, EURECOM, Technical Report, **2003**

[POW1] Power Thesaurus, Powerthesaurus.org
Disponibil la: https://www.powerthesaurus.org/
Accesat la: 5 August 2021

[SAD06] R. Sadoddin, A. Ghorbani, *Alert correlation survey: Framework and techniques*, Proceedings of ACM International Conference on Privacy, Security and Trust: Bridge the Gap Between PST Technologies and Business Services, **2006**

[SKO17] B. Skoglund, *Mobile Handset Requirements: Communication to Emergency Services*, EENA Operations Document, **2017**

[STI10] T. Stivers, L. Mondada, J. Steensig, *The morality of knowledge in conversation*, Cambridge University Press, **2010**

[STS1] STS, *Despre Serviciul de Urgență 112*
Disponibil la: https://www.sts.ro/ro/despre-112
Accesat la: 20 Iulie 2021

[VIV19] B. Vivier, *Emergency Communications and the EU Legislative Framework*, EENA Operations Document, **2019**

[VOS1] VOSviewer, *Visualizing scientific landscapes*
Disponibil la: https://www.vosviewer.com/
Accesat la: 5 August 2021

[WIN15] J. Winterbottom, *Pan-European Mobile Emergency Application (PEMEA) Requirements and Functional Architecture*, EENA Operations Document, **2015**