

BLUEPRINT OF USER EXPERIENCE AND INTERACTION FOR CRAMSS AND APPS

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EXECUTIVE SUMMARY

During the course of the RESOLUTE project, two versions of the deliverable “Blue print of user experience and interaction for CRAMSS and Apps” have been foreseen. This is the second version, submitted at the conclusion of WP5. The deliverable thus shares contents with the earlier version (D5.1), submitted in M16. Particularly, contents were maintained describing findings from literature review or the earliest analyses of user requirements or technical restrictions; however, they were adapted where necessary. What have been altered, based on the advancements in the project, are descriptions of the end user applications, including details about their information content. The completely new content refers to the development process followed, particularly the user testing and how its results have had an impact on the layout of the different applications.

Thus, as predicted in D5.1, this final version includes descriptions of the work carried out in T5.1: The research of user requirements and the resulting user interaction concepts and designs for the three front-end applications to be developed in WP5:

- CRAMSS (Collaborative Resilience Assessment and Management Support System)
 - Resilience Dashboard
 - Evacuation DSS
 - FRAM tool
- Emergency support smart mobile app
- Game-based training app

The aim of this final version is to document the development process and the rationale that led to the final designs. As each of the three applications come with its own report (D5.3, D5.4 and D5.5), each of which describes their functionality in detail, this deliverable is providing a rather abstract description and an overall picture of how these fit together. It is, as much as possible, restricted to describing T5.1 activities, although this is – obviously – not possible without also making reference to results achieved by partners in T5.2, T5.3 and T5.4.

Thus, this deliverable describes the user interaction concepts developed for the three applications, and how they were developed. This includes the following key aspects:

- Target users and their characteristics
- Objectives of these users when using the applications
- Key features (as a synonym of “technical functionalities”), including contents
- Technical restrictions
- Description of the development process, including relevant standards and guidelines
- The outcome of the work, consisting in the user interaction concepts, in the shape of storybooks for the features developed in the project and general guidelines for including future features.

PROJECT CONTEXT

Workpackage	WP5: Platform front-end and end user applications
Task	T5.1: Interaction Design and user experience
Dependencies	Input for tasks 5.2, 5.3, and 5.4

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Abbreviations

Abbreviation	Full term
ACD	Activity-Centred Design
CI	Critical Infrastructure
CRAMSS	Collaborative Resilience Assessment and Management Support System
ESSMA	Emergency Support smart mobile app
GBTA	Game-based Training app
GUI	Graphical User Interface
SAVE ME	System and actions for vehicles and transportation hubs to support disaster mitigation

	and evacuation (SAVE ME project; Grant Agreement No. 234027 of the European Commission)
UCD	User-Centred Design
UI	User Interface
UTS	Urban Transport System(s)
OS	Operating System

Gender writing statement

This deliverable contains gender-specific terms. They have been avoided where possible. Where not possible, the male and the female form were used at random, for reasons of shortness and readability. In all cases, it is assumed that the respective person could be of any gender.

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1 INTRODUCTION

1.1 Scope and structure of T5.1 and this Deliverable

1.1.1 Scope of T5.1

Task 5.1 “Interaction Design and user experience” was focused on the three front-end applications to be developed in the RESOLUTE project:

- The T5.2 CRAMSS (Collaborative Resilience Assessment and Management Support System), which eventually resulted in the creation of three separate applications:
 - Dashboard
 - Evacuation DSS
 - FRAM tool
- The T5.3 ESSMA (Emergency Support smart mobile app)
- The T5.4 GBTA (Game-based Training app)

For these three applications, T5.1 has elaborated user requirements and developed and tested user interaction concepts in the shape of storybooks and wireframes. These have been provided to the partners involved in the tasks developing the front-end applications. What has been labelled “CRAMSS” in the description of work finally resulted not as a single application but rather as a compound of different small applications. Each of these is represented in its own user interaction concept. For one of these applications, the Dashboard, we provided both, concise proposals for designing given information sources, as well as a style-guide, which allows for adding new sources of information in the future that were not available during the project duration. This supports the flexibility of the architecture and simplifies the enhancement of the Dashboard with new features once they become available.

User requirements were collected separately for each application, based on the specific usability / user experience engineering approach chosen. Apart from additional literature research, which resulted in the collection of specific design guidelines or general standards, this approach is mainly based on focus-group discussions and interviews. The development was based on traditional Human Factors (HF) and user centred design methods, enriched by special literature on similar systems (e.g. control room software).

1.1.2 Structure of this Deliverable

This deliverable serves the purpose of documenting the developments in T5.1 and providing the rationale behind the user interaction concepts. An important part of this work was in maintaining a continuous exchange of ideas and thoughts creating a common ground for all partners involved in Work Packages 4 and 5 to harmonize efforts. Each application is described within its own chapter. Where applicable, the following aspects are described that characterize the respective application:

1. An **introduction** about the application in order to describe it within its technical, organisational and social context.
2. The **target users** for whom the application is being designed. It defines and restricts the group of users whose needs are to be addressed in the design.
3. The **objectives** of the application. This refers to the goals the users will be able to achieve using the application. It describes the functionality of the application from a user’s perspective, focussing on the starting situation (desire, problem) and the solution meant to be provided by the system.

4. The **features** of the application. This refers to the technical functionality of the application and describes it from a system perspective. When described on a conceptual level, objectives and features may look very similar. However, differences should appear with a growing degree of detail in the description, to be achieved over the course of this task. This will make sure that user objectives and technical functionality are always developed together and thus the user interaction concepts to be developed in parallel will be applicable. As far as appropriate, the description of the features includes information about the contents of the application. The feature may or may not depend on the content. As an example: The feature is an interactive map – the contents are the positions of fire extinguishers on the map.
5. The resulting **user requirements**. Based on the specification of target users, objectives, features, and other sources such as literature research, relevant user requirements are briefly described that will be taken into account in the development.
6. The **technical restrictions**. This refers to factors related to the technological platforms used for the implementation and also the environmental factors which (possibly) limit the available options in user interface design. For example, if a mobile app is to be developed for Android devices, then respective style-guides should be heeded and certain interaction elements are preferable.
7. The **development process** of the user interaction concepts, including the results obtained from user testing.
8. The final user interaction **blueprint**, consisting of storybooks and guidelines.

Even though during the course of the task we researched user requirements by talking to representative future users, we maintained the sections that represent the starting point of user requirements analysis: we deducted key user requirements from in the Description of Work (DoW) and other parts of the Grant Agreement. These documents contain the characteristics that needed to be fulfilled by the project (unless other findings during the project course would heavily contradict such defined aims). The only major change to what was written in the DoW was the splitting up of the CRAMSS into three separate applications.

1.1.3 Project background

All five WP5 applications (they are five as the T5.2 CRAMSS eventually consists of three separate applications) are meant to support the resilience approach (D2.1) developed in the RESOLUTE project and specified in the ERMG (D3.5 and D3.7). This means that the applications shall contribute to the development of local adaptive capacities, namely by supporting the human actor with access to information that, on the one hand enhances her understanding of the relevant and wider operational status and requirements, and on the other hand, supports the management of local resources in alignment with or towards the adjustment of such operational status and requirements. The information to be provided to users should foremost take into account the contents of the ERMG, mainly in terms of the identification of critical operational interdependencies under various relevant operational contexts:

- The identification and acknowledgement by whom, when and under what conditions resources are to be supplied
- Ensuring a shared understanding of the types and levels of resource needs amongst all relevant stakeholders
- The identification of all relevant operation control and monitoring mechanisms

From the perspective of operations management and in line with the RESOLUTE perspective on resilience, guidance representing the four cornerstones of resilience (Hollnagel, 2011) should also be taken into account:

- **ANTICIPATE**: what to expect (address “potential long term threats, anticipate opportunities for changes in the system and identify resources of disruption and pressure and their consequences for the system”)

- MONITOR: what to look for (address “critical aspects by monitoring system and environment for what could become a threat in the immediate time frame”)
- RESPOND: what to do (address actual state; respond to regular or irregular disruptions)
- LEARN: what has happened (“corresponds to the ability to address the ‘factual’ by learning from experiences of both successes and failures”).

Another scheme of which actions are required to create resilience was presented by the National Research Council of the U.S.A (2012):

- PLAN
- ABSORB
- RECOVER
- ADAPT

WP 5 was meant to ensure that both these similar models are supported by the end user applications. We focused on the cornerstones named by Hollnagel (2011b), as the same taxonomy is used in the ERMG. The following paragraphs detail how we addressed these aspects. This shall serve as an introduction on the purpose of the applications developed, before they are described in detail.

1.1.4 Relevant project objectives

The project’s objectives and desired impacts are stated in the Grant Agreement (see GA, p. 155 f.). Some of them could, at least partially, be achieved through the WP5 front-end applications or they would at least, to some extent, depend on the realization of these applications. The following table sums up these project impacts that we assumed to be relevant for the work in WP5, clustering them to the four key actions necessary to create resilience. Where adequate, we also mentioned user requirements that resulted from the aim of achieving the named impacts.

Table 1: Project objectives related to WP5 actions

Cornerstone	Desired impact	WP5 outcomes to support this impact
ANTICIPATE	“Reducing cost and time for implementing resilience guidelines”	This corresponds to the <i>FRAM tool</i> (see chapter 4) and the Dashboard (see chapter 3). The FRAM tool provides its users with an overview of the resources needed to take certain decisions and the interconnections to other users and functions. This helps users select the relevant guideline to follow. Reducing cost and time also meant that the Dashboard was designed to require a minimum training time and effort for its users towards receiving and understanding the decision support provided. Using the Dashboard corresponds to several guidelines. The automatic processes implemented to assess the UTS’s current and future resilience status also contribute to this.
MONITOR	“Move to a paperless mode of work”	The Dashboard distributes information among actors and thus reduces the need to exchange documentation. Information that was previously documented on paper is now available electronically to authorized users. Additionally, the Dashboard contains a timeline to view past data and analyses, additionally to the functions focusing on resilience assessment and actual / real-time data.
RESPOND	“Drastically reduce the risks for citizens”	The ESSMA (Emergency Support Smart Mobile App) and the GBTA (Game-Based Training App) directly contribute to reducing the risks for citizens. The ESSMA does so by supporting operators in channelling the flow of citizens, either by evacuating them from the area of the critical incident or by, for example, avoiding the overcrowding of certain areas. Ensuring a good usability of the application was important to achieve the maximum impact. The GBTA helps civilians prepare for critical situations and thus further reduces their risk. This required making the training app a fun activity. The ESSMA

Cornerstone	Desired impact	WP5 outcomes to support this impact
		displays only few relevant pieces of information in case of a disruption, in order to achieve effective and efficient adaption of behaviour by its respective users. For the ESSMA to work well, it was also important to ensure a good usability of the Evacuation DSS: citizen evacuation depends on its operator. A training app for teaching civilians how to use the ESSMA has been developed, as well (see chapter Errore. L'origine riferimento non è stata trovata.).
RESPOND	"Reduce the time for taking right decision"	In accordance with the philosophy of resilience engineering, the Dashboard (which is part of the CRAMSS) helps reduce the time for taking right decisions in both emergency and non-emergency situations. This is achieved by providing the user with previously unavailable information that is relevant in decision making. The FRAM tool will further increase the efficiency in decision making by linking decisions to resources actors and guidelines.
RESPOND	"Efficiency in resource allocation during the emergency"	This is actually a subordinate case of making decision making more efficient. The Dashboard lists available resources across actors, who up-to-date had not been exchanging such information, yet. The FRAM tool supports this by naming resources relevant for a certain decision.
RESPOND	"Make emergency services more user-friendly"	To achieve this, we had to ensure that the ESSMA was more user-friendly than what had previously existed by other apps. Previously, available information was published on web sites or send for generalized messaging services. The ESSMA provides individualized escape routes and thus increase this user friendliness, as long as a sufficient level of usability is ensured. As evaluation data of most other relevant emergency apps were not available, the threshold had to be defined based on norms of the measurement instrument, or (if also not available) by expert choice. The interaction needed to particularly take the emergency situation into account, with its special Human Factors requirements. User-friendliness (or rather: high usability) was ensured by the evaluations with citizens (see 6.7).
RESPOND	"Increase communication with citizens and authority"	Evacuation DSS and ESSMA provide features for the two sides to communicate directly. This feature can be used in emergency and normal conditions. As the dashboard includes the twitter vigilance, all authorities have an improved access on such social media contents.
RESPOND	"Ensure widespread accessibility of emergency services"	Although WP5 had no influence on the available number of emergency services it may have helped maximize the output of a given capacity of emergency services by supporting an efficient deployment.
MONITOR / LEARN	"Make the resilience assessment and management process easier and effective"	The information displayed in the Dashboard helps users, over time, detect possible bottlenecks and consequently directs attention to functions or outputs with undesired variability. The FRAM tool helps connect such bottlenecks to system functions, which makes it easier to take corrective actions and thus increase resilience.
LEARN	"Establish coordination with all stakeholders involved in UTS resilience management"	This objective is addressed by the Dashboard, in two ways. By exchanging the outputs of previously separated DSSs, it helps coordinate actions among stakeholders, and by providing a contact list it helps identify who to call in a certain situation. The importance of the contact list was confirmed and the focus groups (see below).

1.2 User Centred Design (UCD)

All application development within the RESOLUTE project followed a user-centred approach. This means that future users of the RESOLUTE applications were involved in every development process as far as possible.

The development of the different applications of WP5 required the application of different Human Factors or ergonomics frameworks. In particular, as we will show later, the design of the dashboard made it necessary to disregard some standards of control room design. Such standards do not apply in this context as they rather reflect rule-based closed safety systems than resilient systems.

While activity theory (e.g., Kuuti, 1995) was promising in the creation of the evacuation DSS, it did not make any sense to apply it in the creation of the Dashboard. In the first case, we referred to the framework presented by Koffesky and Harvey (2015) when analysing user performance with the CRAMSS. The framework divides between three steps of human behaviour: sensing/perception, information processing, and physical/verbal responses. In the end, we did not use this as our main approach in making the Dashboard and the eDSS. In the case of the Dashboard, there is no user input, only retrieval of output. So, following existing guidelines for the representation of information was the better approach, particularly because the Dashboard is the variable system which can be customized by its users and thus looks different in each control room. Thus, it was sufficient to choose the best possible representation format, based on extensive guidelines for Dashboard design. In the case of the eDSS, we followed the approach to analyse the single use cases (e.g. starting an evacuation). However, as we supposed that the key features would be used not so frequently (disasters and evacuations are actually more rare than many other control room events), we opted for making the process easier to understand than saving milliseconds through abolishing the Wizard solution. In a KLS-GOMS analysis, the wizard would require one more click on “next” between step 3 and step 4 in the wizard, compared to the “pro”-solution in which start and end nodes are selected at will. The biggest potential here to increase user efficiency would rather consist in implementing extra algorithms that predict which evacuation is necessary (from where to where) and pre-selects the scenario for the user. That, however, is not in the scope of the project.

Following a user centred design process ensured that the applications and services fulfil the requirements and needs of potential users in an appropriate way and thus lead to well-usable systems and applications.

Further down, in the respective chapters, we will describe the development process in detail. However, all development processes contained the following stages:

- **Requirements analysis:** In this phase of the development process, the main users and stakeholders as well as their requirements regarding the application were identified. Within the requirement analysis the main “W” questions were answered:

WHO is going to use the application – in terms of the main users as well as secondary users?

WHAT kind of functionality or “features” should the application have to enable the users to carry out their required tasks?

WHICH hardware should be considered?

WHERE are the users using the application – considering environmental facts like noise, heat, etc.

The outcome of the requirements analysis consisted of a set of user specific requirements that built the basis for use case or user scenario descriptions, as well as feature specifications for the future RESOLUTE applications.

- **Prototyping:** A prototype is a draft version of an application, depending on the prototype level with no to full functionality range. Prototypes allow developers to explore the comprehensibility and the usability of the application in an early development stage.

Prototypes may generally come in the shape of:

- A series of drawings on paper or paper mock-ups (called a low-fidelity prototype),
- A few screens of the application that the user can click through (for instance a click demo in Microsoft PowerPoint),
- A complete implementation with full functionality (called a high-fidelity prototype).

High-fidelity prototyping is a method in which the prototype used for testing mimics the actual interface as closely as possible. Usually, for software interfaces, another software tool is used to mock-up the interface. This software tool accepts input from the keyboard or mouse like the actual interface would, and responds to those events in the same way (displaying a particular window or message, changing state, etc.) in the same way the actual interface would respond.

The advantages of low-fidelity prototypes are that they can be used in an early stage of the development process and that they aren't expensive in deployment. It is easier to test multiple alternatives of user interfaces with low-fidelity prototypes because they support a fast iteration of alternatives. High fidelity prototypes are more suitable for end periods of the development process. A high-fidelity prototype is close enough to a final product to be able to examine usability questions in detail and make strong conclusions about how behaviour will relate to use of the final product.

As detailed below, we mostly relied on medium-fidelity prototypes.

- **Evaluation:** Within the evaluation phase, the RESOLUTE prototypes will be tested to ensure that user requirements have been appropriately incorporated. The evaluation method depends on the prototype. The main focus of the evaluation was on the usability of the application in terms of understandable wording and interaction as well as the user acceptance. All testing was done under laboratory conditions, as access to running control rooms was no option in case of the T5.2 applications. Guidelines propose that application evaluation in progressed stages of the development should consider testing in the field, taking environmental aspects of the user interaction into account. The pilot test of work package 6 corresponds to this recommendation.

While Activity-centred design (ACD) focuses on the activities of the user to be realised using a piece of technology, User-centred design (UCD) puts an emphasis on the goals and objectives of the user (Saffer, 2010). We stuck with user-centred design, as in many cases it was difficult to foresee which user would engage in which activity. This applied particularly to the control room operators.

1.3 RESOLUTE User Interface development approach

1.3.1 Requirements related to the development approach

All development of user interfaces in the RESOLUTE project was principally oriented at the relevant international norms. This chapter briefly summarizes how the norms are taken into account.

1.3.1.1 Dashboard, eDSS and FRAM tool

In the case of the control room applications, EN ISO 11064 was relevant. The following table sums up how the norm was applied in the project:

Table 2 – EN ISO 11064 – Part 1

Standard / Requirement	RESOLUTE actions
User-oriented design	Representative users were involved in several phases of the design process.
Applying ergonomics	Relevant are only cognitive ergonomics – using design criteria to decrease error probability and mental workload. Physically stressful interactions are not expected with the T5.2 applications.
Iterative development	An iterative process was applied in RESOLUTE. Phase A and B are summed up in the user requirements analysis, C and D are the iterations described in the respective chapters and Phase E is the pilot test (WP6).
Situation analysis	The T5.2 applications (Dashboard, Evacuation DSS, and FRAM tool) are expected to be used in addition to other, thoroughly defined, control room features. Most of their features are directed to spreading information, instead of directly manipulating specific functions. Thus, situation analysis does not require assessing system failures (which would be contrary to the concept of resilience).
Task analysis	Taking all possible action modes of all possible organizations into account that will be using the T5.2 applications was not possible in the context of this project. Instead, we assumed that the tools would be used under high stress, with limited time and possible interruptions. This makes them integratable into other (main) tasks of the operators.
Error tolerance	<p>The Dashboard does not offer any option for false input. Its complexity results of the interactions of many possibly connected users. Errors can especially occur:</p> <ul style="list-style-type: none"> - When a user enters misinterprets given information and act upon it, using his own specific technology, such as a company DSS. <p>The Dashboard will further allow other users to question possibly erroneous data.</p> <p>The eDSS allows for errors:</p> <ul style="list-style-type: none"> - Wrongly configuring an evacuation request. Therefore, evacuation procedures have to be checked and authorized by a so-called Central Decision Maker (CDM). - Wrongly sending a message or newsfeed. This is an unlikely error, we advocate against additional security prompts.
User involvement	This was guaranteed through the requirements analysis and user testing.
Interdisciplinary development team	Psychologists, informatics experts and engineers were involved in the design process (apart from the users).
Documentation of ergonomic design principles	This is done in this very document

The design process defined in EN ISO 11064 –1 was not entirely applicable to the T5.2 applications, which did not involve certain elements frequently found in control rooms (such as controls for valves, doors, etc.) and which followed a resilience approach rather than strict procedures. Although these applications had to fit into existing strict procedures, they mainly constitute additional sources of information to the users. An exception to this is the Evacuation DSS.

1.3.1.2 ESSMA and GBTA

With respect to the mobile applications, other guidelines, such as platform-based recommendations were relevant.

An intuitive interaction with an application is essential for user acceptance. A user should be able to handle the application in accordance with the user's mental model of the application. To provide an intuitive and easy interaction, the RESOLUTE applications needed to consider the distinguishability of interactive and non-interactive areas, the size of interactive areas, latency for user actions, comprehensible UI text and labelling of controls, and a good information- and error-management.

1.3.1.2.1 Distinguishability of interactive and non-interactive areas

A user interface can be divided into areas that are not offering any means of interaction to the user (plain text, status bar, inactive buttons, etc.), while other areas do offer such means of interaction (e.g., active buttons, text entry fields, drop down menus, check boxes, etc.). To provide an easy and intuitive interaction with RESOLUTE user interfaces it had to be clearly distinguishable which areas are active and equipped with functionality and which areas are inactive and just provide information to the user.

The following guidelines apply for distinguishable user interface areas and elements (Microsoft, 2012):

- Interactive and non-interactive areas and elements should be distinguishable by its design (UR).
- For active areas like active UI elements a similar design should be used (UR):
 - Temporarily non-interactive operation elements should be greyed out and/or should not be elevated by means of 3-D-representation (readability of text on elements should be ensured),
 - Active areas: May be elevated by means of 3-D-representation,
 - Interactive text: Should be emphasised.
- For non-interactive areas like text or status information a similar design should be used (UR):
 - Non-interactive text: Do NOT use colours that are in other places used for hyperlinks. Do NOT underline text,
 - Non-interactive areas should have the window background colour.

1.3.1.2.2 Size of interactive areas

For users with limited mobility and for elderly people it is recommended to design interactive areas larger than their related UI element. This guideline especially applies to devices based on touch interaction (UR).

1.3.1.2.3 Information- and error-management

A good information and error management is crucial to give the user the feeling that he/she is in control of the system. Users need to be informed about the system status in a comprehensible way. Error- and information messages can be categorized into the following types:

- Information messages present general information to the user, like the progress of an system action (Gnome, 2008, 2012),
- Warnings and alerts inform users about the possible consequences of a requested action, report on the results of an action, if they may not be expected (for example, when only three of four selected files were successfully downloaded), or report on other types of unexpected situations such as system conditions (for example, when disk space is running low) (Gnome, 2008,2012).
- Error messages report system and application errors to the user (Gnome, 2008, 2012).
- Confirmation alerts ask the user a question, usually before being able to carry out a requested action. For example, if the user uses the backward navigation and the current page is a fill-in form actually not saved the systems asks to continue the requested action with the consequence of data loss or to abort the requested action (Gnome, 2008, 2012).
- Success alerts indicate that an action has completed successfully (for example, a successful data down- or upload) (Gnome, 2008, 2012).

1.3.1.2.4 Latency of user actions

Response time to user action is an important aspect of usability. If the user has the feeling, that the application is not or very slowly reacting, or is reacting too fast to be handled, then the user might stop using this application.

The following guidelines are recommended:

- For response time below one second no progress information is needed (Nielsen Norman Group, 2013).
- Response to user actions should be immediate (UR).
- Even if long response times should be avoided, responses shouldn't come up too fast, the user should perceive the changes in the user interface and should have the possibility to react to changes (e.g. for scrolling) (Nielsen Norman Group 2013).
- If the response time is more than one second the user should be informed (Apple, 2012).
- For lengthy operation a progress indicator should be provided to inform the user how long the operation will take (Apple, 2012).

1.3.2 RESOLUTE UI development model

The overall user interaction approach in RESOLUTE was aimed at supporting the users by providing content through “*enhanced visualizations and other multimodal means, including speech, vibration, automated phone calls, as well as indirect environment-enabled guidance (e.g. traffic lights guidance)*” (GA, p. 151).

The different user groups addressed by the three applications imposed a variety of Human Factors requirements on the development. These requirements are described in the respective chapters below in conjunction with each user group.

As represented in Figure 1, relevant information gathered in laboratory testing during the user interaction development process was fed back to the ERMG development process. This was aimed at further improving the ERMG where necessary between M30 and 36. The outcomes of WP5 work were required for the successful realization of the pilot tests.

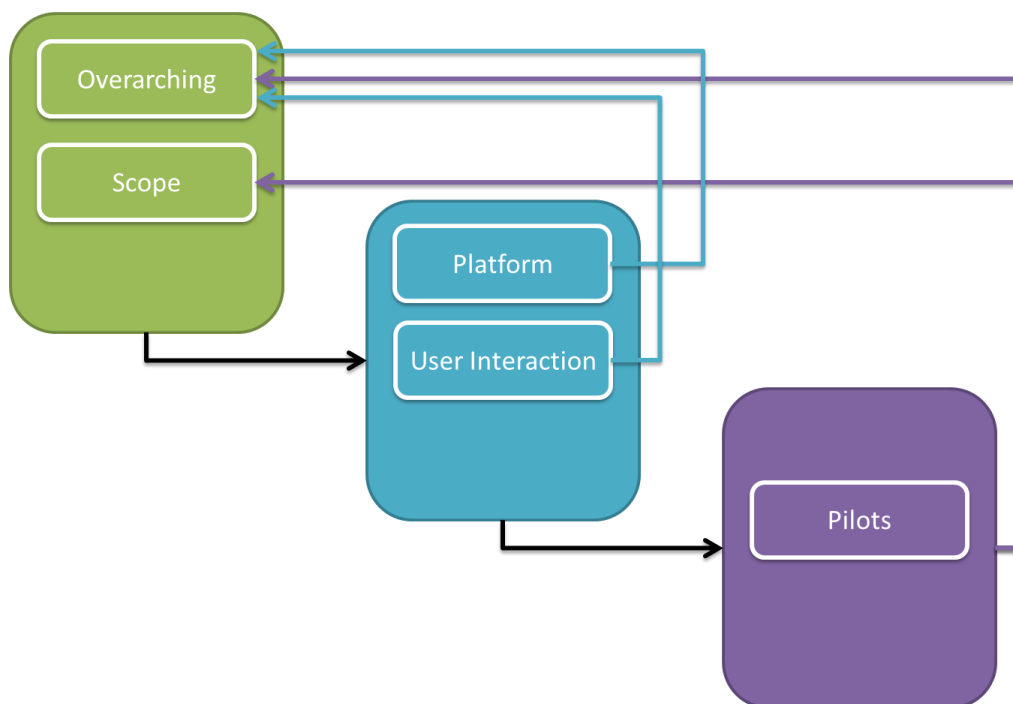


Figure 1. Visualization of the overall usability engineering approach (GA, p. 167)

The RESOLUTE iterative development approach consisted of two iterations.

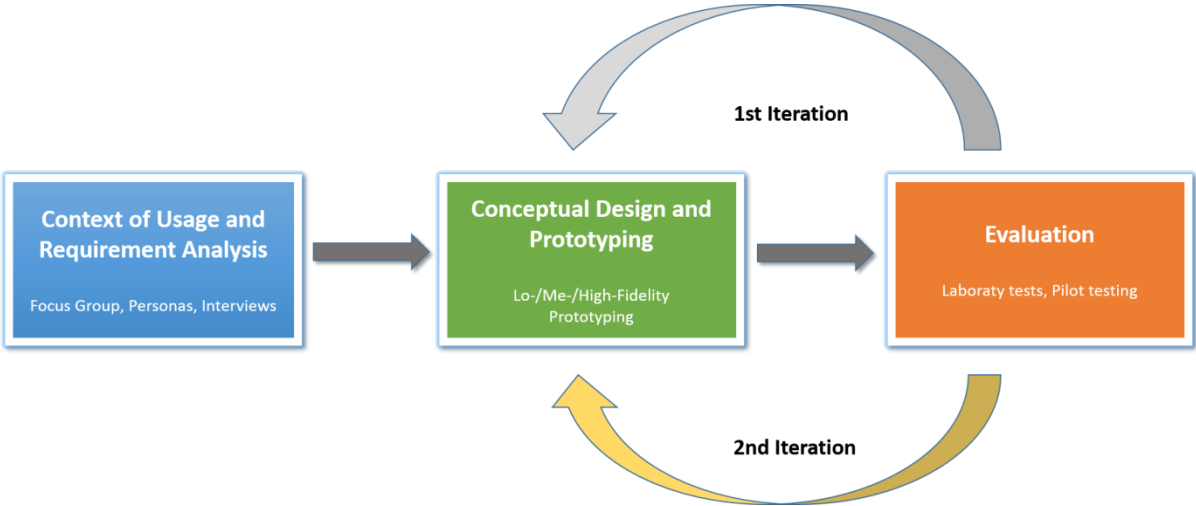


Figure 2: Detailed view of the front-end development approach in RESOLUTE

Iterative development of user interfaces involved steady refinement of the design based on user testing and other evaluation methods. Problems encountered by several test users while using it could then be fixed in a new iteration. The resulting design or prototype was then re-tested to ensure that the problems of the first iteration were now solved and to find any new usability problems introduced by the changed design. Based on the requirements described in this document, materials were created, such as instructional guides for focus group discussions, in order to finalise the requirement analysis. A focus group was conducted to prioritise functions or objectives described below, in order to delimitate the content of the final user interface. Based on the requirements collected, low- or medium-fidelity prototypes of the different applications were produced and tested in the laboratory with end users. The feedback collected here was used to refine the prototypes, which after that went into a second round of testing.

1.3.3 RESOLUTE UCD methods

D5.1 contained a list of possible UCD methods to be used. In the following tables, we maintained the descriptions of the methods that were eventually used. We used Focus Groups for analysing user requirements concerning what at that stage was considered to be the CRAMSS and later divided into the Resilience Dashboard, and the eDSS. Interview techniques were used in the work related to defining the contents of the GBTA, as well as for gathering additional CRAMSS-related user requirements from CdF.

Table 3: Requirements analysis

Method	Description
Focus group	Focus groups consist of a moderated discussion with potential users. It is especially useful to make an initial analysis of the people’s attitudes and beliefs. Within a discussion setting, the participants express their subjective feelings and ideas guided by a facilitator. The particular advantage of this method is that it brings up ideas that would be missed in a questionnaire or a one-on-one interview situation. Relevant information is also revealed through the interaction between the participants.
Structured interview	The interview is a method for discovering facts and opinions held by potential users of the system being designed. It is usually performed by one interviewer speaking to one informant at a time. Reports of interviews have to be carefully analysed and targeted to ensure that they reveal relevant information. An interview can typically gather more information than a questionnaire and go into a deeper level of detail. Interviews are good for getting subjective reactions, opinions, and insights into how people reason about issues. Based on the information required, an 'interview schedule' is prepared. This is a set of

Method	Description
	topics that one needs to discuss with the interviewee in order to obtain that information. One decides on the order in which to cover the topics. For each topic, an 'askable prompt', an instruction on how to ask for the respective information, should be prepared, as well as an explanation of each topic (in case the informant does not understand the 'askable prompt'). For a highly structured interview, each topic will be broken down into a series of sub-topics, each with their own 'askable prompt'.

For all user tests, we used click demos. Functional prototypes will be used in the WP6 pilot tests. They are mentioned here because they still relate to the design process as described by the above mentioned standards.

Table 4: Prototyping methods

Method	Description
Click demo	A click demo is a low fidelity digital prototype that implements some interactive elements of the interface. The focus of the prototype is not on the look and feel of the interface, but in the actions that the user can perform in order to fulfil a task. Click demo prototypes will help designers refine the page flow before implementing any graphical aspects of the interface.
Functional prototypes	In the RESOLUTE pilot tests, functional prototypes will be tested and evaluated. They will be versions of the applications that show the desired functionality, at least under pre-defined limiting conditions. They allow for the most realistic testing and the identification of the broadest range of possible errors in design or technical functioning. They are useful at the end of a development process, based on the effort necessary to create or adapt them.

We used cognitive walkthroughs for evaluating the designs before user testing, in order to ensure that obvious design errors were avoided. The early prototype of the CRAMSS was partially steered by the test instructor, which corresponds to the Wizard of Oz technique. The thinking-aloud technique and usability questionnaires were applied in the first test of the ESSMA and in the last tests of the Dashboard, eDSS and ESSMA.

Table 5: Evaluation techniques

Method	Description
Cognitive Walkthrough	The Cognitive Walkthrough (CW) is a usability inspection method that aims to assess the ease of use of a design through exploratory techniques, based on a cognitive model of learning and use (Wharton, Rieman, Lewis, & Polson, 1994). To do so, a set of expert evaluators or a set of prospective users is asked to perform a series of tasks using a prototype of the interface. The evaluators will use information about the cognitive factor of a set of target users - experience and acquired knowledge – to check if the interface fits their mental models. Each action within each task should be thoroughly reviewed, aiming to elicit whether all target users will understand the actions and responses of the interface. The CW method has, for example, been enhanced for safety critical purposes (Bligard & Osvalder, 2013).
Wizard of Oz technique	The Wizard of Oz technique (Ardito, Buono, Costabile, Lanzilotti, & Piccinno, 2009; Nielsen, 1993) is a very helpful method to simulate system behaviour. In user testing, this technique has a user interacting with an interface without knowing that the responses are being generated by a human, not a computer. This allows testing of some difficult interface concepts before a system is fully working on a functional level.
Thinking-aloud technique	A thinking-aloud test involves having a test subject use the system while

Method	Description
	<p>continuously thinking out loud (Lewis, 1981). By verbalizing her thoughts, the test user enables the developer to understand how he views the computer system. One gets a very direct understanding of what parts of the dialogue cause the most problems because the think-aloud method shows how users interpret each individual interface item (Nielsen, 1993). Disadvantages of this method have been widely discussed (Hertzum & Holmegaard, 2015). A problem of the thinking-aloud method is that it can't be used together with time measurements, because the need to verbalize can slow users down. When using the think-aloud method, the experimenter should often prompt the user to think out loud by asking questions like "What are you thinking now?" and "What do you think this message means?"</p>
Usability Questionnaires	<p>Standardised questionnaires can be used to measure statistically the user experience and user acceptance of a system. Recommended questionnaires are the AttrakDiff (Hassenzahl, 2003), and the Isometrics-S (Willumeit, Gediga & Hamborg, 1996). For other, newer instruments, such as the USE questionnaire (Lund, 2001), validity is likely to assume yet not proven.</p>

The chapters below describe the developments in detail.

2 DIVIDING THE CRAMSS INTO 3 APPLICATIONS

2.1 Why divide the CRAMSS?

T5.2 was focused on the development of the Collaborative Resilience Assessment and Management Support System (CRAMSS) for Urban Transport Systems (UTS). At the beginning of the project, the CRAMSS was intended to be one single application. This was reflected in the first mock-ups, published in D 5.1. However, this concept was reshaped during the course of the project, and now we have a different understanding of what the CRAMSS is.

The development of the CRAMSS started with the definition of user objectives (published in D5.1). Today, an updated summary of these objectives would read like this:

ANTICIPATE:

- Help the stakeholders apply the ERMG. (“The CRAMSS System to be developed within RESOLUTE is meant to operationalize the ERMG guidelines for UTS”; GA, p.148)
- Predict, where possible, critical incidents. This refers not only to single risk factors but to functional resonance. That means: predict danger that occurs due to unwanted variability in several (systemically interconnected) functions of the system
- Help stakeholders spend their limited resources correctly to cover such critical incidents.

MONITOR

- Monitor, if necessary, a multitude of processes or aspects of the UTS; particularly: traffic flow and passenger flow.
- Know what other actors are doing (that means: know the resilience strategies currently in place and those supposedly to be applied next).
- “Coping with uncertainty” (GA, p. 135): maintain an overview of activated resilience strategies, as defined by “control points”, “conditions” and “actions” (see D4.1 and Annex).
- Detect disruptions when they occur. Realize quickly where the disruption is localized and what effects it is already having on the UTS.
- Turn citizens into sensors by exchanging data between CRAMSS and ESSMA.

RESPOND

- Quickly get a reliable overview of the disruptive situation / event.
- Each user should be supported in making their own decisions (based on the specific role, e.g. ambulance dispatcher) by such information given.
- This particularly requires what is part of the MONITOR cornerstone: know what other actors are doing.
- A special case is the support for the evacuation of people (either pedestrians or cars). This rather refers to a new role in the system (evacuation responsible), as the technology provided to this end by RESOLUTE was not available before the project.
- Turn citizens into voluntary helpers by exchanging data between CRAMSS and ESSMA.
- Communicate directly with certain groups of citizens

LEARN

- After an event, replay decisions taken (e.g. from a log) and analyse them with respect to the ERMG and the FRAM model of the UTS: where all relevant factors taken into account when taking the decisions? Which variability was not taken into account?

Some of these objectives apply to a multitude of users, while others rather refer to a single user role within the urban transport system. They also apply to different activities or stages of the work. We separated the respective features into different applications, in order to be able to provide each user with just the desired features and functionalities that correspond to the individual activities. In this chapter, we describe the new concept of the CRAMSS and we give an overview of the applications created in T5.2.

The CRAMSS is primarily a concept or an idea of a collaborative workspace in which DSS operators can share their outputs of or information about their work among each other. Thus, at theoretical level, the CRAMSS is a frame to gather and display output information from separate databases or DSSs. So, for the CRAMSS to exist several technical components are necessary, even though – and that is the very point behind the development of the CRAMSS – these components may be developed and managed by different entities autonomously, such as the DSSs.

The CRAMSS being developed and demonstrated in the RESOLUTE project is just one possible instance of such a collaborative space. With new or other DSSs becoming connected to it, with additional sources of information getting available, or with new cross organizational communication rules being implemented, the content and the design of the CRAMSS may change. The results of the RESOLUTE project are open to connecting further DSSs, which may have an influence on the appearance of the CRAMSS to users.

In any possible realization, the CRAMSS would consist of a backend that communicates with the ESB (both, sending and receiving information) and a front-end for user interaction. In the RESOLUTE project, this user interface is represented by the Resilience **Dashboard**. The Dashboard shows information retrieved from different, usually separated DSSs. Thus, the main purpose of the CRAMSS remains the same that was reported in D5.1: *“to support reference actors at the UTS, such as infrastructure managers, with their decision making under both, standard operating conditions and emergency conditions. The CRAMSS displays information from different sources or independently running web-applications, together with the results of the decision support”*.

So, the dashboard is a connecting link between various decision support systems. In order to fulfil all the above mentioned objectives, and specifically to support the resilience cornerstones RESPOND, RESOLUTE has created an evacuation DSS (eDSS), which is also one of the outcomes of work package 5. The core objective of the evacuation DSS is the calculation of individualized evacuation routes for civilians.

The FRAM tool operationalizes the FRAM model in order to provide operators with an overview of which resources are necessary for which decision, which guidelines apply to the specific decision-making, and who are contact persons in other organizations that provide resources for one’s own decision.

In summary, task 5.2 has produced three outcomes:

1. The Resilience Dashboard
2. The Evacuation DSS
3. The FRAM tool

Each of these applications is presented in one of the following chapters.

Figure 3 provides an overview of these three tools. The resilience dashboard and the FRAM tool are intended to you be used by all operators, by the evacuation DSS is reserved for one specific operator. Each DSS sends information to the ESB, which redistributes the information to the different instances of the Dashboard. The CDS as the central decision maker, for example the mayor. Each of the operators in the picture is expected to be a

member of a different organization. Each operator has an individually considered dashboard and access to the FRAM tool. The evacuation DSS also interacts with all the instances of the ESSMA, which is not included in the figure.

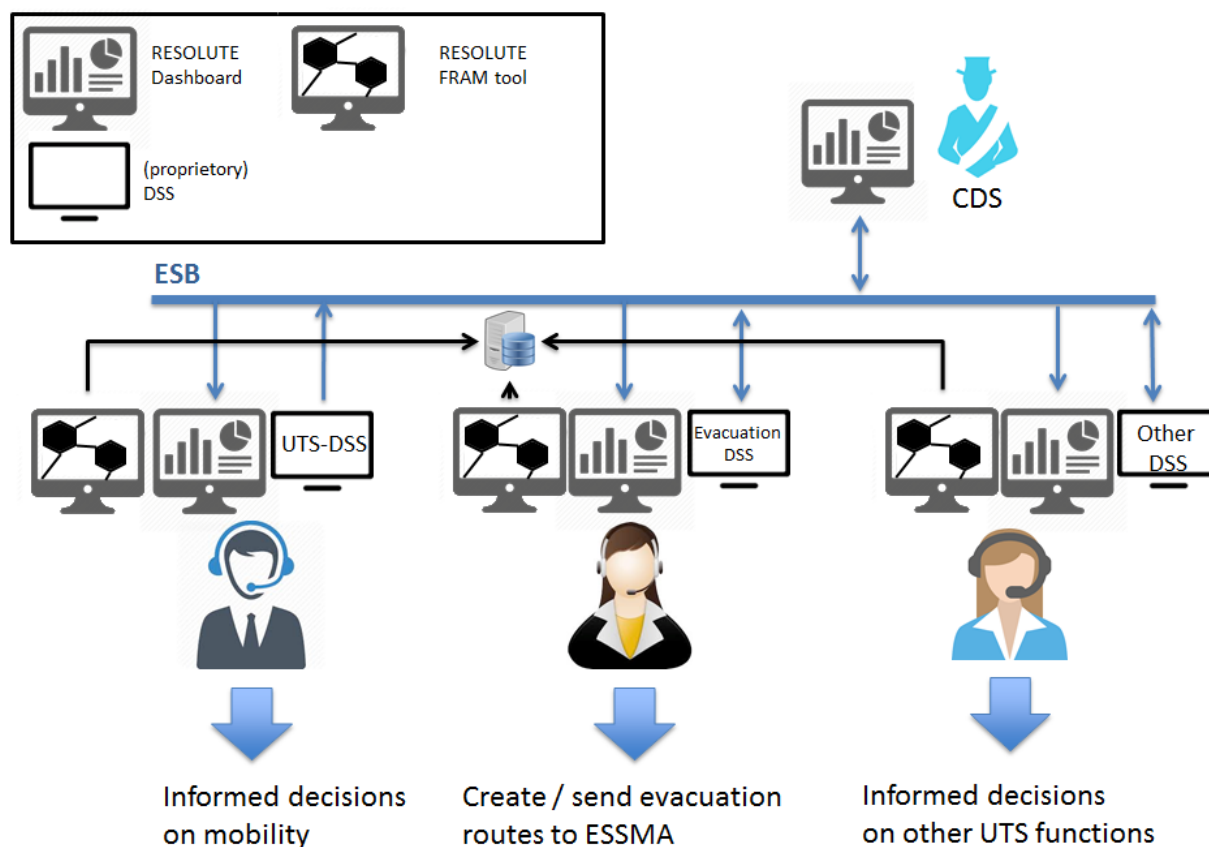


Figure 3 – T5.2 outcomes - overview

2.2 User requirements regarding the T5.2 applications

In D5.1, we had collected user requirements concerning the CRAMSS. They served as guidance during the development process and when we split the CRAMSS into three applications, some requirements were only relevant for one of these applications. Here, we make reference to these and show to which of the applications they now refer.

2.2.1 Based on the Description of Work

Relevant design criteria / user requirements were:

1. Provide “context aware, personalized and timely communication”. (obj.3) (→ Dashboard, eDSS)
2. Only display the most relevant information (obj.3) (→ Dashboard, eDSS, FRAM tool)
3. Reduce time distance between early warning and required action (obj.3) (→ Dashboard, eDSS)
4. Support the integration of new sources of data through “an open, service oriented, multi-layer architecture” (GA, p. 148). Thus, the user interface needs to be designed in a way that requires minimum training (or none at all) for the operator when data sources are changed. (→ especially Dashboard, yet also eDSS, & FRAM tool)
5. User state/trait variables and situational variables to take into account: “extreme stress”, “uncertainty, compressed timelines”, “lack of information and information quality”, “multiple actors”, “requiring dynamic, real-time, effective and cost-efficient solutions” (GA, p. 150). (→ Dashboard, eDSS)

2.2.2 Based on the RESOLUTE workshop results

D7.2 reports the outcomes of the RESOLUTE workshop held in Florence, Italy, on December 15th 2015. The workshop identified user requirements to be taken into account in the creation of the WP5 applications. The following requirements were relevant:

1. Flooding scenario: The main difficulty lies in localising the boundaries of the phenomenon and the prediction of possible consequences; both aspects are highly variant and difficult to predict. This is to be achieved through the monitoring functions (D7.2, pp.11-12). Thus, the monitoring function (**Dashboard**) needs to provide risk maps and real-time data to assess the current status in parallel. In the best case, both can be visualized on the same map while making intuitively comprehensible which data are static scenario data and which are real-time data. The **eDSS** needs to support a quick and effective evacuation of the civilians that takes into account how safe spots or paths may change with continuously rising water. This refers to taking risk maps into account in the calculation of routes. The actions related to the subcases (D7.2, pp.16-17) relate to the different DSSs and the equipment already in place in different control rooms:
 - a. Underpass blocked by water: “informing that the underpass cannot be used” and “traffic re-routing and adaptation.” → **eDSS** (send newsfeed to ESSMA users); UTM DSS / UPT DSS: manipulate digital signalling.
 - b. Social valuable places: “evacuate the place”, “prevent further accesses to the place” and “recognition” (identify such a place based on the dataset). → **eDSS** (calculate evacuation routes).
 - c. Flooded roads [...]: “change traffic light cycle”, “urgency ranking”. UTM DSS / UPT DSS: manipulate digital signalling.
 - d. 30 years / 200 years flooding: “evacuation plan definition”, “citizen information”, event monitoring, close access to the affected areas, mobilise resources to rescue people and goods, activate countermeasures, suspend / partially recover public transport service (only 200 years flooding), “activate short-term recovery plan”, and “detect recovering areas”. → **eDSS**.
2. Vehicle accident scenario: The challenge in this scenario lies in quickly and efficiently redirecting traffic (D7.2, p.13). The **Dashboard** can show the location of the accident to all actors, each of which then does his/her best to prevent repercussions (UTM DSS: re-route traffic; UPT DSS: provide public transport capacities to dampen the effect of the traffic jam; eDSS: evacuate civilians if necessary, or inform about the disruption). The **Dashboard**'s map needs to provide a sufficient resolution to identify the relevant size of the blocked street or road and to take into account which other streets or roads are available for re-routing the traffic. The following processes are supposedly relevant:
 - a. Cars / train: monitoring traffic levels, send information to the other road users, establish possible alternative paths, separate or block affected areas, advise emergency units. → **ESSMA** data provision to **eDSS**
 - b. Dangerous goods: advise special responsables → **ESSMA** chat to **eDSS**
 - c. Motorcycles: advise emergency units → **ESSMA** SOS-call to **eDSS**
3. Bomb attack scenario: A bomb attack on a metro station will possibly result in the need to close several stations along the affected line, or even a complete shutdown of one or several lines (D7.2, p.14). This immediately creates considerable complexity in the re-direction of user flow and traffic. The following processes may be particularly relevant:
 - a. General case: Immediate information (from OCC) to the first responders, social media monitoring. → The former is already covered by existing channels, the latter is included in the **Dashboard**'s twitter vigilance.
4. Large yard event: no general requirements, additional to the ones already defined, seem to arise from this scenario. The following processes should be considered:

- a. Detect the event in real time, guide the people to the nearest exit, advice emergency units. → **eDSS.**

Additionally to the defined processes and requirements of each scenario, the workshop led to several relevant conclusions.

1. In the resilience processes, a multitude of actors from different authorities is involved, and responsibilities and processes may not always be well-defined. → **To account for this, the CRAMSS (→Dashboard) lists the correct or possibly relevant affiliations or persons to be contacted.**
2. The need to “optimally manage the scarcity of resources in term of first responders, goods, and tools available during an emergency” (D7.2, p. 27) is accounted for by the effect that the **Dashboard** is expected to have on cooperation across organizational borders.

2.2.3 Based on the target user description

With respect to the target users, their objectives and the area of work, the following requirements based on Human Factors research are particularly important:

1. All applications must be available in the local language for their users at the pilot sites. An English version will be produced as English is the common project language.
→ **Languages: ENGLISH, GREEK, ITALIAN**
2. Efficiency. During an emergency, the Dashboard and the eDSS are meant to speed up relevant processes. Thus, from the ISO 2941 criteria, efficiency is deemed the most important criterion, user satisfaction the least important one. The following requirements result from an increased need in efficiency of use.
 - a. Dashboard: efficient uptake of only relevant information
 - i. Mark important information (e.g. when critical threshold was passed)
 - ii. Achieve a good data ink/non-data ink ratio.
 - b. eDSS: Short duration of tasks; Intelligent routines to speed up operations
 - c. eDSS: if evacuation is a seldom case, provide enough user guidance to ensure the user does not get stuck. This is more important than saving 10 seconds due to a lean process for expert users.
 - d. Dashboard: Cognitive workload: similarity of routines; minimum number of layouts
 - e. eDSS: Cognitive workload: separate tasks if possible.
 - f. eDSS: Maximize feedback for detecting errors
 - g. eDSS: Minimize time for fixing / resolving errors
 - h. FRAM tool: provide only information relevant to the user’s role.→ **Ensure efficiency of use.**
3. **eDSS:** Minimize the occurrence of errors. Even though this could be part of the efficiency-requirement, this is stated as a separate requirement due to its importance. Errors could have fatal consequences and may be difficult to undo, once the given commands have been acted upon by rescue teams or other responsible actors in the field. Stress is a psychological function that decreases the level of detail perceived. This means that in emergency situations, the displayed information should be limited to a minimum, unless the user requests information in more depth. Based on experimental studies, user interface design takes advantage of the fact that recognition is faster and exceeds less effort than

recalling (Loftus, 1971; Norman Nielsen Group, 2014). As a consequence, the different functions of the user interface will be designed in a way that makes sure recognition is available as often as possible.

→ **Avoid user-based errors. Reduce cognitive workload (need of memory and processing).**

4. Suitability for the task: (Active-passive behaviour; Push- vs. Pull- scenarios; Processes fit smoothly into other activities; processes (apart from being short) can be paused, resumed or repeated when the operator wants to). The information needs to be presented in a way that maximizes the user's working efficiency and that allows for temporally not paying attention to the eDSS, as operators are usually required to perform multiple tasks in parallel during disruptions.

→ **Unobtrusive active behaviour (e.g. when warning) / Make all processes interruptible.**

With respect to the target group, some other Human Factors requirements are also important yet of secondary importance:

5. Learning effort: The user of the eDSS will supposedly receive professional training. In the case of Dashboard and FRAM tool, this is less clear. Thus, the latter need to be particularly supportive to exploration and learning-by-doing. This is the case as these tools essentially do not allow for making critical mistakes – they do not allow for direct manipulations.

→ **Support exploration.**

6. Attention span and perception: Humans have a limited capacity of perception when it comes to searching for changes or patterns over a longer period of time. While the quality of human perception is high, compared to what is currently possible with machine-based solutions, humans cannot stay focused too long. This is particularly true for an operator in a situation of crisis. Thus, information needs to be displayed in a manner that avoids the need for persistent attention (Richter, 2000). The system needs to provide options for easily viewing pieces of information together which belong together and support the user by registering events he himself may miss.

→ **Avoid tasks that require a sustained attention span; make information widgets (Dashboard) moveable. Display different information (e.g. map and user clustering) together.**

2.2.4 Based on the objectives

1. Most safety regulations require a human actor to have the last say in decisions that affect actions in regular and emergency modes at CI. This is why the eDSS is a decision support system, not a decision system. All real-world actions need to be triggered by the operator. Furthermore, the operator needs to be able to override system features that are possibly malfunctioning. Also the Dashboard and the FRAM tool do not take any decisions, they only provide information for the human to decide herself.
→ **Organize real-world action triggers to have them all available when possibly required (independently of sensor input). Especially, include a trigger for starting/stopping the alert mode.**
2. Connect information that belongs together. Decision support based on sensor information should be linked to the sensor's output visualization in order to allow the user to "quickly get a reliable overview of the disruptive situation / event".
→ **Connect decision support and sensor information. We did this in the eDSS, where the effects of the evacuation decision are always visible.**
3. Assigning roles to users of the ESSMA is supposedly mostly related to the location of these persons, taking into account blocked pathways, exits, and other resources. Thus, the ESSMA users need to be displayed on a map, together with information on the user role.

→ **The eDSS and the Dashboard visualize person roles, as far as known, on a map. This includes the results of user profile analysis, too (see D5.3).**

4. Although the eDSS is able to send automated individualized information, to users (e.g. concerning the correct escape path based on the user's mobility profile), it may become necessary to send messages that cannot be automated. This again ensures that the operator is empowered to have the last say in the messages being sent to users while commanding the evacuation. This also requires finding a (visual) representation for the messages sent to the users, even though they are possibly (partly) individualized. Vectors on a map may for example indicate in which direction a person was sent through automated messaging.

→ **We did not limit the operator to sending automated messages: Newsfeed / timeline in the eDSS.**

2.2.5 Based on the features

1. Although some features are only running in the background, it is important for the operator to know if everything is working well.

→ **The Dashboard checks data for plausibility. This extra information is displayed unobtrusively.**

2.2.6 Based on research and other relevant aspects

1. The SAVE ME project¹ (Grant Agreement No. 234027 of the European Commission) produced two key requirements of operators when interviewing operators of a road infrastructure (linked to police and fire brigades) (Leuteritz, 2011).

- a. In the case of traffic incidents and traffic accidents, the operators want to decide by themselves, whether to ask travellers to self-evacuate. Thus, this option has to be always visible. Operators will take about 2 minutes for this decision. (Hence, an automatic solution after 3,5 minutes can be considered)

- b. The situation in the shelters should be described by numbers, not by masses of dots.

→ **Self-rescue should not be triggered fully automatically (also for legal reasons). Simplify information, e.g. by providing numbers instead of dots. Both was respected in the design of the eDSS.**

2. The SAVE ME project also researched the requirements of metro operators (Leuteritz, 2011). Most of the findings are already represented in the list of features, such as the need for information on the disruptive event, alerting, and identifying the location of persons to be rescued. Additionally, the user requirements suggest that messages given by the CRAMSS should be divided into groups, depending on their urgency. Important messages should be demanding more attention than less important messages.

→ **Cluster system messages into Level 1, level 2, and level 3 priorities. We did this in the Dashboard (alerts, warnings, and events).**

3. The operator interviews conducted in the SAVE ME project (Leuteritz, 2011) revealed that travellers frequently disrespect orders, such as requests for evacuation. In a given example, travellers even attacked members of the police who were blocking the access to a subway platform during a fire drill.

¹ The SAVE ME project produced a system for supporting self-rescue of civilians from traffic infrastructure. Thus, it is to some extent a predecessor of the RESOLUTE project and its results part of the relevant state of the art.

As a consequence for engineering the portal, the system should provide an active help to the operator while following up on the behaviour of groups of travellers and identifying locations where orders are being ignored.

→ **Follow up on traveller behaviour, possibly by marking groups of people that show unexpected behaviour. The eDSS thus allows for following up on all users of the ESSMA.**

4. Supporting the OODA-loop: Based on the OODA-loop (observation, orientation, decision, action), which is still used as a basic Human Factors concept in designing mission-critical interfaces, the eDSS should help the user go from step to step and thus take into account that in non-equilibrium situations, the OODA-loop may be closed faster than in equilibrium situations (Rahman et al., 2008). Based on Gestalt-psychological principles, processes and visualizations should support the loop and actively decrease the rate of error, e.g. by displaying relevant controls sequentially or next to each other, or by making less relevant controls temporarily disappear.

→ **Provide sequential or special grouping of information elements and controls to support quick OODA-loops. This was done by keeping the eDSS simple, grouping action types in the toolbox and by automatizing modes (e.g. auto-selection of the circle-tool) through the evacuation dialogue.**

5. The eDSS is a mission-critical instrument and compared to, for example, the ESSMA, it has one special characteristic: when a critical event comes up, no action might be better than a wrong action. Thus, the support for fast decisions should not be provided in a way that supports overly fast decisions. The eDSS should prompt key criteria for the decision making and support taking a well-informed decision and consecutive action, rather than running the user through standard procedures.

→ **The Dashboard provides additional information on whether to evacuate or exclude an arc from evacuation routes.**

3 DASHBOARD

3.1 Introduction

As stated above, the CRAMSS provides a collaborative space in which operators can exchange information among each other. RESOLUTE's Resilience Dashboard realizes such a collaborative space. It provides its users with an overview of the information collected in the ESB.

How does the Dashboard support increasing the resilience of UTS?

A central idea in resilience engineering is that complex socio-technical systems cannot be controlled based on sets of rules; instead, expert actors take decisions under uncertainty on how to allocate limited resources in order to enable the system to cope with unexpected variability in its functions (see D2.1), or to actively dampen functional variability. In order to achieve this, it is vital for the actors to see the whole picture, for example: the entire output of the function (e.g., service delivery) that they are having an influence on. As an example, the information that several lines of the public transport system have to be shut down temporarily due to an incident is also relevant for the actor that manages urban street traffic.

The Dashboard thus helps increase the resilience of European UTS by providing features that help (possibly) locally dispersed actors make best use of the given resources, resulting in optimal efficiency and efficacy. To achieve this, the Dashboard serves mainly as a distributor of information; the operators can retrieve information from it that is entered in an automated manner; the Dashboard (with a few exceptions) does not serve for its users to enter input.

But why is the Dashboard needed? Nowadays, critical infrastructures depend to a great extent on decision support systems (DSSs). In many infrastructures, such decision support systems are linked together and provide their output to a range of interests that operators that may depend on such information. This is true at airports or nuclear power plants, for example. Cities are special in the sense that their critical infrastructure is managed by a multitude of organizations, and thus by locally dispersed users. Each organization (government/administration, police, fire brigades, civil protection, UTS companies, electrical energy suppliers, etc.) uses their own DSS and is responsible for maintaining the confidentiality of their data. Due to the complexity of sociotechnical systems, managing resources and outputs of one function affects other functions as well. Particularly, interaction effects caused by functional variability have to be controlled in order to achieve an acceptable level of resilience. The core objective is to inform actors about such interdependencies and the risks of functional resonance. Consequently, operators should have access to relevant information about the activities of other stakeholders – or the problems and variabilities encountered by those.

However, providing users outside the organization with direct access to such data, be it input or output to the DSS, is a risky or per se prohibited in many organizations. This is the fragmentation problem addressed by RESOLUTE. The dashboard provides a solution to this problem. Through the Enterprise Service Bus (ESB), the decision support systems can exchange a selected number of their outcomes without compromising the databases in the background. To authorized users, the Dashboard can show a summary of such outcomes and other information that is queried from databases, tailored to the individual user's needs. It bypasses the named liability issues.

This corresponds to Bungay's (2011) *directed opportunism* approach: instead of maintaining "command and control", he proposes "mission control" which allows decision makers to take free ("opportunistic") decisions in order to account for current conditions that are not reflected in overall strategy. This requires closing three gaps: the knowledge gap (which represents the difference between the decision maker's desired knowledge and actual knowledge), the alignment gap (which represents the difference between what actors are expected to do and what they actually do) and the effects gap (which is the difference between the expected and the actual results of the actions taken). The Resilience Dashboard addresses the knowledge gap, referring to a-priori knowledge, and the effects gap, as it helps the operator keep track of what is actually being achieved, compared to what was planned.

The Dashboard particularly relates to resilience, as it visualizes the results of resilience assessments (compare GA, p. 136), which are provided through a back-end module. The resilience concept is propagated through the combination of the Dashboard and the FRAM tool: the Dashboard indicates where unusual variability is happening in the system and the FRAM tool relates such variables to the FRAM model and helps understand the consequences of such variability.

In accordance to the resilience concept described in D2.1, all features of the Dashboard are available in normal operation conditions, as well as in emergency conditions. Thus, it does not have an "alert mode". It is meant to be used the same way at all times (see 3.4).

From the perspective of user interaction design, it is important to note that the Dashboard will not substitute existing systems at the operator's or manager's control desk. It will be an **additional** system, even though it may share common features with existing ones, or serve to reach the same objective: improving the operator's situation awareness. This is important because, as a consequence, the Dashboard does not represent the standard emergency procedures in the control rooms of the RESOLUTE pilot sites – which would in any case be unrealistic due to the differences between the application areas, legal background, etc. Instead, it needs to fit in between the existing processes, providing shortcuts or boosting efficiency by addressing relevant needs and bottlenecks that are expected to arise in emergency conditions.

3.2 Target users

3.2.1 User characteristics

Target users of the Dashboard are managers and decision makers at Critical Infrastructures (CI), as well as so-called “operators”. A relevant characteristic of a user of the Dashboard is thus that such an operator is a person entitled or empowered by the organization to take decisions during normal operations and in cases of emergency.

In this deliverable, the term operators refers to all persons working at a CI who are in charge of monitoring the flow of vehicles or passengers and whose responsibility it is, in a case of emergency, to redirect traffic or person flow or to coordinate mitigation attempts. These professionals are trained to know the procedures to be followed in different types of emergency, usually based on a handbook with clear instructions. They are trained at using the tools available at their workplace, including IT-infrastructure for monitoring or steering the flow of traffic.

Managers or other decision makers are persons with a higher responsibility and executive power, yet they are not necessarily involved directly in ground level operations. They are not necessarily aware of the detailed procedures to be followed in emergency situations. Their primary task is to provide the correct resources and to make strategic rather than tactical decisions, thus ensuring that the CI is constantly maintained at a partially or fully functional level.

Target users of the Dashboard for the Florence pilot will be the City Administration, led by his excellence the Mayor of Florence, with the following divisions:

- the Mobility division, supervising and regulating traffic and main public and private transport infrastructures
- the City Police, patrolling traffic, the first to escalate problems in daily operations and to take care of ordinary stresses
- the Civil Protection – a critical function, which is triggered in case of natural disasters – it can be triggered on event-driven basis, or upon political decisions, and
- the Information Technology division, which provides internet, intranet, data, business continuity, IT disaster recovery, etc.

Under the supervision of the City Administration other operators from all the main public and private utilities may possibly become involved in the use of the Dashboard, such as:

- Bus company
- Tram company (and their subcontractors)
- Street maintenance company
- Street lights and signage company
- Taxi companies
- Rental companies
- National high speed railways companies
- Regional railway organization
- Ambulance services (emergency call 118 or 112)
- Electrical power providers

Other actors that might become involved in ordinary stress or extraordinary events in Florence are:

- Fire Service
- State Police

- State Military Police (Carabinieri)
- State Financial Police
- Region of Tuscany Civil Protection
- National Civil Protection
- Regional Hospitals

Out of these many possible actors or involved organizations, represented by different persons, the development will be focused on the users with the broadest range of responsibility and influence regarding decision making. These are the users that need to access the greatest range of different sources of information and make the most complex decisions – affecting several subsystems or organizations. These users are the representatives of the four divisions led by the Mayor of Florence.

Target users of the Dashboard for the Athens pilot will be Critical Infrastructure Managers, mainly Metro Operation Control Centre (OCC) Managers, as well as Managers of First responders. A list of CI Managers and first responder managers of the agencies involved follows.

Critical Infrastructure Managers

- OCC Manager
- Traffic Regulators
- Power Regulators
- Information Officers

First responders

- Fire Service managers, as well as managers of the supporting agencies involved
- General Secretariat for Civil Protection (CP) and its Operational Centre 199 SEKYPs
- Region of Attica CP
- Police Officers (GADA)
- EMAK Rescue Team
- EKAB first aid and
- Hospital managers

3.2.2 User groups

Two types of users will use the Dashboard:

- Operators / stakeholders: all these users have a read-only access to the data provided in the Dashboard, as long as they are logged in.
- The Central Decision Maker: there is only one in each city. He/she is the final authority regarding the evacuation of citizens (e.g. the mayor or regional governor).

3.3 Scope and objectives

The scope describes the main cornerstones of the application according to what has been defined in the Description of Work (DoW). The objectives describe the behaviour of the application from the perspective of the user: what needs to be achieved (compare ISO 9241). These objectives later form the basis of usability engineering and usability testing.

The Dashboard, as RESOLUTE's instantiation of the CRAMSS, has been designed to master the three key challenges related to achieving resilience in UTS:

“1) excellent coordination between different relief /rescue groups;

2) appropriate information (especially geo-referenced information); and

3) intelligence in communicating orders and information to different participants” (GA, p. 148).

The dashboard addresses these challenges in the following way: it helps improve the coordination between relief or rescue groups as it allows different organizations to share positioning info as well as information about applied strategies or tactics with other operators. With respect to the second challenge, the appropriateness of information is given by automatically reading such data from databases or decision support systems and the data is furthermore checked for plausibility in an automated manner. For example, geo-referenced information is checked by analysing if normal user behaviour can lead to the variability measured. If a user is localized acquisitions that are hundreds of kilometres away within a very short time frame, then an error is likely to have occurred. The third challenge is addressed by the dashboard in combination with the FRAM tool: the latter helps users tailoring the information they receive from the dashboard to their individual needs.

The dashboard is based on one main user objective: **Get an overview of the current status of the UTS, including activities by other involved actors/organizations.**

In summary, it contributes to resilience in the following way:

- It supports resilience by giving each authorized user (read only) access to relevant information, such as weather data, traffic flow, twitter analysis, etc. This increases situation awareness and thus reduces uncertainty that is a source of output variability.
- The aim is to ensure that each actor can see by him-/herself which current and future conditions to take into account when assigning resources in the system.

There is a scientific debate on whether the construct of situation awareness is a good construct to be used in cognitive engineering; Hollnagel, whose work plays a significant role in the theoretical foundations of this project advocates against the use of this construct (Parasuraman, Sheridan & Wickens, 2008). Without entering this debate, on whether and how it can be measured fulfilling scientific standards, we use this term here by stating: the Dashboard serves to increase operators' situation awareness.

Situation awareness relates to mental workload: “Generally, mental workload has been most often characterized in terms of the level of attentional demands placed on the operator in the course of performing required tasks, whereas SA is primarily associated with the informational content of the operator’s memory systems during task performance.” (Vidulich & Tsang, 2015, p. 95). This means that the dashboard should contribute to the operator developing a mental image and holding in the short-term memory all the information currently relevant for his actions. The dashboard also helps to quickly recover information that is too extensive for holding it in the limited human short-term memory. However, the dashboard is more than just a situation awareness tool: it is meant to provide access to the complexity of the urban transport system and develop the level of understanding that goes beyond following the development of few key variables in the operator’s close vicinity.

3.4 Features

The features of the Dashboard provide support for the four cornerstones of resilience. While some features may address several cornerstones, others are limited to only one of them. The features are described in detail below. This is how the Dashboard shall support resilience:

- **ANTICIPATE:** With respect to other DSSs connected (e.g. the UTM DSS), the Dashboard visualizes resilience strategies, including the definition of onset conditions for each strategy. This means that an operator can anticipate the onset of such a strategy before it comes into place, by following the relevant

indicator. The user can plan ahead and reassign resources accordingly. Additionally, the Dashboard can make predictions based on real-time data. For example, based on risk maps, current and projected flooding situation can be visualized quickly. Currently, the predictive capacities of the Dashboard are limited, as sophisticated prediction algorithms are not yet available (e.g., currently, there are no prediction schemes for the water bomb scenario in Florence). Yet the Dashboard is easily enhanceable to that respect. However, the availability of predictions depends on the type of event.

- **MONITOR:** This is the main cornerstone supported by the Dashboard. It allows the user to develop a better understanding about what is going on: it increases situation awareness. Particularly, it provides notifications and warnings about other sub-systems of the UTS that were not available until today.
- **RESPOND:** In the emergency condition, the Dashboard provides a quick overview on existing resources and needs through the monitoring functions, thus reducing the time required for mapping these to one another and organizing rescue and mitigation.
- **LEARN:** Resilience is based on learning rather from successful operation than from disruptions (see D2.1). The Dashboard can support users in de-briefings, e.g. by comparing reaction times to certain events.

In summary, the configuration of the Dashboard to be tested in the RESOLUTE project will include data from the following sources:

- A broad range of data from the Data layer
- Vulnerability analysis through the ESB
- Events and strategies from the UTM DSS through the ESB
- Events and strategies from the UPT DSS through the ESB
- Log-data, media content and strategies from the eDSS through the ESB

Based on the results from the user requirements analyses (particularly the focus groups conducted in Athens – see 3.7.1), and on the data available (see D4.1), it was decided to make the following information available through the Dashboard. By the time this deliverable was finalized, it was not known if all these could be implemented. This list is a recommendation of what would be nice to have.

Table 6 – Contents selected for the Dashboard

Info type	Source	Variables	Visualization (summary)
Critical incidents	ESB	[Event type; coordinates; text; alert severity (minor, major, critical); alarm status (open, closed); timestamps (for status transitions)]	1. Map widget (click on needle → Context details) 2. Table of events
Resource variability indicator	[see below]	Desirable: <ul style="list-style-type: none"> • [people density > Xcrit]; • [Cumulated delay in public transport > Xcrit]; • [Number of voluntary helpers < Xcrit]; • [No. of available hospital beds < Xcrit]; Xcrit could refer either to an absolute value or to the standard deviation of such value.	[If one of the below named resources falls under a defined limit (e.g. 2 SD), then a message is generated, highlighting this value. Alternatively, variability can be shown as a gauge, with a critical / cut-off value.
Data reliability indicator	[see below]	[Variable name + tag (binary tag: plausible / not plausible)].	If an automated plausibility check on one of the below named variables returns a critical outcome, then we flag the involved widgets with an exclamation mark, including a tool-tip.
Traffic density	Data layer	Road traffic density as a measurement of	1. As numbers on a map. Optimal:

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		density at certain measurement stations across the city: [Integer + coordinates].	visualize not total density but Z-value or other statistic indicating exceeding usual variability 2. table with mean, limits for defined values; current value.
Positions of buses	Data layer	Positions of public transport vehicles (Bus) in real-time (possibly only at pilot date.): [Classification variable for the type + Coordinates].	Dots on the map.
Environmental sensor	Data Layer	River level, rain gauge, anemometer, hygrometer, etc.	Dots on the map and widgets with current value and trends (e.g. last 2 hours) – UI representation similar to traffic density sensors.
People positions (Wi-Fi-based)	Data layer	[coordinates per area; area size; density per area] or [coordinates per start area; start area size; coordinates per destination area; destination area size; number of individuals] note: this should show big gatherings and thus provide extra info on city events (e.g. marathons, demonstrations, ...)	1. Density map / heat map 2. people movement map as vectors
Helper positions	Data layer [UNIFI app for 3 exemplary police-officers]	[User ID + coordinates] (user ID identifies who is a helper)	Dots on the map
Public events	Data layer	[option: deduct mass gatherings from people positions heat map]	Table / List with geo-references
Parking /filling	Data layer	Number of places availability	Indicators on the map with the number of places occupied. A table is also possible (columns: name of parking with link to map, capacity, available spaces)
Contact list	Data layer	CSV or similar, contains [person's role; organization; telephone number; email; keywords (e.g. on expertise/responsibilities)]	As a table, optimally with sortable columns and a search field for keywords
Weather info	UNIFI. Data layer	As in KM4city dashboard	Similar to the realization in the KM4city dashboard (see below).
POIs	UNIFI. Data layer	Hospitals [string: name; coordinates; integer: current free capacity, integer: max capacity] Schools [string: name; coordinates; binary: open/closed; integer: number of persons]	Needles on map, with context menu showing details.
Security cameras	(possibly provideable by Florence Civil Protection)	[Video stream + location info (e.g. address) + timestamp]	
Twitter analysis	external tool (Twitter vigilance)	[Trending channels / hashtags]	Optimally: A widget in the Dashboard shows the most relevant trending topics. → Hyperlink opens the external analysis.
Vulnerability analysis	Application Framework (via ESB)	[Node-ID + vulnerability metric (possibly 3 categories: low, medium, high)].	Visualization of the UTS network (arcs + nodes diagram; vulnerability displayed for each arc as shape + colour coding).
Evacuation plan	Evacuation DSS	[Start nodes (node-ID/coordinates); End nodes (node-ID/coordinates); paths as combinations of arcs/edges; number of people per path] Optional: movement type [pedestrian,	On map: each path in a different colour; number of people next to it. Path and respective number are highlighted on mouse-over. Alternative 1: Vectors on the map. Pins for start / end. Alternative 2:

		car].	table format (columns: start, edges, end, number of saved; number of travelling) Note: See “features” for process of CDS authorizing the plan
Traffic (UTM) events	UTM DSS (via ESB)	[List of arc_IDs / coordinates; event code (accident, traffic jam, roadworks, etc.) , severity; start/stop timestamp; additional descriptive information about the specific event]	Representation on map. The code and severity of the event define the graphical representation of the traffic event (like color-coded traffic jams on Google maps). The additional descriptive information can be visualized on mouse-over.
Proposed UTM actuation strategies	UTM DSS (via ESB)	[Strategy description (text); activation threshold; activation type (e.g. automatic, manual, etc.); current value (percentage) -> all control points in an area; priority of strategy; time of last update]	For each strategy: a gauge – or bar chart, with the activation threshold as a target value, and colour according to the current value;
Tramway (UPT) high-level events	From UPT DSS operator to ESB to Dashboard	Same scheme as in critical events: [(Tramway high-level) event type (e.g. “technical issue”, “line suspended”, “line separated in two rings”); coordinates; text; alert severity (minor, major, critical); alarm status (open, closed); timestamps (for status transitions)]	Widget: Event displayed on an events list
Proposed UPT actuation strategies	UPT DSS to ESB to Dashboard	[(text); ENTITY (=affected entity id; e.g. [station, line, train]); optional: COORDINATES (of entity); TIMESTAMP; REQUEST TYPE (e.g. status, speed); REQUESTED VALUE (e.g. closed; low_speed); REQUEST STATUS (pending; rejected by human; processed=accepted by human)].	Table. If the entity comes with coordinates, then the entity is a hyperlink; Clicking it will centre the map on this entity. Entity: translate to real-world name
ESSMA user profile analysis	Evacuation DSS to ESB to Dashboard	ESSMA user clustering information of the following format: [A list of the users’ IDs that correspond to the depicted nodes; the (x,y) position of the nodes in the 2D space/window; the ID of the behavioural cluster to which they have been assigned to.]	Display the nodes (each representing 1 ESSMA user) in a 2D graph and mark (e.g. by colour/shape) by In eDSS, not in Dashboard

In the final stages of the development, another content was identified that could potentially benefit users in learning from past events (cornerstone 4). Presenting this content would require a change in the ESB that was not possible anymore at this stage of the work. We maintain this as a future recommendation:

Table 7 – Additional content recommendation for the Dashboard

Info type	Source	Variables	Visualization (summary)
Evacuation Log file	Evacuation DSS	Each hour, the ESB receives a log file from the eDSS, containing: [Logged events of Evacuation DSS user-activity (e.g. un-/blocking of edges, soliciting evacuation plan, starting of the	Timeline: Similar to a “wall” in social media (e.g. Facebook): a list; newest events are added at the top. Content plus timestamp. For SOS-calls:

	evacuation, SOS-call...) with timestamp; special event type: SOS-call Location data (Coordinates) + type of incident (0;1;2;3;4;5) + Gender (0;1) + age (integer) + timestamp (received) + user id] media content: [input forwarded by the Evacuation DSS operator: [text (chat) message, image, video, voice recording] + timestamp + Location data (Coordinates)]	Needle on map; Widget: number of SOS-calls active; Widget: New SOS call received.
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Why isn't there any alarm mode?

It is important to note one feature that the dashboard doesn't have: an alarm mode. Such an alarm mode had initially been planned and it is mentioned in the description of work (T5.2). However, over the course of the development, it became clear that that was in the interest of the users to avoid the inclusion of such an alarm mode. In informatics terminology, such an alarm mode would actually be a system state, invoked by an external cause, such as an alert signal being received.

Usability experts, such as Jakob Nielsen (1994) explicitly recommend to avoid the use of modes whenever possible, as this avoids mode errors. Mode errors occur when a user is unaware of the mode being active, which means that his input into the system is interpreted differently than when the mode was inactive.

In the task 5.2 applications, an alarm mode would serve to adapt the features available to the user to the more specific needs in the alarm condition. However, this contradicts the resilience philosophy followed in this project. Instead of focusing on critical events, users are expected to concentrate on the very same processes necessary for system functioning that are present in everyday routine. Consequently, operators should use the same tools under normal conditions and in emergency cases, and they should use them in the same way. If emergency cases are rare, reorganizing the user interface would likely increase operator workload as they are less familiar with this user interface than with the one used in normal conditions. Finally, the Dashboard does not contain any data that becomes more or less important in case of an emergency. The idea behind the provision of this resilience tool is rather to make sure that's important resources can be tracked by the operators at any time, in order to prepare for expected or unexpected critical events.

The same applies, for the same reasons, to the FRAM tool and the evacuation DSS.

3.5 Design standards

The ERMG name key standards to be heeded in UI design of the Dashboard:

1. EN 614 Parts 1 and 2 (Machine safety requirements).
 - a. Work task design (EN 614-2) is relevant as through the design of the features and interaction concepts of the Dashboard, operator work tasks are being defined. Although the Dashboard will fit into a mostly already defined job, the "new" operator job including the use of the Dashboard should meet the criteria defined in the norm. Important in this context are, in this order, "over- and underload", "feedback", "autonomy", "learning opportunities", and the "meaningful whole".
 - i. "Over- and underload": Mental overload is avoided by making the Dashboard customizable: each operator configures it to fit his own needs. The FRAM tool supports this configuration.

- ii. “Feedback”: feedback is essential to provide the user with information on his/her own effectiveness and a requirement for long-term motivation. The dashboard exceeds the limitations of feedback given in the existing system. It shows possible repercussions of the operator’s actions.
 - iii. “Autonomy”: the GUI is split into widgets which can be arranged by the user based on the current needs.
 - iv. “Learning opportunities”: through the dashboard, the operator is enabled to learn how other parts of the system work. In the best case, he is able to transfer this knowledge to improve his own work.
2. Control room standards such as EN 11064 – Part 5 mentions quality criteria for control centre technology, most of which are applicable – at least to some extent – to the Dashboard. Two of these criteria are of particular relevance:
 - a. System authority: The human operator always needs to be in (final) control of what is going on.
 - b. Memory: The design needs to take the human short-term memory span into account. All system processes will be designed in a way that avoids, wherever possible, the use of short-term memory and ensures that such processes, if they cannot be avoided, cannot lead to critical errors.
3. EEMUA 191 equals EN 62641-9 and particularly defines alarms and conditions from a perspective of (electronic) system engineering. 3.8 contains the rationale for the specific alarm design chosen. In short, these norms seem to have limited applicability in systems designed for resilience and cross organizational corporation. However, alarms need to be designed in a way that meets the users’ expectations and fulfils that function of creating the right user awareness.
4. ISO 6385:2004 (Ergonomic principles in the design of work systems) may be a helpful norm to assess the overall working situation around the Dashboard, as a second priority after making sure that all requirements of EN 110764 have been respected.
5. “Staff should be involved in the design process” (D3.5, p. 109). This has been realised by basing the development in information collected in workshops and end user interviews, by doing focus groups and user testing with the respective end users.
6. “Monitoring interfaces should be usable in both normal and emergency situation. The CHI design and evaluation needs to be conflict free, independent and stakeholder and situation oriented” (D3.5, p. 109).
7. “Human Factors concerns on human-computer interfaces, contents and dialogues should be set up in order to ensure easy, safe, comfortable and efficient interactions avoiding errors or any type of fatigue or distraction” (D3.5, p.133).

Another relevant standard is EN ISO 9241-110; it describes ergonomic principles for the design of dialogue systems. The Dashboard is a dialogue system, thus the norm is applicable.

- a. Suitability for the task: the Dashboard is meant for information retrieval, it does not require information input except for the special case of the CDM authorizing evacuation and the rearrangement of widgets by the user. The Dashboard is suitable for any task to be included in, as it can be used or be left alone at any moment, as the operator wishes.
- b. Self-descriptiveness: This is achieved through the application of norms concerning the display of statistical information and dashboard design, as well as user testing and making sure the terminology used allows for fast recognition of elements and features. Tooltips were added for this purpose.
- c. Controllability: As already mentioned, the Dashboard was defined in a way that allows the operator to interrupt and resume the Dashboard tasks at any point in time. Providing the UI in the user’s language is also commonly referred to as a controllability feature (e.g., Ertl, 2010).

- d. Conformity with user expectations. This was achieved through user testing and by adopting as many commonly known UI conventions from control room design and dashboard design as possible. The map, e.g. features controls known from common maps, such as “maps.google.com”. Logout and configuration features are found in the upper right corner, as in most web-based applications (Google, Facebook, Amazon, etc.)
- e. Error tolerance: All user actions should – based on what is practically possible – be reversible. This does not apply to the dashboard, with the exception of the CDM’s authorization process. The latter was designed to account for possible errors.
- f. Suitability for individualization: this is attained by following the widget approach, allowing the user to create her own user interface.
- g. Suitability for learning: The current design allows the exploration of the existing widgets at will.

The requirements related to psychological strain in ISO 10075-1, Nielsen’s heuristics for designing dialogue systems (Nielsen, 1993) were similarly relevant.

Furthermore, implications for the design of the Dashboard were deduced from NUREG 0700 (Human System Interface Design Review Guideline from the U.S. Nuclear Regulatory Commission, 2002) and Bockelmann, Nachreiner & Nickel (in press); these are reported in Table 8: Exemplary selected guidelines for control rooms and CRAMSS implications

Table 8: Exemplary selected guidelines for control rooms and CRAMSS implications

Guideline(s)	Implications for the CRAMSS
Consistent interface design conventions should be evident for all display features (such as labels).	design and interaction of widgets should be consistent over all widgets
Information should be displayed consistently according to standards and conventions familiar to users.	The layout and design of the web based Dashboard should be in alignment with standards for web page design (e.g. login/logout functionality in the upper part of the page; scrolling should be avoided)
There should be an explicit mapping between the characteristics and functions of the system to be represented and the features of the display representation.	Changes in the appearance of the widgets should have a one-to-one relation with the CI states it represents.
The characteristics and features of the display used to represent the process should be readily perceived and interpreted by the operator.	Icons and graphics should be designed in a way, that the operator understands it meaning on first glance
While viewing secondary (lower-level) displays, a perceptual (audible or visual) cue should be provided by the system to alert the user to return to the primary (higher-level) display if significant information in that display requires user attention.	In case of a status change on a basic widget/ window the user should be informed, independent of the widgets actually displayed
Displays should contain reference(s) to the values of normal operating condition(s).	The Dashboard should provide clear indicators for normal working conditions of any monitored CI and deviations from normal mode
Navigational links to and from high-level and lower-levels of information and to reference and supporting information should be provided when needed for operators' tasks.	The Dashboard should support easy switching between widgets, e.g. by using back/forward navigation or breadcrumb navigation
The allocation of system components and its visual translation in the user interface needs to be clear and unambiguous	The Dashboard should use colour coding to differentiate between system components and system conditions. A too obtrusive use of colours should be avoided - status changes might not be perceivable. Coding of information should be multimodal. The usage of colour only might exclude user with colour blindness.

Guideline(s)	Implications for the CRAMSS
The operator should be supported in carrying out daily work routine by appropriate support and learning systems.	The ERMG provide support that goes beyond the dashboard. The dashboard itself does not have any routines and doesn't need to provide such support.

The Dashboard will contain the widget for displaying alerts and warnings. This widget needs to fulfil design criteria for alert systems in control rooms. Such criteria are summarized by Crampin (2015); here is the list of those criteria mentioned that can be applied directly to the design of the Dashboard.

- 1 *"Ensure alerts are presented until the operator has responded or until the alert state is no longer active";*
- 2 *Ensure alerts have enhanced luminance, compared to other widgets or displays in the working environment;*
- 3 *"Use larger characters for alert text (up to about 60 minutes of arc), especially under adverse viewing conditions".*
- 4 *"Accepted alerts should be clearly distinguishable from unaccepted alerts";*
- 5 *"Consider polarity changes of contrast for different alert text and symbols";*
- 6 *"A sound and flashing light should accompany the onset of an alert";*
- 7 *"Auditory alerts and warnings should be presented at a sound level above the normal ambient noise of the equipment or control room";* not knowing all possible control rooms, the sound should be controllable for the user to adjust individually.
- 8 *"A pulsed tone is more likely to be received by an operator than a continuous tone";*
- 9 *"[...] all flashing indicators should be synchronized."*
- 10 *"In the absence of any sophisticated alert handling system", which is the case in the Dashboard, "alerts should be listed chronologically. Most recent alerts should appear at the bottom of the list";*
- 11 *"For listed alerts, the entire background colour, red or amber, should flash. Note that the text should be either white or black in order to achieve the best contrast ratio for readability";*
- 12 *"Alerts that have been accepted should change from flashing to steady. Should an alert not be accepted and it subsequently resolves itself, for example, by a low pressure resuming its normal state, then this should still flash until accepted, whereupon the alert disappears";* → In RESOLUTE, alerts in the Dashboard cannot be made disappear directly by something the operator does. It can only vanish if the cause of the alert is no longer present or detected.
- 13 *"A mute should be provided for some alerts".*
- 14 *"The individual alert that is to be accepted should be separated slightly from the other alerts listed in order to make it clear which alert is being accepted".*
- 15 *"Coding of alerts and warnings should follow accepted human stereotypes, e.g. red for alarms, amber or yellow for warnings and green for normal running".*
- 16 *"Where flash coding is used, ensure that*
 - a. *The background is free of flashing stimuli;*
 - b. *All flashing alerts are synchronised at between 2 and 10 Hz (4 Hz is preferred) with a duty cycle of 70%;*
 - c. *Text flashes at no more than 2 Hz, with a duty cycle of 70%."*
- 17 *"Operators should use the recent history of alerts to assess plant trends. The presentation of previous alerts should facilitate the efficient extraction of information by the operators and the search for any particular type of alert should be as effortless as possible. Some alerting systems often collate past alerts into long, monotonous tables which operators have to scan repeatedly to extract relatively simple information. In many cases, it will be helpful if the display or page layout allows operators to compare selected information in parallel."*

One should note that this type of design is focused on rule-based risk management systems, not resilient systems: “Presentation of alerts should lead the operator through the perceptual (initial detection), decision making and psycho- motor (action required) processes concerned with handling that alert.” (Crampin, 2015). In our case, most operators will not be able to influence the cause of the alert. And in the case of an alert, each operator would be required to do something different.

For designing the other widgets of the Dashboard, we took specific literature on the design of Dashboards and control rooms into account. The relevant standards and findings to this respect are referenced further down in sections 3.8.1 and 3.8.2 and thus not repeated here.

It should be noted here that a living system such as the Dashboard and its back-end modules should be continuously updated based on an alarm management concept. Such concepts are, for example, depicted in ISA 18.2, which complements alarm design recommendations in EEMUA 191 (Honeywell, 2011). The creation of such an alarm management process for the Resilience Dashboard exceeds the scope of the project and depends on the way the alert system is enhanced in the future, or, for example, how often certain alerts actually happen, compared to what is supposed.

Note that also, these concepts for industrial alarm systems only partially apply to resilience-focused ICT systems, such as the RESOLUTE system. While the overall concept still applies, single subordinate methods (such as fault tree analysis) have to be replaced by others (such as functional resonance analysis). This could be subject of a research of its own.

3.6 Technical restrictions

The Dashboard is web-based application to be used on a PC. With respect to UI development, browsers impose the following restrictions:

1. Less screen space available and more controls visible (omnipresent browser taskbar).
2. Representation of contents may depend on the browser type and version installed.
3. Widgets may overlap if screen space is limited. Thus, urgently relevant information needs to be displayed in a way that it will always catch the user’s attention.

As written in the Grant Agreement, the Dashboard builder was used to implement the Dashboard. This meant that we had to use the widget-structure, which was desirable anyway based on the above named user requirements.

3.7 User interface development process

As a first step, we conducted focus group discussions with operators and other area experts in order to find out which information should be displayed in the Dashboard in order to support the decision-making processes of the individual actors and how this information should be provided to them. This refers to the format of display, such as tables or graphs. After that, we conducted the user test with the first prototype. Then we improved the design according to the results and conducted a second test, resulting in yet another round of improving the designs.

In the first user test, dashboard and evacuation DSS were still one single application and thus tested together. Here, we display the results of this test.

It is exactly the complexity of the processes involved in resilience that in the end made the application of scenario approaches almost impossible. The number of possible scenarios in which the Dashboard is going to be used is enormous, as it comprises all use cases of all related control rooms. And the relevance of the scenario is limited. There are only these main cases:

1. The operator is idle and following the development of relevant variables on the Dashboard

2. The operator is engaged in an activity and passes by the dashboard in order to collect some additional information.
3. The dashboard alerts the user, and there is a parallel alarm on the user's main device.
4. The dashboard alerts the user and there is no other alarm.

In all cases, the only relevant criteria are the best presentation of information for a most efficient uptake and ensuring that the dashboard's alarms were not interfere with the operators main tasks. This corresponds to the High Velocity Human Factors (HVHF) criteria:

- to perceive the currently most relevant information,
- to comprehend this information, and
- to see the connection of this information in the context, to infer from this mental model what is about to happen and what could be done.

The Dashboard is meant to include different sources of information, which may even change after the conclusion of the project. New sources of information or algorithms may be added to enhance the reliability and usefulness of the Dashboard. Hence, it was necessary to create a short style-guide that can easily be applied by the developers of such new functionalities. The style-guide ensures the learnability of whatever is added.

3.7.1 The focus groups

Preparation

A standardized instruction was created to be followed in all focus group discussions. An informed consent form was created and signed by all participants.

Overview

The focus groups were conducted during the resolute workshop in Athens. Participants were firefighters, police officers, control room and metro employees, officers and experts on security, engineering. We conducted five parents focus groups, in each of which 10 to 12 participants and the instructor discussed requirements of the CRAMSS. Most of these requirements relate to what now is the Dashboard.

How to interpret the results

This document sums up what users said they would like to have as information to aid them in their daily work, particularly in decision making in critical situations. While interpreting these results we needed to consider:

- Not every piece of information may be equally important to the users, or not even helpful at all. These are rather "wishes", than confirmed "requirements".
- The CRAMSS is meant to promote resilience. Many users in the focus groups are focused on critical events / emergencies and procedures. We needed to find a balance between what they say they need and what the resilience approach would demand us to show.
- Users answer as individuals. The CRAMSS is meant to provide information that is relevant to all its users. The CRAMSS should not provide information that would actually have to be provided rather by a particular tool, e.g. in the command central of fire fighters.

Athens Focus Groups - results

What information is needed?

Scenario: The participants were mostly thinking in terms of emergency scenarios (e.g. fire in the metro station); however, some of the information also relates to non-emergency preparation.

[*** = high priority; ** = medium priority; * = low priority]

- 1 Different information according to roles (command and control, people on the scene..)
- 2 Same system with different credentials / user access that gives information regarding confidentiality,

Different access

- 1 Information about the critical event
 - a. Location of event***
 - b. Time of critical event, recovery time (estimate / time of arrival of units)*
 - c. Type of event, further information (direction of fire (in a tunnel), Special circumstances (e.g. hazardous materials, etc.)***
- 2 Position, number, type, condition (operational readiness), general and contact information of: Ground units (/civilians):
 - a. Emergency medical services / Firefighting [Position of ground staff possible]**
 - b. Police **
 - c. Persons in charge (liaison officers / water supply / manager of each station/scene): position and Contact information, incl. VHF channel*
 - d. Utilities repair units*
 - e. Passengers/ civilians: position, number (in system /train estimate according to peak / off-peak time), Condition: condition of injured people (can they still walk?), number of passengers /trapped, injured, passengers with special needs (e.g. wheelchair etc.)***
- 3 Information on the status of urban systems and general information
 - a. Traffic information (public transport), possible indicators: passenger volume (planned vs. actual; on which relations is reduced service; delays)***
 - b. Alternative transport means*
 - c. Traffic information (individual traffic)- position, direction, congestion, quickest route to arrive to location [planned]***
 - d. Utilities, hospitals, etc. (position, kind, operational readiness, contact information)**
 - e. Station Specific information: ventilation, Temperature (from temperature sensors in stations in case of fire etc.)*
 - f. Electricity supply in and around the station(s). Available from the grid-operator. (Resolution: This part of the city is "on" or "off"). This is currently not available but reasonable to expect in the future. **
 - g. Access to camera surveillance (stations and trains, surroundings), live and also recordings (requested by police and control room operator)*
 - h. Meteorological information [planned]**
 - i. General information about Stations: floor plans / escape plans / fire systems of station / rescue ways / exits / shafts of tunnel, diagram or topographic visualization of all the underground lines / 3D-building-visualization*
 - j. Commonly agreed procedures*
 - k. Statistical data from past events (location, type of events: "What went wrong in last operations". "Where and when are repetitive events [heart attack of older persons, etc.] most likely to happen?") [Currently difficult as the police are not partners]. However, a feature for marking incidents could help. *
 - l. News updates: Where are strikes / gatherings / marathons / ... happening in the city?***
 - m. Social networks analysis (Facebook, Twitter), Pictures or videos uploaded by users on site. Validity /reliability of information provided [question: how to filter this information; how to show what's relevant?]**

- n. Estimation of Reliability of the Information (for operators, it is critical to know how trustworthy an information is. That may depend on the source of the information: is it a trustworthy source?) [e.g. “reputation”] **
- 4 Role and contact list integrated with a messenger:
 - a. Roles and contact list: general Information of responsibilities, Jurisdictions, information graphs: chain of command, who is the process / maintenance owner of certain parts of the UTS (e.g. drainage on streets). [Contacts list]. ***
 - b. Display hierarchy of decision-making? Who takes what decision? [Contacts list]
 - c. Direct communication with other parties / decision makers of other organizations, status of communication between organizations (did they get the message?), automatic notifications of others.* →This is not the task of the CRAMSS. However, the CRAMSS should create awareness about events.

Which decisions need to be made?

- 1 Which kind and how many units to dispatch
- 2 If special equipment is needed
- 3 If to send units inside a station /building or not (e.g. because it might not be safe), and how many of them
- 4 Open emergency gates, open water valves
- 5 Close lanes of road
- 6 Communication: Inform passengers (also on alternative routes), traffic police, etc.
- 7 Change route of buses
- 8 Operators: close station in case of smoke alert, etc. □ this follows fixed procedures. If necessary, the operator makes one 110-call.
- 9 Security police department (not to be confused with counter-terrorism department): main job is “catch the bad guy”. Cases come through 110-calls and are dispatched to the respective departments.

How should it be presented? What should be personalized?

- A map with events, updated automatically
- Displays for Police and Fire-fighters’ cars /vehicles, with maps showing location of what is happening and where, quickest route to arrive the routes
- Application on a smart device for first responders –to receive and send information

(For first responders said: detailed first information is very important)

- App for civilians with emergency button that will be delivered to the police etc.

Roles:

- 1 Different information according to roles (command and control, people on the scene..)
- 2 Same system with different credentials / user access that gives information regarding confidentiality,
- 3 Different access / roles for each organization (fire brigade, police, etc.).
- 4 Every organization should have also 3 different users roles:
 - a. first responders
 - b. unit leaders, and
 - c. command and control (“super user”)
- 5 For the public side of the UTS, we could divide into
 - a. Strategic level: local politics. This requires a macro-view of the situation.

- b. Operational level: this is where the Dashboard (or other CRAMSS instantiations) should reside. Here, people could get a broader picture of the situation, using the Dashboard.
- c. Tactical level: “station master” (at each station in the UTS; 8-hour-shifts). Very procedurally organized.

Which information should be highlighted or prioritized?

- **Event:** Type, Location, time,
- **People in danger:** location, number and condition (can they walk?),
- **Rescue forces:** location, number, and condition (operational readiness)
- **Exits** of station

Which notifications and in which format/modality?

- By voice (verbal / different tones for different incidents)
- Banner at the top of app, with a yellow background etc.
- With an acknowledgement button. (Tone repeated in different variation (like an alarm) until acknowledged)

Other possible purposes of the Dashboard

- Public servants sometimes do not take decisions that would apparently be correct, just because they are scared to do something out of the protocol, as they might be held responsible. Legal issues are out of the scope of the Dashboard. Nevertheless, the Dashboard may help individual actors understand the consequences of their decisions, and also to make possible legal issues visible.
- Communicate incidents to the societies. From operator to citizens. E.g. when detecting smoke / fire in a station: inform all citizens that the station is getting closed – divert traffic and citizen movement.

CdF requirements

The City of Florence has provided additional information that serves similar as an input to the focus groups and that is repeated here, in order to have all user “wishes” or “requirements in one place:

What operators of the civil protection in Florence are currently missing is (as examples):

- real time info from traffic supervisor
- info about people positions and trajectories (via connection to the municipal Wi-Fi)
- main public events

(Note: this list is not exclusive. While the former three were emphasized by CdF, others were also found to be important, such as: level of the environmental sensors, level of the rivers, UTS related events like car accidents, yards, etc.).

What is already included in the CP but needs to be improved?

- coordination with other authorities (specially with public utilities)
- cooperation with experts from the academic, industrial world
- access to historical data

We used this information to compare it to the results obtained in Athens and thus to understand what are common priorities across the pilot sites.

Grant Agreement requirements

Additionally to the results of the focus groups, the project rationale also have an influence on which data was selected for a presentation and the dashboard. This was based on the concept laid out in the Grant Agreement.

- *“Monitoring the event evolution dynamics (extension, impact, etc.) and the behaviours/movement of the emergency operators on the field”* (GA, p. 131, Obj3). → This refers for example to the display of flood sensor data on the map.
- Social networks (twitter) or public sources (CrisisNet, GDELT, etc.). → This refers to the twitter analysis.
- *“Management of citizen identity, collective behaviour and reputation based profiling, taking into account dynamic aspects of user behaviour, profile, cognition, capacity, reputation, and role in the off-line social network, etc. in order to dynamically engage people as ad-hoc volunteers on the base of the event occurring”*; GA, .131, Obj3). → This category is actually split: movement patterns based on Wi-Fi Network data are displayed in the dashboard. User profiling based on user behaviour data from the ESSMA is available in the evacuation DSS; it is visualized on a graph and on the map.
- *“analysing cascading behaviour in UTS modelled network, predicting in time the evolution of the network itself and its resilience metric with respect to the degradation of service (effect) and not only node failure (both cause and effect)”* (GA, p.148). → This is represented by the vulnerability analysis (Table 6).

3.7.2 The first user test and iteration

By the time the first user test was conducted, the CRAMSS had not yet been divided into three separate applications. All features of the CRAMSS were tested together, and the results are presented here. The detected errors can only be interpreted with respect to the CRAMSS prototype and thus they are presented together. Nevertheless, certain results may rather apply to that below mentioned evacuation DSS or FRAM tool.

Objective

The objective was to gather qualitative data and first impressions of the application that would be helpful to improve the design. Specifically, we were interested in finding out if the navigation between a different features was understandable and if icons and terminology were consistent with the users' expectations.

Methods

Sample. 10 Greek security experts, such as fire-fighters, police officers, and city employees participated.

Click dummy (Stimulus). We created a medium-fidelity prototype in form of a presentation to be shown on a laptop PC screen. We used the wizard-of-Oz technique, which means that the test instructor changed the pages depending on which interaction element the participant pointed at. This mock-up at two main views: a dashboard and a map. The dashboard was mostly used for looking up information. The map served for displaying position information, for example civilians and points of interest, as well as the evacuation features.

The prototype contained a navigation menu on the left with the following main pages to choose from:

- Dashboard
- Notifications
- Timeline
- Maps
- Social Networks

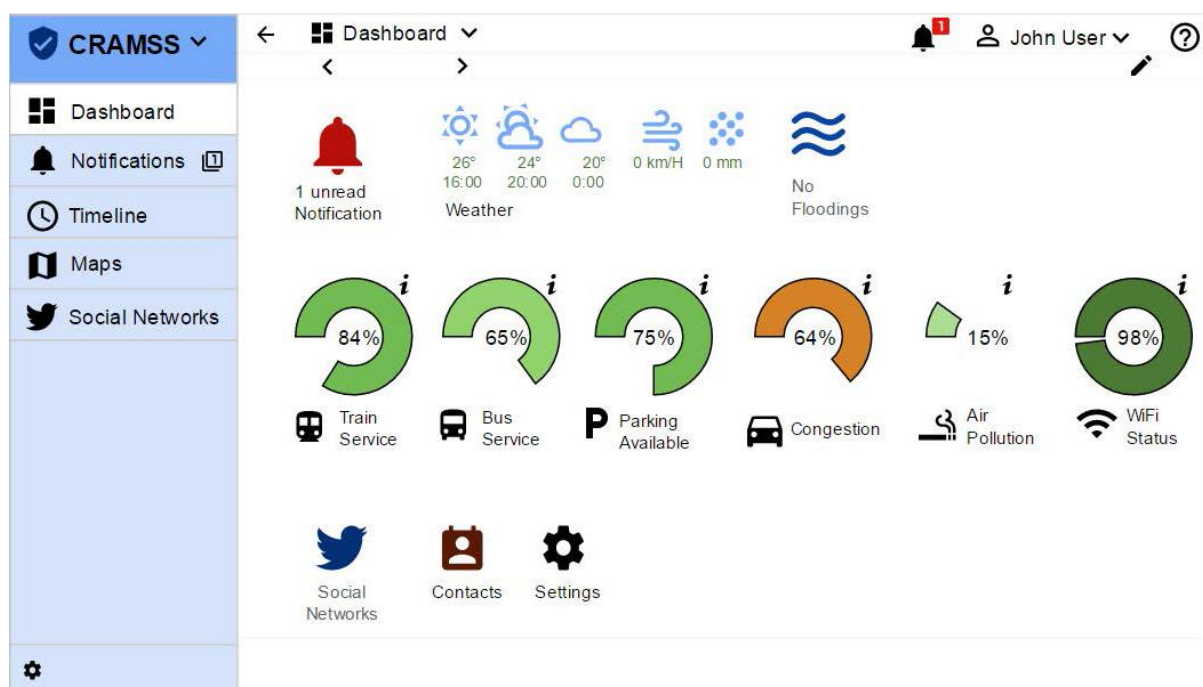


Figure 4 – Dashboard screen from the mock-up used in the first user test

Procedure. We created a test instruction to guarantee standardized conditions. Participants were given 11 tasks to be completed using the prototype. In some cases this task consisted only in finding a certain information. Especially these tasks related to what later became the Dashboard. When participants got stuck and would in real life have abandoned the task, they could ask the instructor for the next step. After each task, the test instructor interviewed the participant to get insights about the encountered problems or inconsistencies. Each test took between 20 and 40 minutes. The sessions were video recorded.

Analysis. We performed content analysis methods on the videos.

Results

The following usability problems were identified:

- Starting on the Dashboard, some users had difficulties finding the map (see Figure 4.)
- Some users had issues finding the weather forecast, the problem was switching back to the dashboard. Users got stuck in the map view.
- Users had difficulties interpreting the social media analysis (twitter vigilance graphs).
- 33% of the users could not find the timeline, which at this point was meant to be a log.

Based on the test results, we deduced the following recommendations that apply to what now is the Dashboard.

- Dashboard should not be the opening page
- Add redundant navigation elements (arrows) to make changing between screens easier. Chose a different design for the navigation bar.
- Social media analysis should provide a summary, e.g. of most used hashtags, that is easier to comprehend
- messages should be combined with contacts ; general notifications, news should be together with social networks, timeline

3.7.3 The second user test and iteration

Objective

The second usability test of the Dashboard continued the iterative process of developing and optimizing the UI Design. The objective was to gather qualitative data that could be used to further improve the design of single widgets, as well as the Dashboard's overall layout.

Methods

Sample. 10 participants took part in this UX study. All participants were possible future users, employed by the police, Metropolitan Authority, Civil Protection, and transport companies of Florence, Italy. Recruitment was arranged by the project partners from the City of Florence. All participants were Italian and male. A translation help was used in the case of language barriers, as not all were fluent in English.

Click dummy (Stimulus). As in the first test, we use the medium-fidelity mock-up in the shape of a presentation shown on a laptop screen. The mock-up of the Dashboard provided access to different features, including a notification bar, a map, an alerts / critical events list, timeline, planned events list, local weather, local twitter analysis, a contacts list, parking and train status.

Procedure. We created a test instruction to guarantee standardized conditions. The test tasks consisted in looking at the Dashboard, explaining what type of information they found there, and pointing out what was difficult to understand. The participants were invited to the Comune di Firenze offices in Florence and greeted by the staff. Prior to taking the test, participants signed the informed consent and nondisclosure forms, and were asked to help improving the design of the prototype by thinking aloud while using the prototype and doing the tasks. Participants were reassured that the test was about the user interface design and not about their performance. The study was video recorded for later analysis.

Analysis. The thinking-aloud remarks of the users as well as their behaviour while interacting with the prototype were analysed qualitatively and quantitatively during the study and afterwards using the video files.

Results

The following usability problems were noted by at least one user:

- Timeline, tramway colours not clear
- Timeline, events not clear
- Parking, tram stations: should be detailed and on map; notification sound, road signs
- Twitter not clear, too much information
- Notification bar not noticed;
- Contacts should connect to timeline;
- Alerts not clear
- weather stations not clear
- Notification bar not noticed
- Map legend missing, details on map (parking), weather on map, point on map at emergency,
- Notification bar should be more prominent (flashing)
- Notification bar – should be blinking, red
- The messages sent by different people are not clear.
- The colours may be confusing in the stops.
- The goal of the dashboard is not clear.
- The dashboard is too crowded.

Seven improvement potentials for the Dashboard were identified:

- Differentiation of the Alerts/warnings list (critical events), DSS events and/or the Timeline.
- Alerts list: Reducing the severity levels to 4 and removing the circles.
- Adjusting the size of the boxes and minimizing.
- Click event - zoom on map
- Events – “taking care of” / “mute” / “read” button should be added
- Critical events – open a suggestion window
- Notification bar was not noticed

3.8 Blueprint of user interaction & experience

Deliverable 4.2 contains an extensive list of available data. From these types of data, we selected those for the first implementation of the dashboard that seem to be useful for a majority of operators, based on the results of the focus groups and our own reasoning concerning resilient cities.

The Dashboard is an additional system added to control rooms. Consequently, all data made available in the dashboard should be meaningful for a majority, if not all, operators that will have access to the Dashboard. Further down, but provide a short guideline that guarantees the scalability of the dashboard: it helps to include new contents at a later stage, if such contents meet this criterion of being important to more than just one specific operator. If a certain type of data seems to be particularly important for one operator, it is rather recommendable to include it in his main system, thus giving it a priority of perception.

3.8.1 A design guideline for the RESOLUTE data

For the development of our implementation proposals for the widgets, as well as the general layout of the Dashboard and the guideline for introducing more widgets in the future, we mostly relied on the work by Few (2004b) and we also relied on other publications with a similar scope (Opto 22, 2013; infoComm 2005). Such publications usually contain design criteria for information output and for input. The Dashboard does not allow for input, at least not in the sense of handlers that are usually found in control rooms. Thus, only the output-related guidelines are applicable here.

Choosing an optimum form of representation of data in a dashboard is a complex task. Even extensive literature (e.g. Few, 2004b) does not give clear indications only based on the type of source data. The best way of representing data for a user depends on the task that the user has to complete based on the data. Most dashboards are developed for one specific user role within limited and known variety of tasks. The main technical difficulty in designing single widgets for the Resilience Dashboard lies in the fact that it is going to be used by a multitude of users, each of who has totally different tasks and background knowledge. One way to address this issue could be to provide the same data in different formats and have the user chose the format it fits her purposes most. The disadvantage of this approach is that it partly transfers of workload and responsibility to the operator. Another approach is choosing the design that is most likely to fit the majority of users.

The most common example, which is also quite relevant for the type of data collected in RESOLUTE, refers to the question weather data should be displayed in the shape of the table or a graph. Research (e.g. Gelman, Pasarica & Dodhia, 2002, p. 122) has shown that users can more efficiently retrieve single values from a table, while graphics such as bar charts offer a more efficient manner to compare values to each other. Although we do not know how individual operators intent to benefit from using the dashboard, it is likely to assume that with respect to most of the displayed variables that represent the state of certain processes or outcomes within the urban transport system, they would either be interested in knowing if the current value is close to the usual or expected value or if two values match, such as the number of hospital beds required vs. the number of hospital beds available. Displaying absolute numbers in a table format would therefore in most cases only be beneficial

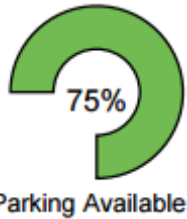
when displaying relevant numbers for comparison next to it, or when the absolute number itself contains all the information required in a certain moment. This would be the case when there is a commonly known threshold.


The guideline lists types of data and recommends the representation format for each of these.

3.8.2 General style guide for adding more data

If in the future, more information is to be made available for the dashboard, the following guideline is intended to help choose the correct representation of such information.

Table 9 – Guideline for adding Dashboard widgets

Data family	Data type	Examples	Representation format
Geolocalized data	Static patterns	Risk maps; traffic density	colour-coding on the map. Use standard colouring (e.g. red for danger or high concentrations).
Geolocalized data	Dynamic patterns; Sensor data	traffic density, air quality	colour-coding on the map. Use standard colouring (e.g. red for danger or high concentrations). If the information refers to map elements (e.g. nodes, arcs,), a table is possible. However, the table should be linked to the map to easily identify the location.
Geolocalized data	Points of interest – context info	Schools, Bus stops, (transient or recurrent) events	Symbol on map that does not scale when the user zooms in or out. Context menu opens on click of the symbol. If the information refers to map elements (e.g. nodes, arcs,), a table is possible. However, the table should be linked to the map to easily identify the location.
Geolocalized data	Moving objects	People, vehicles	Symbol on map that does not scale when the user zooms in or out. Context menu opens on click of the symbol. Stationary symbols and moving objects should be distinguishable by icon type (e.g. 2D-icons for POIs, 3D-icons for moving objects or agents).
Non-geolocalized data	Percentages, probabilities	Rain probability, parking spaces occupied	Display the percentage as a number, together with a graph for quicker comprehension: 
Non-geolocalized data	Profiles	Events	To represent items each of which is described by several variables, a table may be the most adequate format. This is particularly true, when it is not clear from the beginning which variable is used for comparisons. Table should be sortable by columns. Each item/profile should be a line, each variable a column. Long tables should have a search feature. When possible, include a timestamp to sort by date and time.
Non-geolocalized data	Absolute values and thresholds	Trigger criteria, water level	If an absolute value comes with a threshold, or various thresholds, then a gauge the best option. Thresholds should be marked outside the area that may be covered by the indicator.

			
Non-geolocalized data	Developing values	Stock prices, twitter hash	Continuous variables that need to be interpreted based on the development over time should be displayed as line graphs. If one graph shows several lines, the lines that need to be clearly distinguishable. Metrics need to be provided on the axes.
Non-geolocalized data	Pairs of values	Congestion levels at different places	Use bar charts to compare absolute values. If necessary, provide the current actual value in big characters.

If icons are used, on mouse-over they should provide a tooltip to help the user understand the meaning of the icon.

Avoid the use of representation formats that require statistical training, such as box plots or scatter plots.

Examples of gauges

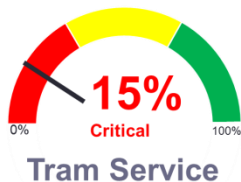


Figure 5 – gauge – example 1



Figure 6 – gauge – example 2

Example of a line chart.



Plausibility indicators

It may be possible to install algorithms that check the plausibility of received data automatically. If the algorithm detects a possible problem, the dashboard may indicate that the information is to be interpreted with care. The icon added to indicate this problem should provide a tooltip that explains how the data is being checked.



Figure 7 – plausibility indicator

General advice on how to design a dashboard and its widgets.

„A dashboard is a visual display of the most important information needed to achieve one or more objectives; consolidated and arranged on a single screen so the information can be monitored at a glance“ (Few, 2004a). This means that the purpose of a dashboard is quick and easy access to the selected variety of information. “The real value of dashboard products lies in their ability to replace hunt-and-peck data-gathering techniques with a tireless, adaptable, information-flow mechanism. Dashboards transform data repositories into consumable information” Hovis, 2002).

Few (2004b) lists 13 mistakes to be avoided in the design of dashboards. Some of them apply to the overall layout of the dashboard, while others refer to the single pieces of information presented. When designing the widgets for the RESOLUTE Resilience Dashboard, the following should be avoided:

- *Supplying inadequate context for the data*
 - This means: try to avoid pie charts – they are difficult for human perception. (We cannot compare two-dimensional areas).
- *Displaying excessive detail or precision*
- *Choosing a deficient measure*
- *Choosing inappropriate display media*
- *Introducing meaningless variety*
 - Where possible, use the same data aggregation / display logic. This facilitates interpreting different data sources in parallel.
- *Using poorly designed display media*
- *Encoding quantitative data inaccurately*
- *Arranging the data poorly*
- *Highlighting important data ineffectively or not at all*
 - Use bright colours, for example, to highlight important data
- *Cluttering the display with useless decoration*
- *Misusing or overusing colour*
 - Do not redundantly colour-code information that is already represented differently (e.g., do not use coloured bars in a bar chart only for the purpose of assigning a colour to each category).
- *Designing an unattractive visual display*

Few (2004b) also provide some general advice on how to improve the design of the dashboard:

1. Apply Gestalt principles
 - a. Group objects / data together if they belong together
 - b. Use open axes instead of closed boxes for bar charts
2. Mark “unusual” data. Focus attention on what is outside the normal range of values.

3. Minimize “non-data” visual elements, compared to relevant contents (see: „data-ink ratio“, Few, 2004b, p. 84). Avoid grid lines in bar charts. De-emphasize non-data pixels (e.g. use grey axes and black chart lines).
4. Use fill neutral (which means: not bright) colors to delimitate the widgets.
5. Display data in a format that allows for the correct comparisons (e.g. display mean and standard deviation in absolutes, not mean in absolutes and standard deviation in percent).

Few (2004b) also recommends to cluster many similar sources into one single widget. However, this cannot be done in the resilience dashboard, as it would make it impossible for the user to pick the single widgets needed. This is a consequence of the fact that we are providing a dashboard for many different users with (possibly) different information needs.

We recommend using monochromatic or analogous colour schemes; complementary colour schemes come with the side effect that different items displayed in complementary colours are more difficult to perceive in parallel. (infoComm, 2005).

Opto 22 (2013) proposed three key design criteria for control room technology:

- *“Put data in context to increase the operator’s situation awareness.*
- *Make it easy by reducing the operator’s cognitive load.*
- *Build an information hierarchy that’s easily navigated.* “

The first aspect is in most cases realizable if the respective widget, or its content (such as a specific sensor) is geo-localized on the map, or if it provides a hyperlink or a help feature that names other highly relevant widgets / sensors, etc. For example, traffic flow may heavily depend on the UTM DSS strategies currently applied. The widgets should be designed in a way that helps the operator regard these together, or at least jump from one to the other.

The second aspect is achieved by applying the above named design criteria, as well as applying the Gestalt psychology principles in the overall layout of the widget: Proximity, Similarity, Good Continuation, Closure, Figure and Ground. In fact, visually grouping indicators that are referring to similar class of events (e.g. environmental, mobility, resources, etc.) can make it faster to recognise the domain of a problem and respond to the event effectively.

The third aspect is of limited applicability in the Dashboard. However, for example with the twitter vigilance, the true output might be complex and too big for a widget. A widget could provide a short overview or a summary of the information presented by the full application. However, it is crucial that user interaction should be minimised. In fact, the operators should be aware about what is happening only looking to the dashboard indicators that it is worth to remind it represents a synthesis of the status of the UTS. Detailed information needs to be obtained through the other control rooms.

Implementation proposals for the main layout

Here, we present the final recommendation for the overall layout of the Resilience Dashboard.

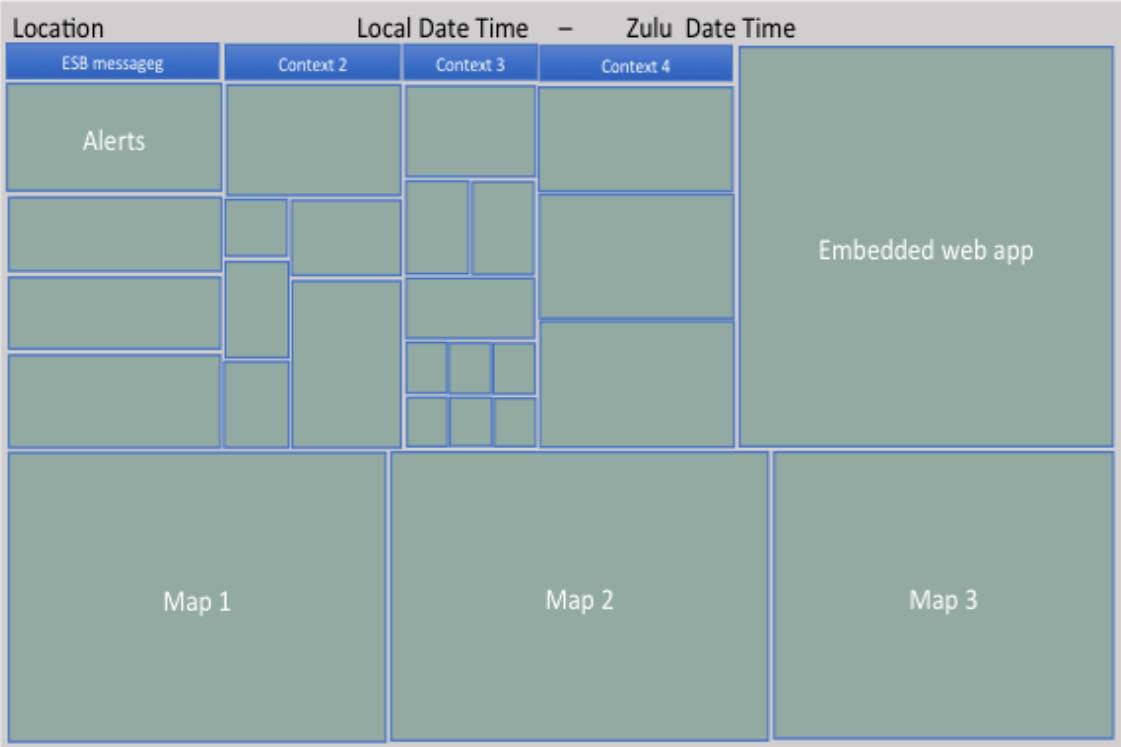


Figure 8 – Resilience Dashboard – overall layout

The header bar should contain the name of the city, local date and time, and the Zulu date time for operational purpose. If additional menu options need to be added, it is necessary to login into the Dashboard builder (the back office editor of the dashboard) where it is possible to add, remove, relocate, resize, etc. the widgets.

Currently, no practical evidence has yet been collected that would indicate how many widgets most users would be using at a time, anyhow the main scope is to reduce the user interaction and the mental workload while maximising the informative value of the signals. In fact, the user should not dedicate time to interact with the interface looking for specific information but the should be able to understand the situation in seconds just looking at the screen. The dashboard can be organised as a patchwork with widgets of different dimensions but visually grouped in columns according to the context of reference (e.g. environment, mobility, etc.). According to the Gestalt principles such a visual organization provide some benefit in terms of stimuli recognition.

The dashboard should display all the relevant information in a unique view. Indeed the information can be presented through a unique screen or can be organised into multiple screens according to the control room requirements. In the Figure 8, is reported a layout for a unique screen since it is has been a requirement of the City of Florence. In the example it is possible to see that the information are organised according of the Gutenberg Diagram (Lidwell et al, 2010) where the primary optical area is situated a the top-left of the screen. In that screen region should be accommodated all the signals able to provide indicators of the status of the system (indicators, ESB messages, alerts, etc.) while maps and the web app embedded since are more complicated to read, should be positioned at the bottom and on the right.

In case a multiple screens configuration is required, the most suitable solution is to have a screen for each widget containing maps and the embedded apps.

As we said, through the Dashboard builder, the user can move the widgets around and reorganize them as she pleases. However, we recommend to maintain to widgets in the decided positions in order to benefit of the velocity of the recognition cognitive process respect to the remind that is slower.

3.8.3 Implementation proposals for specific widgets

The following list of proposals refers to the contents presented in Table 6.

Note: as requested by the description of work, the widgets are being implemented using the dashboard builder created by UNIFI. The dashboard builder comes with its own design elements, to which only limited changes are possible. Therefore, the following figures do not represent a mandatory graphics design. They are meant only to display the format in which data is represented. This refers to the spatial alignment, wordings and icons to be used, and interaction principles. Colours, fonts, icons, and interaction elements may be changed to what is available.

Alerts

The alerts list contains alerts and warnings. Alerts are notifications about events that may require immediate action by the operator. Warnings are notifications about events that may require not immediate action by the operator but action in a considerable time-span.

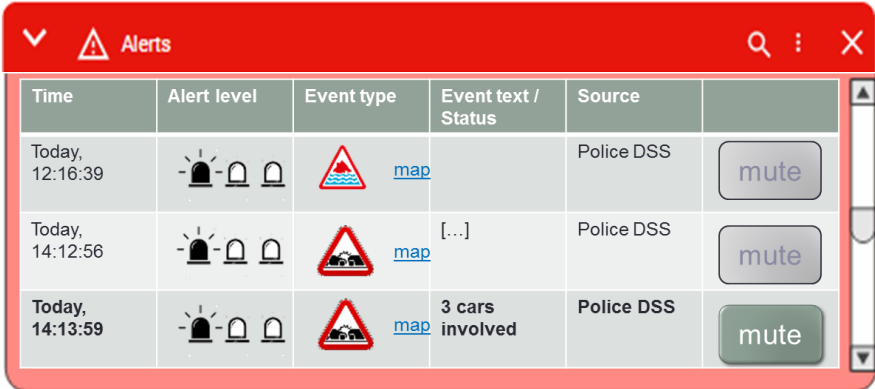


Figure 9 – alerts widget

The alert level (if reported by the operators) should be visualized using icons. The event type can be displayed as icons, in case unambiguous icons are available for all events. The word map in each line is a hyperlink that will centre the map widget on the respective event (inter-widget interaction). Each new alert is presented with something that can attract the operator’s attention (e.g., widget header blinking, sound). The button on the right serves to mute this sound and to mark the alert as read.

Map

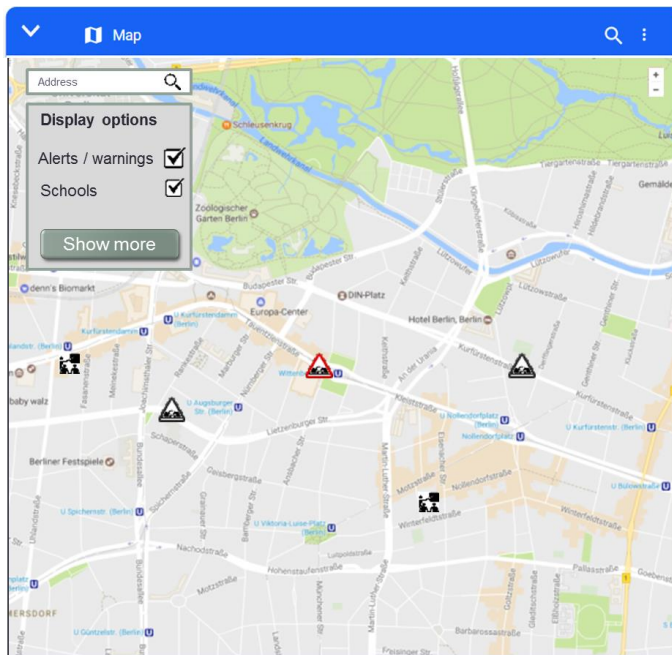


Figure 10 – map widget – list collapsed

The map is a multipurpose widget and may be the most important one. It should come with a collapsible list of types of information to be displayed. It serves for the display of all geolocalized points of interest or agents, as well as status information that the first and nodes or arcs.

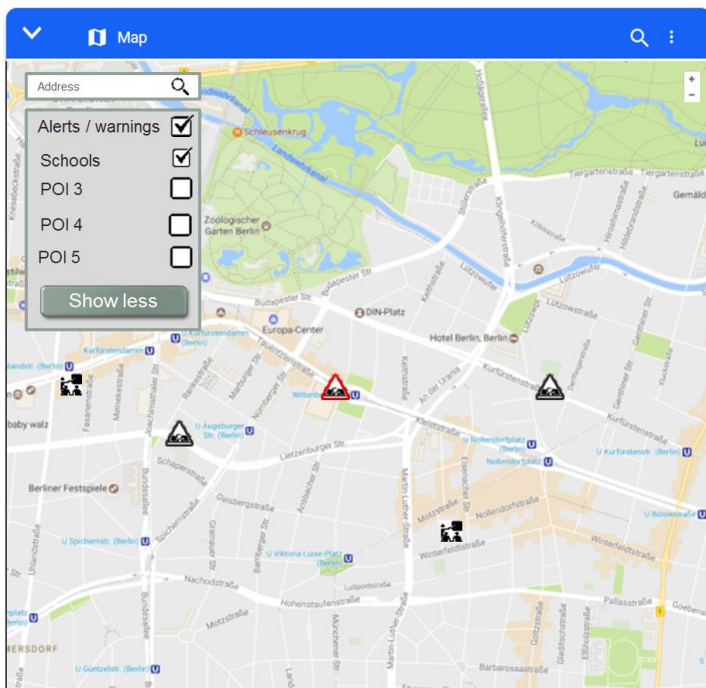


Figure 11 – map widget – list unfolded

Traffic density

Depending on the data available, the best way to display this information would be one gauge per a sensor. Currently, it seems that critical values are not available. Therefore, we recommend a table format. In the column for the sensor, there is a hyperlink to the map.

Current (cars / min)	Difference to mean	(Optional alternative)	Sensor
120	+ 9%	[Gauge – if critical values are known]	A1 [map]
50	-20%		A2 [map]
200	+70%		A3 [map]

Figure 12 – traffic density – widget

On the map, the sensor should be shown by an individual icon class. It would be desirable to have the current value of each sensor displayed next to its icon.

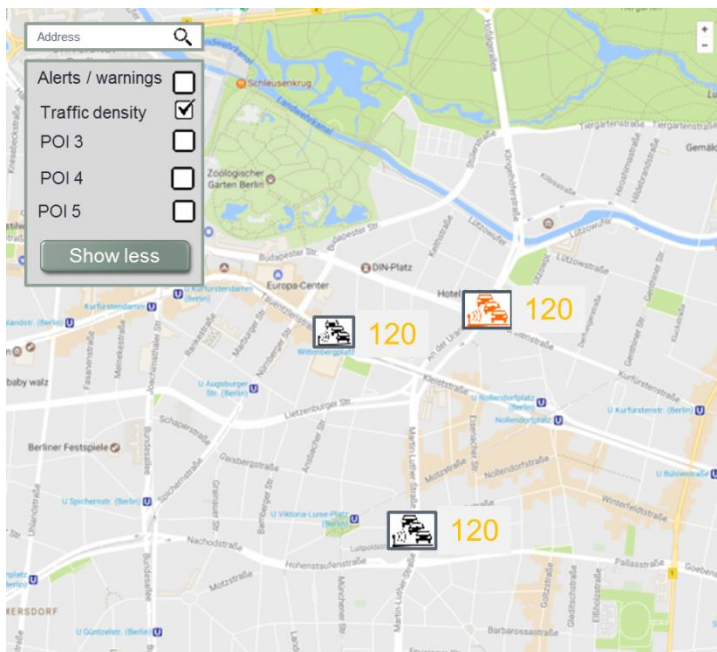


Figure 13 – traffic density – map

The same concept can be applied to the city sensors (e.g. river level).

Bus positions

The positions of public transport vehicles, if available, should be displayed on the map.

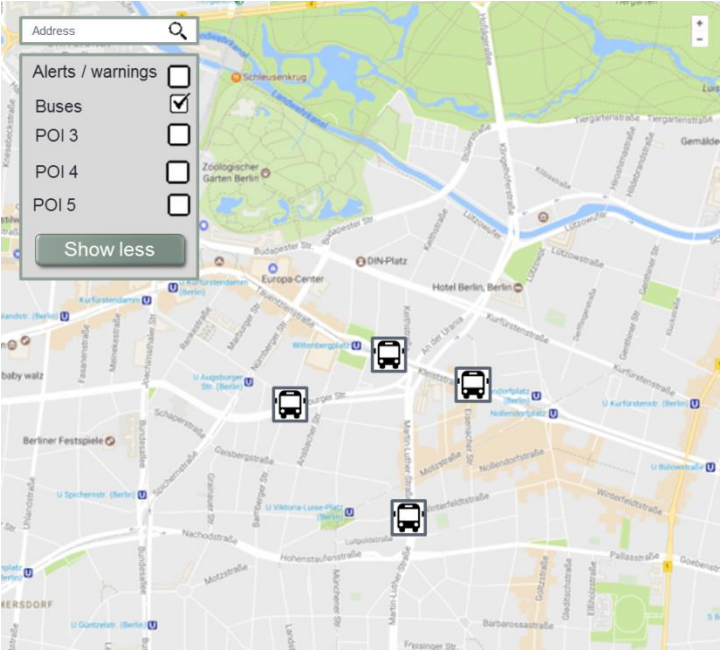


Figure 14 – bus positions – map

Civilians' positions

An analysis of the Wi-Fi data in the city of Florence can provide a heat map of the concentration of people around the city. Such a heat map is recommended for use by the when there are too many people to be visualized to use single dots, or when the positioning data is not one precise pair of coordinates for each agent but rather a probability value of where a person or a certain number of people is likely to be found.

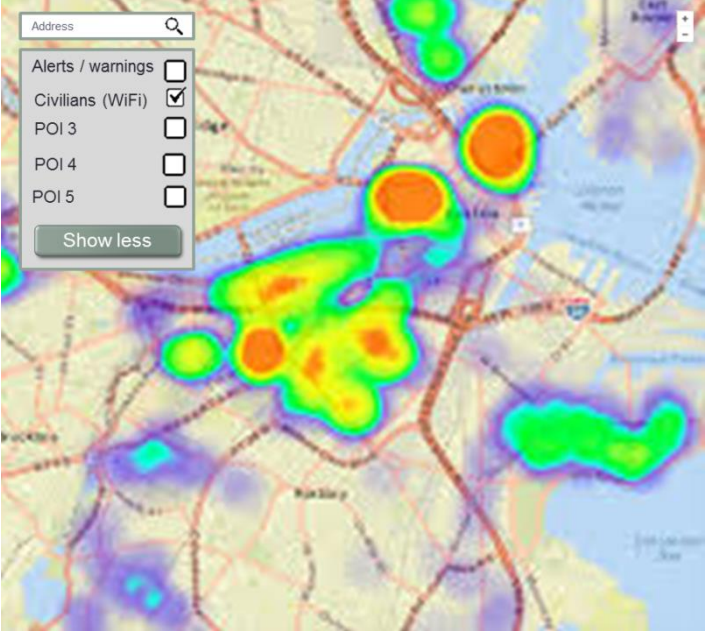


Figure 15 – civilians' positions – heatmap

In Florence, data is available on the movement of people around the city. It is known how many persons move from one area of the city to another. There are various options to display this information. The information to be transmitted is the number of people and the direction. This could be done by vector arrows that vary in size or did come with a number indicator. The following screen should is just one of many possible examples.

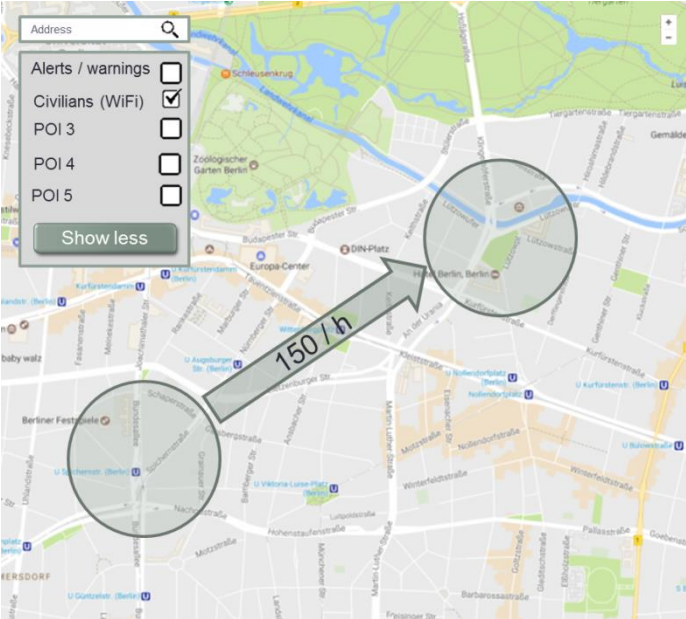


Figure 16 – civilians’ movements – map

Helper positions

With respect to agents of the involved organizations, such as policemen, firefighters, emergency personnel, maintenance staff, and others geolocized a share of each individual should be known. These could be displayed using icons on the map.

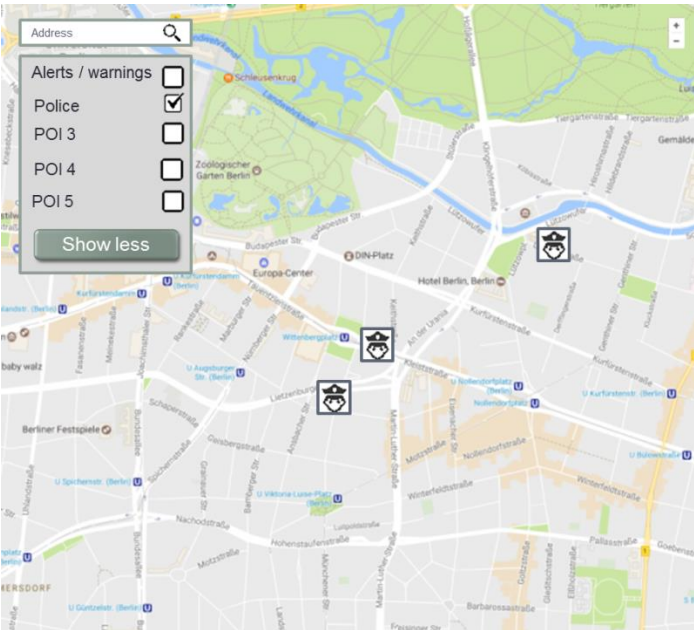


Figure 17 – helper positions – map

Planned events

Events are typical example of information that is well represented in tables. The table format allows for sorting the events by different characteristics. A search function is necessary as we expect there to be too many events for going through the list to find a specific one. To truly fulfil the purpose of the dashboard, which is giving the most important information at a glance, some algorithm should analyse which events are most important, for example creating the greatest risk, and thus should be placed at the top of the list.



Figure 18 – planned events widget

Contacts

This refers to one key outcome of the focus groups: many operators said that with respect to some problems, they would not know whom to contact. In the best case, each widget could be linked to the contact of the person responsible for this type of information or sensor. The contact list has to be searchable for keywords. These key words should represent the responsibilities of the contact role.

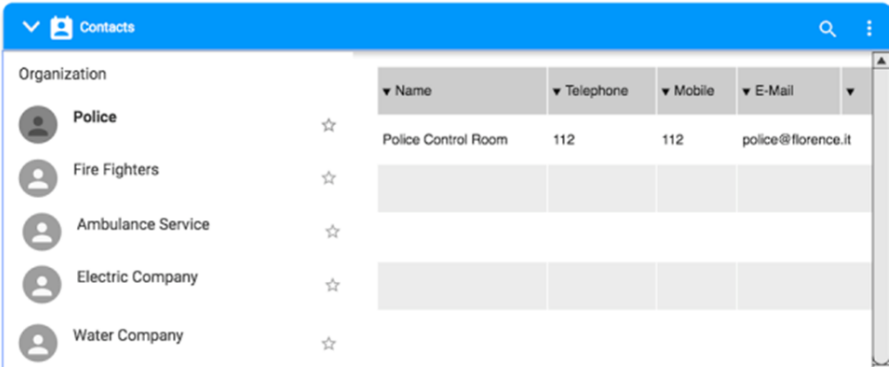


Figure 19 – contacts widget

POIs

Any type of point of interest should be displayed by its own icon on the map. Each icon should be unique. Currently, we expect to have information about hospitals and schools.

Table 10 – POI icons

Hospital	
School	

Live cameras

At the moment, we do not know whether the dashboard will be able to display video feeds from security cameras. In case that such information becomes available and is to be integrated, the following graphic shows what the widget could look like. If more than two video feeds are available, a dropdown list should be available above each video to select two out of many sources at a time.

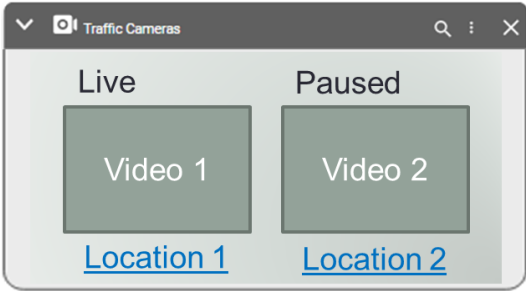


Figure 20 – live cameras widget

Twitter analysis

The dashboard will be linked to the twitter vigilance tool. This tool creates outputs that are too complex for the dashboard. They need to be opened in a separate browser tab or window to be displayed in a comprehensible format. For the dashboard, it would be nice to have a short summary of the currently most relevant trends on twitter to be displayed in a small widget. Font size indicates the importance of the respective hash tag. Items are sorted by size.

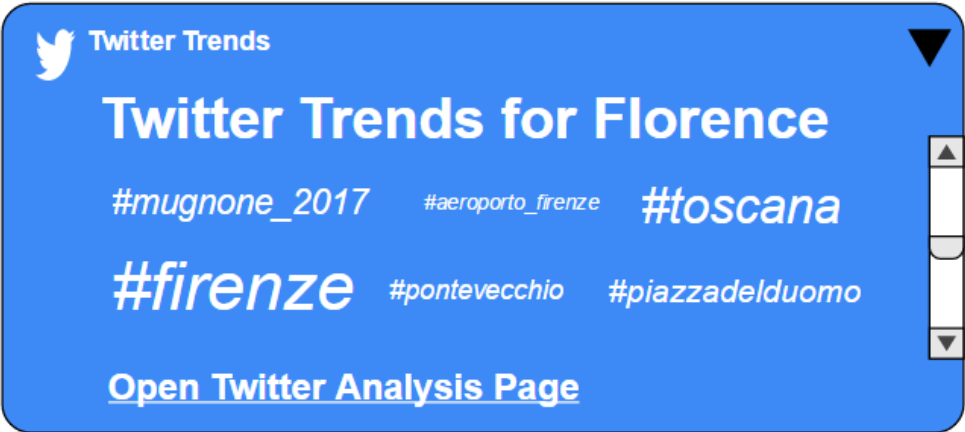


Figure 21 – twitter trends widget

Vulnerability analysis

The best way to show this information is supposedly on the map. Colour coding should show which charts are more and which are less vulnerable. The most vulnerable should be read, medium vulnerable arcs should be marked yellow or orange, and the least vulnerable ones either green or blue. Additionally, there could be a table based widget that displays whether it is an arc or node, its ID, and the linked the map. The collar of the ID could indicate the vulnerability.

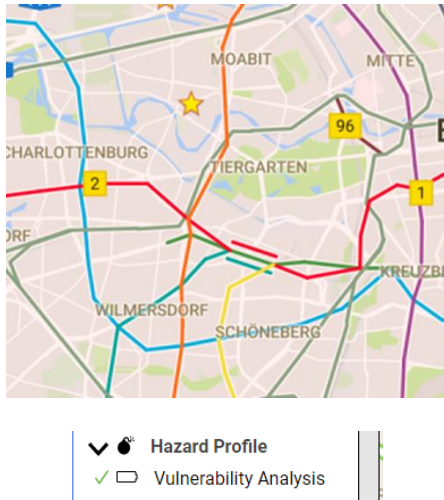


Figure 22 – vulnerability analysis – map

Vulnerability Analysis		
Arc / Node	ID	
	S38-C59	[map]
	F67-T98	[map]
	F29-T37	[map]
	R69-M89	[map]

Figure 23 – vulnerability analysis – table widget

Events (UTM DSS)

Contrary to the abovementioned alerts and warnings, events are notifications that do not necessarily require any immediate or medium term action by the operator. The events widgets are possibly the most relevant contents of the Dashboard when it comes to the innovation of the RESOLUTEproject. This is the type of information that is currently not available outside the organizations that manage the respective DSS.

Events UTM DSS						
Time (start-stop)	Severity	Event type	Event text / Status	Source	Location	
Today, 12:16:39 – 14:30:28	low !!!	roadworks [map]	Street closed southbound	UTM DSS	Via Romana 23-56	
Today, 14:12:56	Medium !!!	roadworks [map]	[...]	UTM DSS		
Today, 14:13:59	high !!!	roadworks [map]	3 cars involved	UTM DSS		read

Figure 24 – UTM DSS events widget

Events (UPT DSS)

The UPT DSS also publishes events on the USB. They are characterized by a different set of variables. The representation style is also recommended to be a table.

Time	Severity	Alarm status	Event type	Event text / Status	
Today, 12:16:39	low !!!	Open	Technical issue	[...]	
Today, 14:12:56	medium !!!	Closed	Line suspended	[...]	
Today, 14:13:59	high !!!	Open	Line separated in 2 rings	[...]	<button>read</button>

Figure 25 – UPT DSS events widget

UTM actuation strategies

The UTM DSS provides information the air the ESB about the actuation strategies available. Deliverable 4.1 contains more detailed information about actuation strategies. Not all of the strategies have to be approved manually by an operator.

Strategy	Priority	type	Criterion: current value (SD)	Criterion: Threshold	Activation Status	Last update
[text description], e.g. close left lane (northbound) on main street [map]	★ ★ ★	Manual	120 (29)	130	active	14:30:29
[text description], e.g. close parking King street [map]	★ ☆ ☆	Automated			Not active	

Figure 26 – UTM DSS actuation strategies

UPT actuation strategies

Apart from a list of events, the UPT DSS also provides, the air the ESB, information about the actuation strategies being invoked by the DSS and its operator. In summary, the DSS receives sensor information and compares it to thresholds. For each actuation strategy to be proposed to the operator, one or several thresholds have to be crossed. The operator then decides whether to accept and thus start the actuation strategy, to reject the decision support or to postpone the decision.

Time	Entity	Request type	Requested value	Request Status
Today, 14:12:56	Tram-Vehicle 3569 [map]	Speed	lower	Pending
Today, 14:12:56	Station „Via dei pescatori“ [map]	Change open/closed	Closed	Rejected
Today, 14:12:56	Tram-Vehicle 3569 [map]	Processed

Figure 27 – UPT actuation strategies widget

Evacuation plan

Once the operator of the evacuation DSS has started and evacuation process, the eDSS sends information about the routes to the ESB. This can be used to inform all operators about the planned evacuation ongoing.

This is how the Central Decision maker will see the evacuation plan when he/she is requested to authorize it:

Evacuation Request

Track path	Path ID	Evacuees by group	Evacuees total	Route elements
[map]	0	Blind: 15 Normal: 10	25	(RT987350945, 0-0) – (GH609808970, 189-189)
[map]	1	Wheelchair: 2 Normal: 10	12	(OI764090967, 56-56) – (LK46560896, 2-2)
[map]	2	Normal: 50	50	(RL76809776, 76-76) – (VG76897899, 78-98)

Figure 28 – Dashboard evacuation CDM 1

There should be a security prompt after pressing the button (“are you sure to ...” with a yes / no decision). This is important because once the evacuation has been started, it is difficult, if not impossible, to reverse it. Once the evacuation request has been processed (either rejected or authorised), the respective result could appear like this:

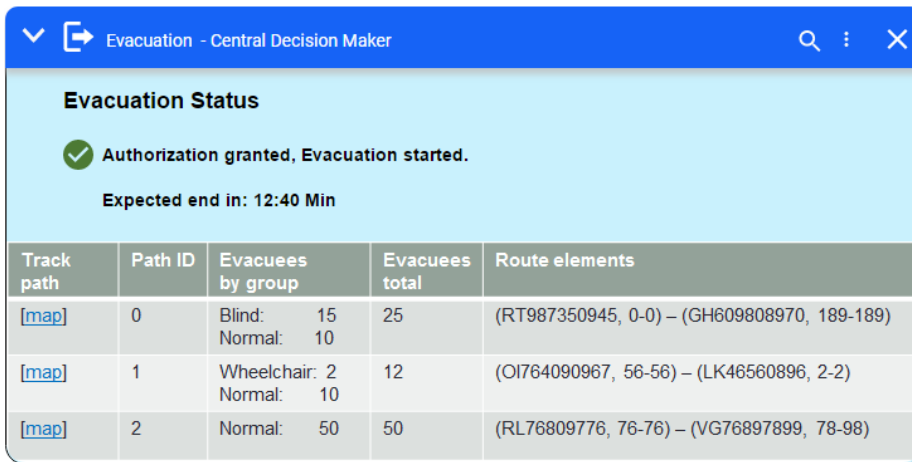


Figure 29 Dashboard evacuation CDM 2

For all other users, the result could be shown like this, once the evacuation has been authorized and thus started:

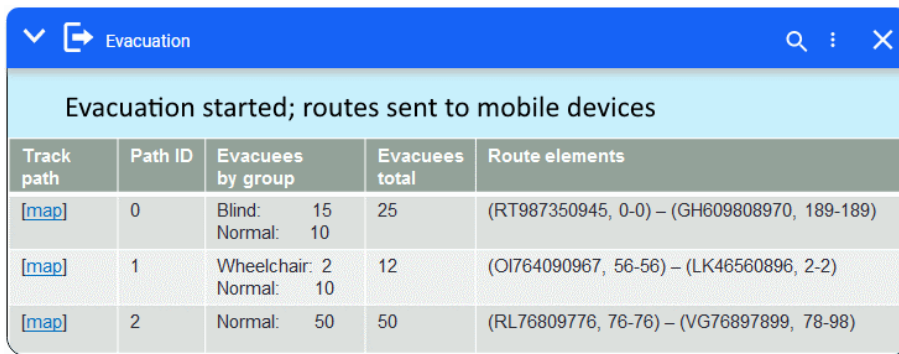


Figure 30 Dashboard evacuation normal users

As the evacuation plan only exists when an evacuation is being planned, it would make sense to transform this not into a widget but into a pop-up window. It could be linked to an alert / warning appearing in the alerts list. This way, the operator would not need to crowd his/her screen with a widget that is empty in more than 95% of the working time.

Evacuation log

The evacuation DSS may also provide the ESB with information on the operator's activity and the activity of the ESSMA users (optional; see Table 7). The log would include links to the map for geolocalized information.

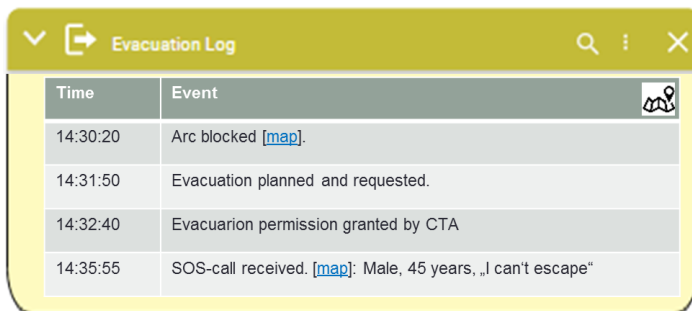


Figure 31 – evacuation log widget

Triage information

The following widget prototypes represent the information regarding the status of the emergency room in the hospitals. According to the operator’s point of view, there are several perspective that might be of interests to display in the dashboard: an overview of the status of the all hospitals in the city (Figure 32), the detailed status of a emergency room of a single hospital (Figure 33), and its summary (Figure 34).

TRIAGE - Florence hospitals overview 9s					
Priority\Hospitals	Red code	Yellow code	Green code	Blue code	White code
PS SANTA MARIA NUOVA	0	18	20	3	0
PS AO CAREGGI	9	20	26	8	1
PS SAN GIOVANNI DI DIO TORREGALLI	0	8	20	2	0

Figure 32 Triage - hospital lists

TRIAGE Careggi - Details 49s					
Priority\Status	Red code	Yellow code	Green code	Blue code	White code
Addressed	1	4	0	0	0
Waiting	0	2	4	3	1
In visit	3	8	15	4	0
In observation	5	6	7	1	0
Totals	9	20	26	8	1

Figure 33 Triage Hospital detail

TRIAGE Careggi - Totals 49s				
Red code	Yellow code	Green code	Blue code	White code
9	20	26	8	1

Figure 34 Triage hospital status summary

Civil protection alerting

In the Figure 35 is depicted an example to represent the alerts provided b the Civil protection.

NULLO	BASSO	MEDIO	ALTO
RISCHIO IDRAULICO			
RISCHIO TEMPORALI			
RISCHIO IDROGEOLOGICO			
RISCHIO NEVE			
RISCHIO GHIACCIO			
RISCHIO VENTO			
RISCHIO MAREGGIATE			

Figure 35 Civil protection alerting

The 7 risks are identified and a scale of colours from zero risk (green) to high (red) represent the potential impact of the event and the extension. In the Table 11 Meteo alerting table is reported the meaning behind the widget representation.

Table 11 Meteo alerting table

Impact	Alerting state	Scenario	Individual behaviour expected
No impact	normality	None	Being informed
Low impact	watchfulness	Localised events	Being aware
Medium impact	Alertness	Widespread events	Being prepared
High impact	Alarm	Widespread events with high intensity with impacts on rivers and on the ground	Ready to act

4 RESILIENCE DSS TOOL

4.1 Introduction

The RESILIENCE DSS tool was initially not foreseen as a part of the CRAMSS. However, it corresponds to the main project objectives defined in the description of work. During the course of the project, the idea of creating it evolved with the aim of providing a tool that connects the guidelines and the FRAM model to real time data collected in the project. The idea behind the RESILIENCE DSS tool is to support operators in understanding relevant interdependencies of the complex sociotechnical system as a whole through the FRAM notation.

To a certain extent it represents the first attempt to operationalize the FRAM model that is basically descriptive. The scope is to help decision makers in understanding dynamics of the system and the impact of their decisions decisions at strategic, tactical, and operational level.

The RESILIENCE DSS aims at supporting the four cornerstones of resilience in the following manner:

- **ANTICIPATE:** The FRAM tool can be used as a strategic instrument to analyse the interdependencies between one's own work and other actors, resources, outputs or other aspects in the socio-technical system. This may help identify risks that were previously unexpected.
- **MONITOR:** The tool supports monitoring, again by helping the user focus on the most relevant information given that certain decisions need to be taken. Its main aim is to reduce mental workload by focusing the UTS's situation awareness of the most relevant data.
- **RESPOND:** In the emergency condition, it may help identify quickly relevant contacts that are needed for harmonizing the emergency response.
- **LEARN:** once system failures have occurred, the tool helps identify which decisions may have been wrong and what lack of information or resources may as than responsible for this.

Thus this tool contributes to resilience by:

- Helping overcome the fragmentation of actors in the UTS modelled.
- Supporting the quick application of the ERMG.
- Monitoring the functional variability and resonance in the system along the function 's interdependencies

4.2 Target users

Target users of the FRAM based tool are all decision makers in the urban transport system. With respect to the RESOLUTE pilot tests, the users are the same as those of the resilience dashboard (see 3.1).

4.3 Scope and objectives

Decision makers in the urban transport system are confronted with the complexity of the socio-technical system and a multitude of data available to monitor system states and processes. When making a decision, the responsible person needs to identify which data is relevant for the decision and to understand the greater context in which this decision is making an impact on more distant aspects of the system. The tool supports the decision maker by answering the following questions:

- Which resources or data do I need to take the decision correctly?
- Which upstream dependency is critical/relevant for my activity (function)?

- Which downstream dependency critically depends to my activity?
- Which is the function in the system responsible for...?
- Which are the critical elements (precondition, resources, time, control, input) that affect my activity performance?
- Do I have the capacity to dampen a possible income variability?

Thereby, it supports the user in achieving these objectives:

- Detect dependencies between the user's own role, functions, or decisions and outputs generated by other functions, managed by other actors.
- Get a task specific overview of the urban transport system.

4.4 Features

Two simple system features are necessary for the user to reach the named objective:

1. Specify the decision to be taken for a specific function.
2. Provide an output listing resources that serve as a basis for their decision, the data available for measuring these resources, and the contact information to their roles in the system responsible for these resources.

This requires a number of background features:

- A FRAM model editor online, able to create functions and specify the interdependencies among them. This includes the aspects, such as inputs, outputs, resources, preconditions, control, and time. The editor needs to be support users (FRAM designer) in the basic operations as creation, delete, modification. However a number of advanced features to support more complex modelling or to speed up the editing process are needed such as: WYSWYG approach, functions grouping, FRAM model duplication, instantiation duplication,
- A decision tree structure based linked to the FRAM model and connectable to the data
- A mapping of decisions, roles, resources and data.

4.5 Standards and development guidelines

4.5.1 Relevant human factors standards

The FRAM tool represents the core concept of resilience: instead of taking decisions strictly rule-based, the decision makers are expected to develop an understanding of the broader picture and a greater context and to take decisions under uncertainty. The tool is meant to be used not only in emergency situations, but equally at the strategic all, tactical, and operational level. Although it is meant to be used in control rooms, it is not a classical control room application. It does not allow for manipulating the system directly and it does not receive alerts from the system either. It is rather that the user would approach to tool to satisfy a certain the mound of information. Hence, standards and relate to alerts, such as EEMUA 191 and EN 62641-9 I are not applicable.

Generally speaking, the design of the application needs to ensure all foremost that the user can efficiently make input into the system, which means specifying the decision to be taken, and that the user can interpret the output to effectively, at any desired point in time. Therefore, general usability standards, such as EN ISO 9241 or Nielsen's heuristics for designing dialogue systems (Nielsen, 1993) are likewise important. Possibly, standards referring to mental workload, such as EN 614-2 may apply, too. This is not to say that the application should not

fulfil all control room standards named in the section above describing the development of the Dashboard (see 3.5). However, due to the reduced complexity of the FRAM tool, standards referring to learning opportunities, autonomy, or system authority seem impossible to apply all violate in this context.

4.6 User interface development

By the time this deliverable has been finalized, the implementation work of the FRAM tool is still in progress. Although task 5.1 is now finalized and closed, changes to the currently preferred user interaction concept may still become necessary.

As the tool is not part of the CRAMSS, and as its development was started late, there has not been any opportunity to test the design with representative users. If possible, we will intend to evaluate the usability during the pilot tests, with a small and reasonable amount of resources.

4.7 User interface concept

Log-in

The user needs to log in, as only authorized persons may access the tool and as the user's role decides on the information displayed. There could either be one combination of user name and password for each organizational role, or the system could rely on individual login data for each user.



Figure 36 – FRAM tool – Log-in page

If the user has forgotten his credentials, he should recover them from a responsible inside his organization. Moreover, accessing with login and password allows in managing the credentials on the FRAM model produced. Thus only the author can apply changes on its models while the others can open that models in a read-only fashion.

Main page

The main page shows, as main features,

- a) The list of the FRAM models and their related instances (left area)
- b) The toolbox for editing (on top)
- c) The main area where the FRAM model is designed

d) The toolbox for **model navigation**

A **model or its instantiation can be displayed** clicking on the left side of the screen on Model or Instance. A number of exagons and their connectons are then displayed (see Function and dependency creation

The FRAM designer can start his/her work modelling the system adding hexagons and links to an existing model or starting from scratch using the Add new function tool

For each new function it should be possible to add a name and a description. Moreover it is needed to manage the to/from dependencies directly from the function **control panel**. **In fact, through it adding dependencies to the corresponding Aspect of the function is necessary. Such dependencies should be modified or removed (see Figure 38).**

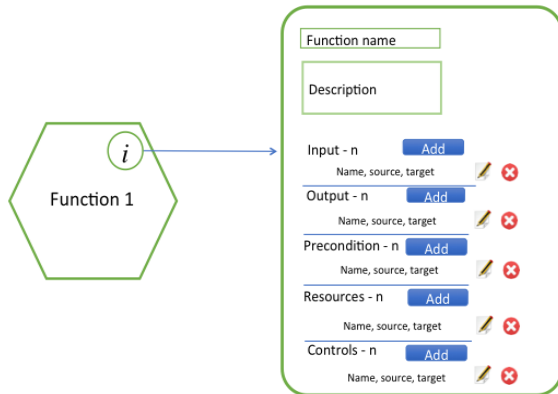


Figure 38 - Function setting

The dependency could be also created exploiting the drag & drop advanced feature.

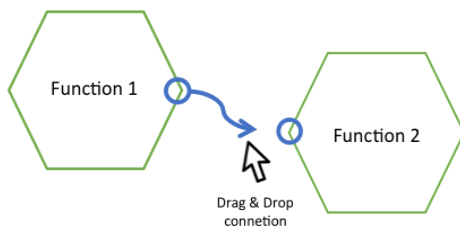


Figure 39 - Drag & Drop for dependency creation

Through the **Drag & Drop** it is possible to click on the source aspect, drag the mouse pointer up the desired function and then drop it over the aspect of the destination facton that the user want to connect (Figure 39). For each dependency, a label needs to be created with the form. Through this feature, it is possible to create complex model also following a quick & dirty approach that might be useful during the focus groups or interviews sessions.

Grouping

Another advanced feature is represented by the **Group element creation**. If the model owner does the access, the editing toolbox will be displayed (on top).

When a model is request to be shown, from the top menu is possible to: edit the model, delete the model and import a new FMV model to modify or test. While editing a model, is showed a top menu that allows the user to

undo and forward the basic operations (Precisely: add/remove/modify of functions, aspects and groups and add, remove functions in groups)

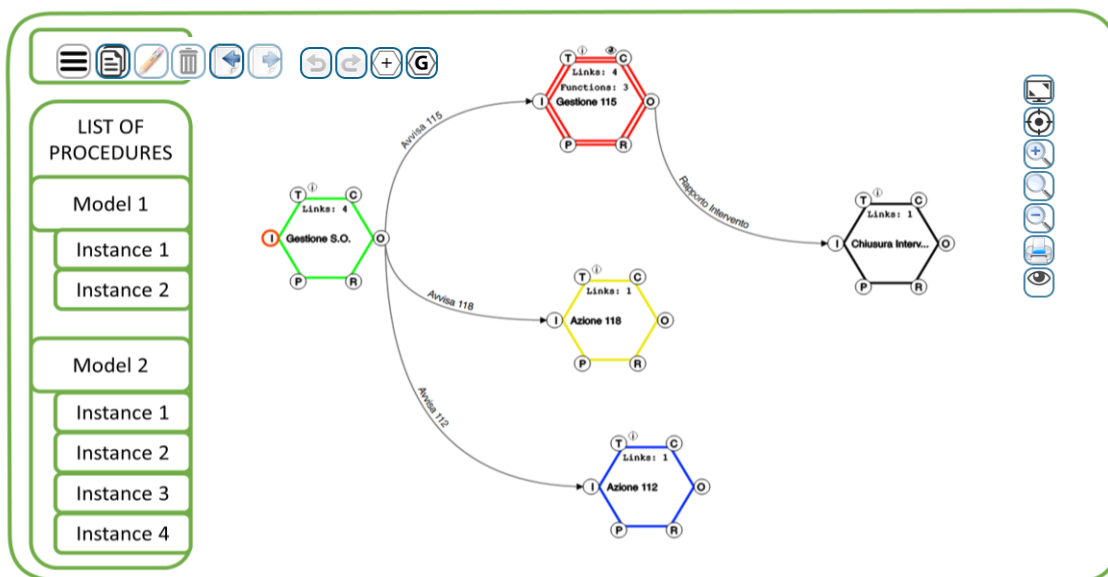


Figure 37 – RESILIENCE DSS Main page

Function and dependency creation

The FRAM designer can start his/her work modelling the svstem adding hexagons and links to an existing model or starting from scratch using the Add new function tool

For each new function it should be possible to add a name and a description. Moreover it is needed to manage the to/from dependencies directly from the function control panel. In fact, through it adding dependencies to the corresponding Aspect of the function is necessary. Such dependencies should be modified or removed (see Figure 38).

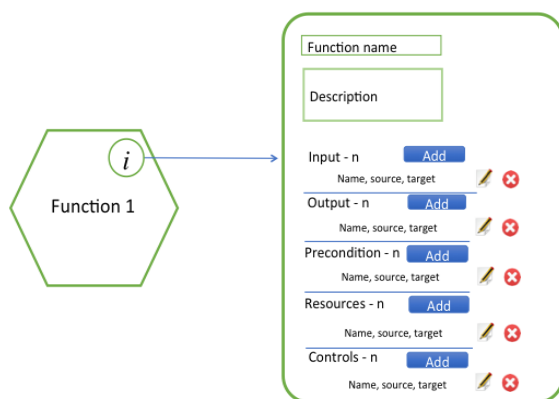


Figure 38 - Function setting

The dependency could be also created exploiting the drag & drop advanced feature.

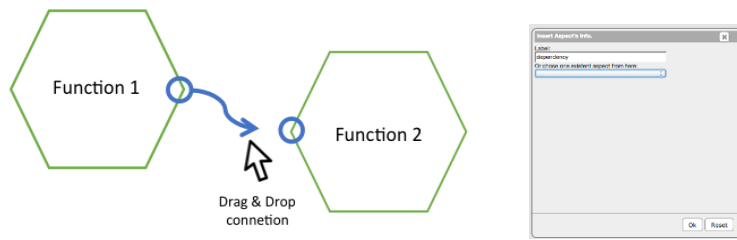



Figure 39 - Drag & Drop for dependency creation

Through the Drag & Drop it is possible to click on the source aspect, drag the mouse pointer up the desired function and then drop it over the aspect of the destination function that the user want to connect (Figure 39). For each dependency, a label needs to be created with the form. Through this feature, it is possible to create complex model also following a quick & dirty approach that might be useful during the focus groups or interviews sessions.

Grouping

Another advanced feature is represented by the Group element creation. 

A Group can be seen as a container of functions or an high level function composed by a number of sub functions. This situation happens when, from the analysis, a function is considered too complex for being managed as a single one. In this way, it is possible to create a multi level and view model, spanning from a simplified (all the Group elements are grouped) to a more complicated view (all the Group elements are exploded). The elements in the Group assume a strong semantic relation each other that will help the operators in understanding the system complexity.

To intuitively add a function to a Group element the Drag and Drop action should be implemented (See Figure 40).

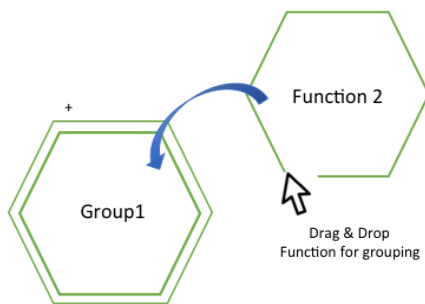


Figure 40 Drag & Drop grouping

As said, a Group element can be exploded in its sub-functions as depicted in Figure 41 (red area).

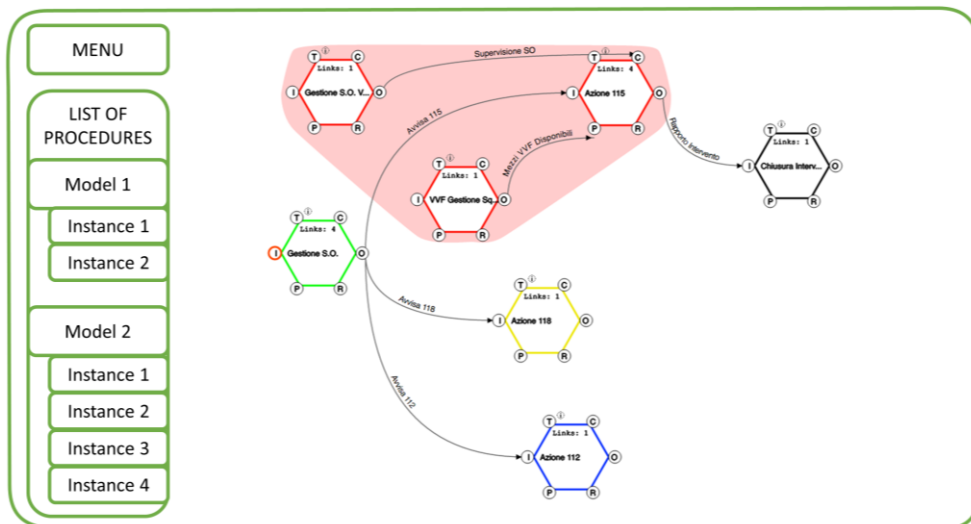









Figure 41 - Function Grouping

Visual inspection

To manage the model visual inspection a number of suitable tools need to be considered. In particular:

-  Application full screen on/off
-  Center on the model
-  Model Zoom in
-  Fit the FRAM model into the screen
-  Model Zoom out
-  Model Print
-  Turn off the Model dependencies (links)

Export to SmartDSS 

In order to connect the FRAM functions to a decision model (decision tree) it is necessary to connect the RESILIENCE DSS to the Smart DSS tool (Bellini et al, 2016). Smart DSS is a multi-criteria decision support system based on the Analytical Hierarchical Process and developed by DISIT lab². Such a tool can be connected to real time data to quantify the uncertainty of the success/failure for a specific decision. In order to benefit of the SmartDSS capability to manage data, it is necessary to create a smooth transition of the FRAM based models created into RESILIENCE DSS to the Smart DSS. The objective is to identify the core decisions that are taken by a function and connect such a decision to the contributing Aspects (input, resources, precondition, control, time). Each aspect of a function in the model will be valorised by a defined set of information coming from the RESOLUTE Data Layer. The final aim is to quantify the capacity of a function to operate as expected on the base of real data (instead of the classical expert judgment). In Figure 42 is represented a FRAM function

² www.disit.org

imported from the RESILIENCE DSS and computed into SmartDSS. The Italian Flag represents the uncertainty that is propagated and weighted in the three.

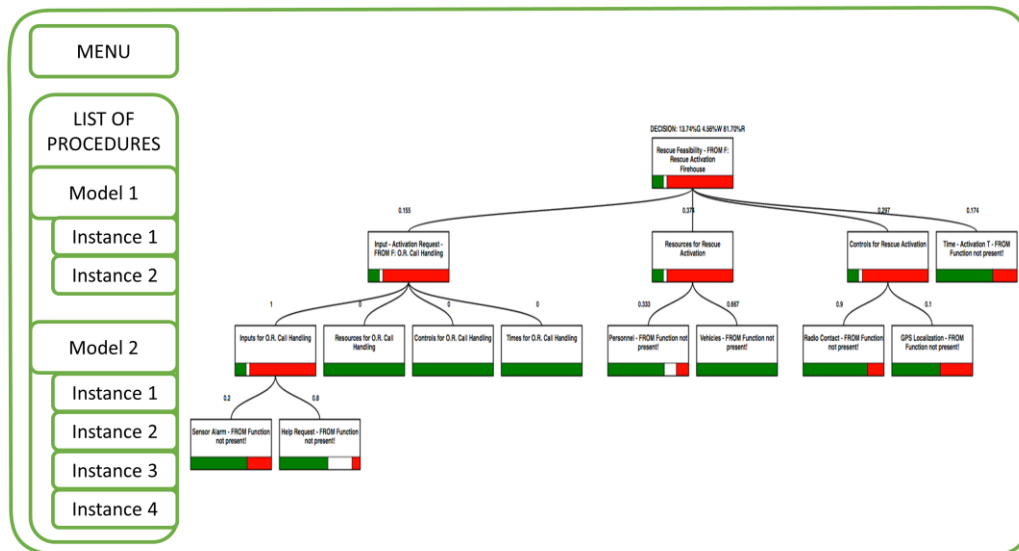


Figure 42 FRAM function representation in the SmartDSS

The RESILIENCE DSS is intended to be a tool for analysing and monitoring the resilience of the entire system instead of a tool for a prompt response. In particular, the RESILIENCE DSS aims at informing the operators about the level of variability of the functions monitored as an indicator that something is or is not working as expected. The tool supports the orientation of the operator towards those functions that seems to be more critical. In this way it is possible to concentrate the attention only on a sub set of the entire system reducing the mental workload required to gain the right understanding of the situation.

5 EVACUATION DSS

5.1 Introduction

A system’s resilience resides in the ability to understand and monitor resources and the capacities that they provide towards coping with both expected and unexpected amplitudes of performance variability (Hollnagel, 2011). The RESOLUTE project takes advantage of data to mobilize capacities necessary for coping with events, or even avoiding events before they happen. The above described the Dashboard mobilizes such capacities by using data to improve the communication between operators. The evacuation DSS uses real time data to improve the coordination between authorities and citizens. Its main purpose is to calculate individual evacuation routes for citizens in an affected area and to send these routes to the citizens’ smartphones.

How does the evacuation DSS support resilience?

In an urban transport system, the citizens individual mobility capacities, that is their ability to move around on their own, as well as the capacity of streets and places in the city to contain a maximum number of people can be considered as resources. The evacuation DSS helps the involved humans, operator and civilians, to make optimal use of these resources and thus contribute to minimizing damage during a critical event (RESPOND) or

even preventing critical events from happening by evacuating areas before a mass panic can even start (ANTICIPATE). Like all resolute technology, its features are available under normal and alarm conditions.

5.2 Target Users

Target users of the eDSS are professionals in a control room that will be receive the task to organize citizen evacuation when necessary. In Italy, this is likely to be the civil protection, an organization for the purpose of preserving the population from damage in catastrophes. In Greece, this could likewise be the General Secretariat for Civil Protection (CP) and its Operational Centre 199 SEKYPs.

Apart from knowing the basics of the application, the application does not require any specific knowledge, unless incident response plans of the city would require that.

5.3 Scope and objective

The scope of the eDSS is to enable a specific operator to efficiently steer citizen behaviour in an optimized way, so that critical situations can be avoided or dealt with, thus minimizing damage to human health, as well as avoiding a blockage of certain parts of the UTS. To this purpose, the eDSS is meant to help the user achieve the following user objectives:

- Track the position and flow of ESSMA users in the city; analyse user behaviour based on profile clustering.
- If necessary, evacuate people through a route guidance that is optimized by a Decision Support System, so that the citizens are empowered to reach the required safe zones in a minimum of time. This includes:
 - Define start positions (from where to evacuate)
 - Define destination positions (safe zones to go to)
 - Define, if necessary, which arcs (streets) in the network may be used for the evacuation
- Communicate with the citizens via a newsfeed (all users) or individualized messaging, e.g. to alert them about a dangerous condition close to their location.

5.4 Features

The features of the eDSS are also linked to the four cornerstones of resilience:

- **ANTICIPATE:** The integrated user profile analysis furthermore allows for developing a deeper understanding of how different types of users travel through the city on a regular basis.
- **MONITOR:** The eDSS allows for real time monitoring of the users of the mobile app. This means that critical masses of people can be detected before a mass panic occurs. During a critical event, the operator can use the monitoring data to adapt his tactical approach.
- **RESPOND:** In the emergency condition, the decision support ensures that the best evacuation strategy is used, based on the known circumstances. This is likely to save time, resources of rescue teams (as citizens are more likely to successfully rescue themselves), and even human lives.
- **LEARN:** The eDSS log file, sent through the ESB can contribute to understanding how to improve reactions to similar events in the future.

5.5 Design standards

The eDSS is effectively a control room software, and hence, the same standards apply as those referenced in section 3.5. Compared to the Dashboard, the eDSS is not only meant for information retrieval but also for making inputs that affect processes in the UTS (citizen behaviour). However, the application of a great part of those standards was, again, difficult here, as the eDSS is not designed for one clearly existing (or newly created) workplace in a closed system, all operated by one organization (as would be the case in nuclear power plants, airports, etc.). Instead, the eDSS may reside in different control rooms, or even move from one operator to another.

In the following paragraphs, we describe how the standards collected in D5.1 apply to the eDSS.

5.5.1 Based on standards and the ERMG

The ERMG name key standards to be heeded in UI design of the Dashboard. They were already mentioned in deliverable 5.1. We kept this list here and, where adequate, we added a short information on how the standard was respected in the design of the evacuation DSS.

1. EN 614 Parts 1 and 2 (Machine safety requirements).
 - a. Work task design (EN 614-2) Important in this context are, in this order, “over- and underload”, “feedback”, “autonomy”, “learning opportunities”.
 - i. “Over- and underload”: Mental overload was reduced by minimizing the requirements of using short-term memory and cognitive processing. The operator interacts directly with elements on the map and is guided through the process.
 - ii. “Feedback”: all user actions that have an impact on the citizens produce a direct feedback in the very same interface. The progress of the evacuation can be monitored by following the users of the mobile app on the map, messages appear in the respective section in the newsfeed timeline order tool for individual messaging. Book tour and blocked streets are also displayed on the map.
 - iii. “Autonomy”: the interaction concept is restricted to the minimum of necessary interactions, based on the date and technology currently available. All processes can be interrupted and user errors can be corrected at each stage individually.
 - iv. “Learning opportunities”: for the evacuation procedure, there is a guided mode and an expert mode. The user profiling also constitutes a learning opportunity.
2. Control room standards such as EN 11064 – Part 5: two criteria are of particular relevance:
 - a. System authority: The human operator always needs to be in (final) control of what is going on. This is the case. The eDSS provides decision support, it doesn't take its own decisions.
 - b. Memory: The design needs to take the human short-term memory span into account. All system processes will be designed in a way that avoids, wherever possible, the use of short-term memory and ensures that such processes, if they cannot be avoided, cannot lead to critical errors. The DSS has no special memory requirements.
3. EEMUA 191 equals EN 62641-9 and particularly defines alarms and conditions from a perspective of (electronic) system engineering. The eDSS does not have any alerts.
4. ISO 6385:2004 (Ergonomic principles in the design of work systems) and EN 110764 have been respected.
5. “Staff should be involved in the design process” (D3.5, p. 109). This has been realised by user testing with the respective end users.

6. "Monitoring interfaces should be usable in both normal and emergency situation. The CHI design and evaluation needs to be conflict free, independent and stakeholder and situation oriented" (D3.5, p. 109). This is true for the eDSS.
7. "Human Factors concerns on human-computer interfaces, contents and dialogues should be set up in order to ensure easy, safe, comfortable and efficient interactions avoiding errors or any type of fatigue or distraction" (D3.5, p.133). We followed this guideline in the development.

Another relevant standard is EN ISO 9241-110; it describes ergonomic principles for the design of dialogue systems. The Dashboard is a dialogue system, thus the norm is applicable.

- a. Suitability for the task: with its limited, easy-to-use, and interruptible basic features, the eDSS fits easily into any task, independently of the control room it will finally be used in. One feature that particularly corresponds to this criterion was separating the processes of blocking or on blocking arcs from the evacuation process. Also, the recommendation to fill the nodes with standard numbers representing custom users corresponds to this.
- b. Self-descriptiveness: This was achieved by using a wizard approach for evacuation and blocking/unblocking. We used commonly known interface elements, such as an interactive map and action buttons.
- c. Controllability: As already mentioned, the eDSS allows the operator to interrupt and resume the tasks at any point in time. Providing the UI in the user's language is also commonly referred to as a controllability feature (e.g., Ertl, 2010).
- d. Conformity with user expectations. This was achieved through user testing and by adopting as many commonly known UI conventions as possible. The map, e.g. features controls known from common maps, such as "maps.google.com". Logout and configuration features are found in the upper right corner, as in most web-based applications (Google, Facebook, Amazon, etc.). The timeline resembles the Facebook wall, etc.
- e. Error tolerance: Most user actions are reversible. In cases where this is not directly possible (e.g., once an evacuation has been started), decisions require a second / separate confirmation. The fact that the CDM has to authorize the evacuation contributes to the error tolerance.
- f. Suitability for individualization: the DSS is not customizable.
- g. Suitability for learning: The current design allows the user to use a guided approach, or use an expert tools more separately from each other.

The requirements related to psychological strain in ISO 10075-1, Nielsen's heuristics for designing dialogue systems (Nielsen, 1993) are similarly relevant.

Furthermore, implications for the design of the DASHBOARD were deducted from NUREG 0700 (Human System Interface Design Review Guideline from the U.S. Nuclear Regulatory Commission, 2002) and Bockelmann, Nachreiner & Nickel (in press); these are reported in Table 8: Exemplary selected guidelines for control rooms and CRAMSS implications

Table 12: Exemplary selected guidelines for control rooms and eDSS implications

Guideline(s)	Implications for the eDSS
Consistent interface design conventions should be evident for all display features (such as labels).	We folled a common logic in the design and user testing did not identify any inconsistencies.
Information should be displayed consistently according to standards and conventions familiar to users.	This was also checked in the user testing.

Guideline(s)	Implications for the eDSS
There should be an explicit mapping between the characteristics and functions of the system to be represented and the features of the display representation.	Users directly interact with the displayed system features.
The characteristics and features of the display used to represent the process should be readily perceived and interpreted by the operator.	This corresponds to the chosen wizard approach.
Text displays should be worded simply and clearly.	The eDSS contains very few text displays. All of them formal of simple and clear wording.
The computer should acknowledge every entry immediately.	All relevant user actions provide a direct feedback.
When processing in response to an entry is lengthy, the user should be given some positive indication of subsequent completion.	This applies to the authorization process. The user is notified once the authorization has been given.
The operator should be supported in carrying out daily work routine by appropriate support and learning systems.	This also corresponds to the wizard, as the evacuation procedure is supposedly not a daily work routine.

5.5.2 Other relevant control room standards

Additionally to the above mentioned aspects, which were already collected in D5.1, we also took additional sources of design recommendations into account (infoComm, 2005; Porthin, Liinasuo, Kling, 2016). There is a great overlap between such guidelines, which themselves collect and summarize recommendations from various sources. It would exceed the size of this deliverable to mention them all in detail. However, in general, we focused on making the structure of the interface intuitively understandable and helping the user to understand – even without specific training – what it is capable of doing for him. We put particular effort into reducing cognitive load, basically by reducing as much as possible the information the user needs to carry in memory to complete a task. The navigation structure was held flat, which was not difficult after we limited the functionalities to what was most important. And all processes are interruptible, so that the operator may use any other interfaces parallelly without any negative consequences for the tasks done in the eDSS.

5.6 User interface development process

5.6.1 The first user test and iteration

The first user test of what now is the evacuation DSS was done as a test of the first version of the CRAMSS. The objective and method of this test are reported in chapter 3.7.2. Here we only summarize the results that are important in the development of the evacuation DSS.

Results

The following usability problems were found:

Table 13 – usability issues eDSS (CRAMSS) – user test 1

Test task	Problem
Check where in the city green waves are currently being activated. A green wave, also called phased traffic lights, is a setting of traffic lights that allows vehicles to pass several green lights in a row.	half of the users looked picked the dashboard > car congestion
You want to evacuate all persons from “position A” to the gathering point, named “position B” on the map. The	almost all could not find the evacuate icon, many clicked directly on the street / civilians, junction-pins were not

CRAMSS DSS will then send the people on the correct route via their mobile phones.	understandable
You have been informed that there has been an accident on the Great Avenue and that no cars will currently be able to pass. You want to block this street, so that the DSS will divert the citizen's routes around this street instead of through it.	almost all failed this task, many clicked directly on a street, without switching to the arcs view (clicking on "block street" first).
Get the latest information from other operators and from the "Central Decision Maker", e.g. the city's mayor.	Users suggested that this should be combined with contacts; news were associated with social networks
You need some extra information about the CRAMSS and how it works.	Half of the users did not find the help, clicked on dashboard, arrow of CRAMSS-logo

Based on the results, the following design recommendations were phrased:

- Either link the map-based information features to the Dashboard, or link all road-traffic-related widgets to one single category. *Note: the former of the two options was eventually achieved by separating eDSS and Dashboard.*
- Make a more visible toolbox for the buttons that allow the user to intervene (e.g. evacuate). Check options for changing size, colour and location.
- Clicking on the map should open a context window that allows for an alternative path to intervene with the system (e.g. configure an evacuation).
- Messages should be grouped together with the contact list

5.6.2 The second user test and iteration

Objective

The second usability test of the eDSS features was aimed at gathering qualitative data to support the further improvement of this interface, which was now to be presented in a separate application, without the Dashboard contents.

Methods

Sample. 10 participants took part in this UX study. These were the same participants as in the second user test of the Dashboard (3.7.3). Police officers, employees of the metropolitan authority, Civil Protection, and transport companies of Florence, Italy took part. All participants were Italian and male. A translation help was used in the case of language barriers, as not all were fluent in English.

Click dummy (Stimulus). As in the first test, we used the medium-fidelity mock-up in the shape of a presentation shown on a laptop screen. The available features were:

- Start an evacuation procedure (this required defining start and destination nodes).
- Exclude an arc (street) from the evacuation routing
- Re-include an arc (street) from the evacuation routing
- Messaging (chat with individual users or groups of users)
- Forward a user's message to the Dashboard for all operators to see
- Use the help feature
- Change the language (settings)
- Log out

Procedure. We created a test instruction to guarantee standardized conditions. The test tasks consisted in using each of the above named features once. Before the test, participants signed the informed consent and nondisclosure forms, and were asked to think aloud while using the prototype.

Analysis. The thinking-aloud remarks of the users as well as their behaviour while interacting with the prototype were analysed qualitatively and quantitatively during the study and afterwards using the video files.

Results

The following usability problems were noted by at least one user:

- Users clicked on the map instead of using the evacuate-feature from the toolbox. This resembles an error detected in the first testing phase.
- In order to forward messages, users intended to use drag-and-drop interactions to move the message from the messaging module to the timeline.

The following design recommendations resulted from the test.

- Update the map mechanics to allow for direct interaction with the map. This means that by clicking on the map, the user should be able to start the interaction modes necessary for selecting ESSMA users, for defining start and end nodes of the evacuation, and to remove or re-include arcs into the calculation.
- If possible, allow for drag-and-drop of messages. In any case, increase the visibility of the forward-button.

Due to updated information of the application's mechanics, the following changes were also applied:

- Re-organisation of the evacuation process:
 - Address search is not available for selecting nodes.
 - An interaction mode for drawing circles on the map will be used to select ESSMA users in the area to be evacuated. This now corresponds to the first step of the wizard
 - The context menu of the nodes displays options for setting the node as a start node and as an end node. Start nodes have entry fields for entering the expected number of citizens not using the ESSMA (divided by user categories).
- The timeline is now used for managing the newsfeed that appears on the ESSMA.

5.7 Storybook

The basic layout of the application is divided into 4 main elements: Map (1) and Map Layers (2), Control Panel (3), and Application Bar (4). Figure 43 shows the basic layout:

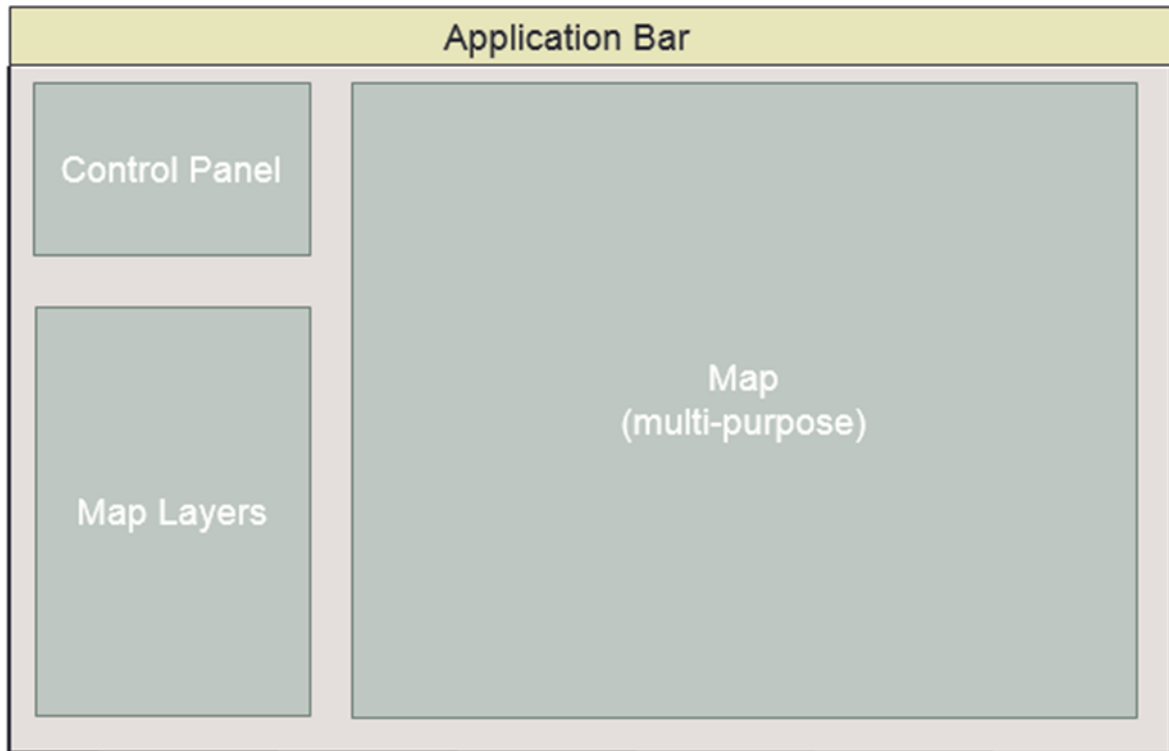


Figure 43 – eDSS main page layout

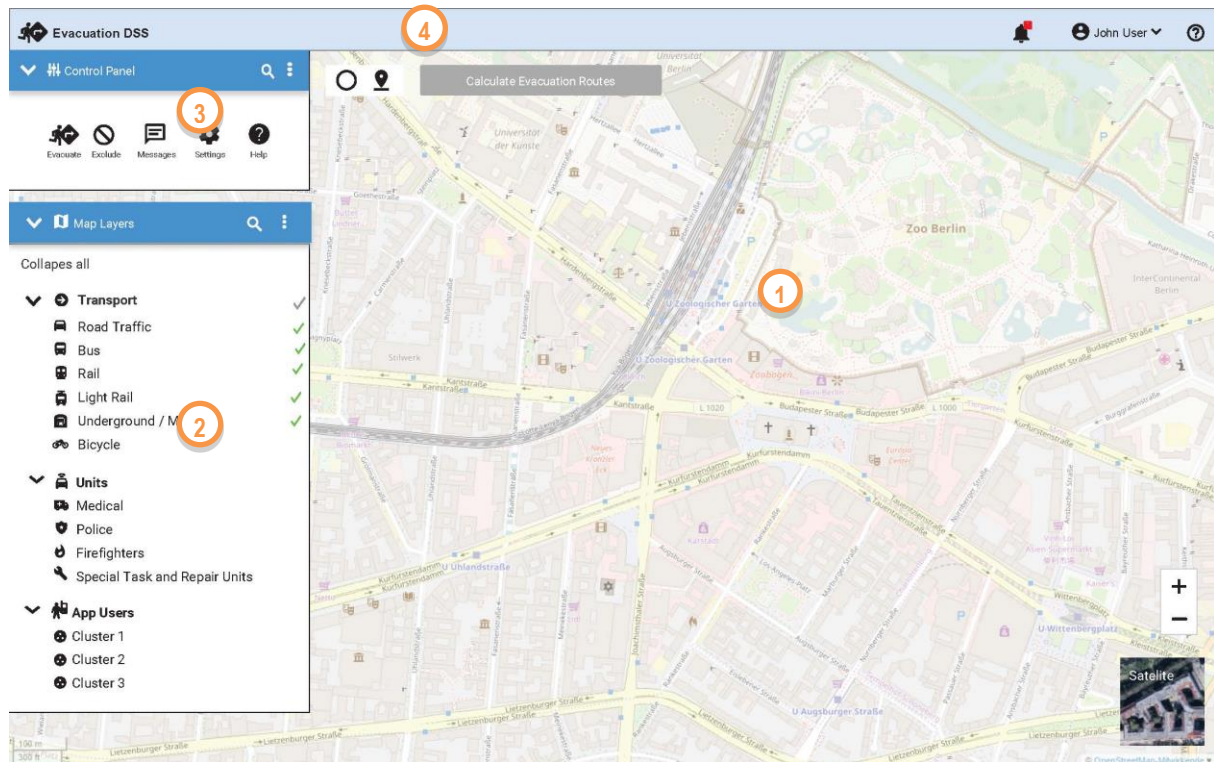


Figure 44 – eDSS starting page

Table 14 - eDSS starting page

No.	Description	Function	Behaviour	Comments
1	Map	Dynamic image	The map can be moved and shows the information chosen by the Map Layers. It also includes buttons to zoom in and out in the bottom right corner, as well as 3 “power-user” shortcut buttons activating the evacuation on the top left corner	
2	Map Layers	Checkboxes	Actual information can be shown simultaneously on map when the corresponding checkbox is activated	
3	Control Panel	action buttons	Action links on the left of the map. Each button activates another function of the eDSS, like evacuate, exclude (/include), Settings and Help.	
4	Application Bar	Action buttons	A horizontal bar at the top of the map with buttons of help, log out, (and notifications, if available)	

Map

The map is the main element for interaction, as most actions related to the evacuation refer to geolocalized positions. The map has standard interaction features known from other popular online maps. There are also specific tools: (4) in the following figure.

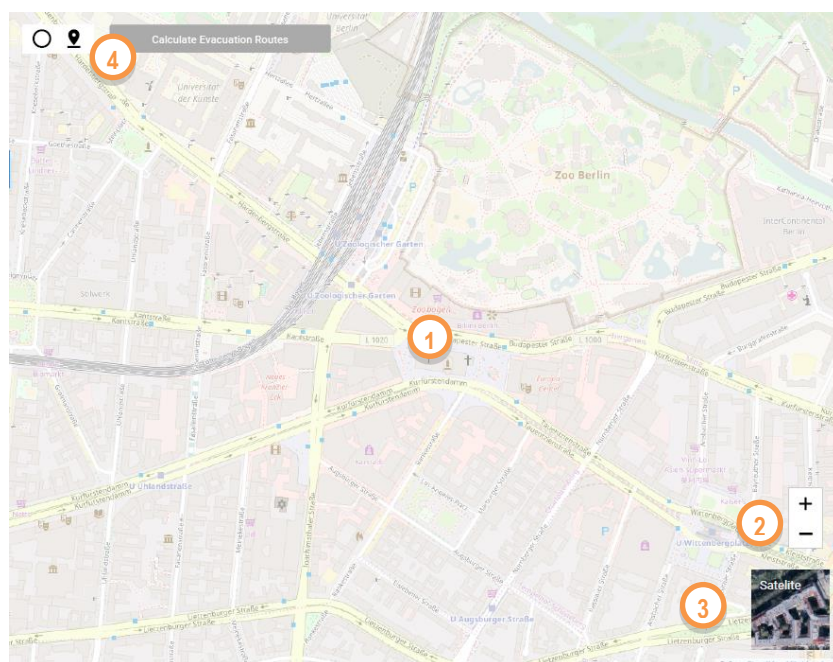


Figure 45 – eDSS map layout

Table 15 – eDSS map layout

No.	Description	Function	Behaviour	Comments
1	Map	Dynamic image	The map can be moved and shows the information chosen by the Map Layers. It also includes buttons to zoom in and out in the bottom right corner, as well as 3 “power-user” shortcut buttons activating the evacuation on the top left corner	
2	Zoom buttons	action buttons	buttons to zoom in and out in the bottom right corner	
3	Satellite mode	action buttons	Switches to satellite view (or other map representation formats).	Optional: This can either be represented in the map layers (see Figure 44), or as shown here in a separate button.
4	Pro-user buttons	Action buttons	The circle – button activates the tool to draw a circle on the map for selecting ESSMA users for evacuation. The POI-button activates the mode of the nodes; the nodes are then displayed on the map and can be interacted with through a context menu. The button on the right starts the calculation of evacuation routes based on all the input available (ESSMA users selected, start nodes and end/destination nodes defined).	These correspond to the pro-user interaction routine, which does not require the wizard.

right-click

On right-click on the map, the context menu opens, with an option to evacuate or to exclude the clicked area, as shown in the following figure.



Figure 46 – eDSS context menu on the map

Note: The map has a mode in which the nodes and arcs are displayed. In these modes, the context menu displayed on right-click differs. In the mode displaying nodes, the context menu contains options to make the respective selected node a start or end node. For start nodes, custom citizens can be defined per category (e.g. normal, wheelchair user, elderly, car, bus).

When pressing “evacuate” in Figure 46, the evacuate feature is started, selecting the current node as a start node. When pressing “exclude” in Figure 46, the exclude feature is started, proposing the arc clicked on when opening the context menu as an arc to be excluded.

Map layers

The map layers interact with the map and control the information displayed on the map. Different types of information may be turned on and off by these layers, which work like checkboxes.

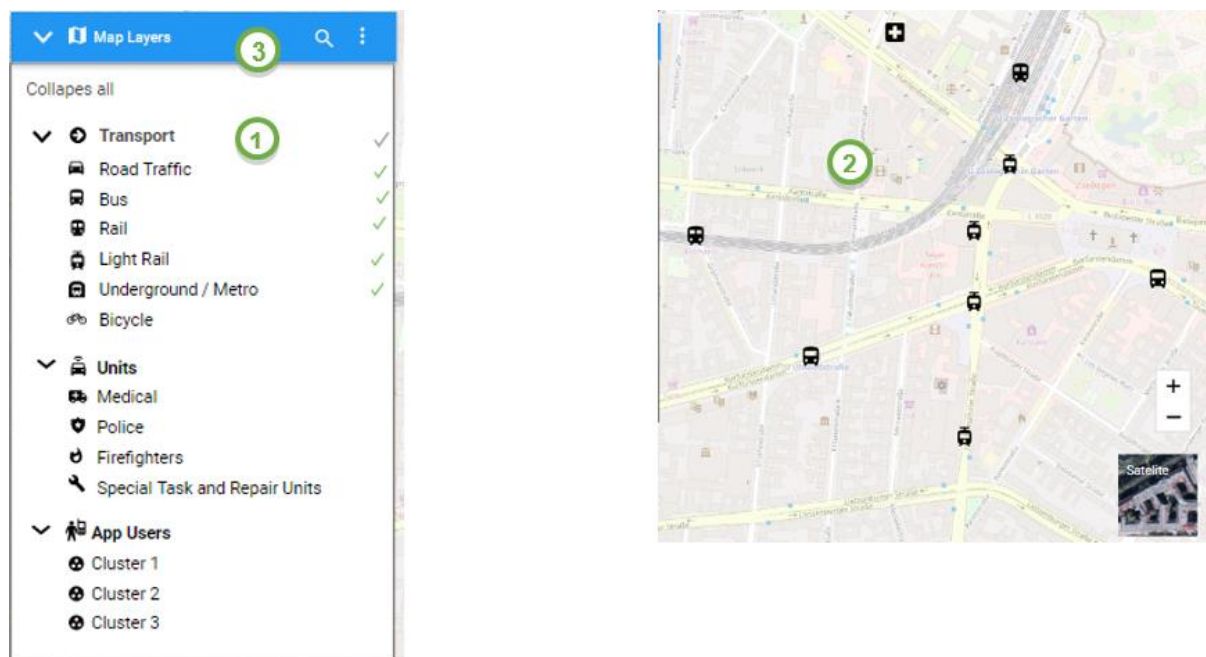


Figure 47 – eDSS map layers

Table 16 – eDSS map layers

No.	Description	Function	Behaviour	Comments
1	Map Layers categories	Checkboxes	The different categories determine the visual representation of the corresponding information on the map (2)	
2	Map	Dynamic image	The location of the checked map layer is displayed on the map, in this example the trams, trains and buses	
3	Box Bar	Action buttons	See Box Bar (next figure/table)	

An additional included visualization (UsersClustering) enables the user to view and select clusters of civilians that are created as a result of a profile analysis (see. D5.3). These may either be depicted as another layer, or in a separate window on top of the map. An example of the former is given here:

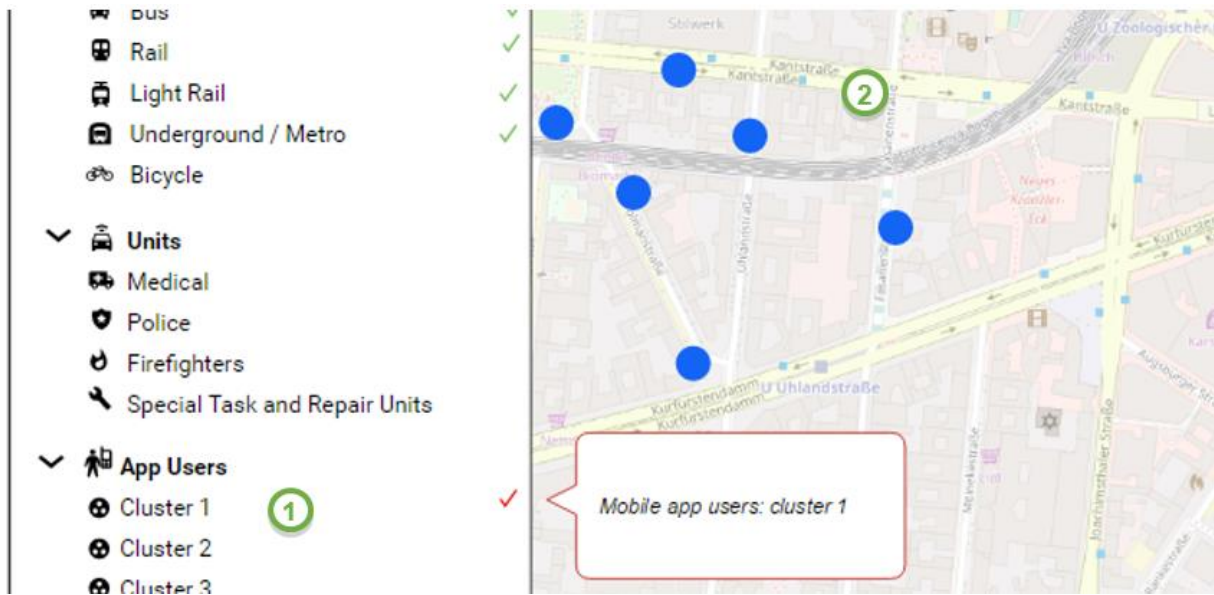


Figure 48 – eDSS user clusters as layers

Table 17 – eDSS user clusters as layers

No.	Description	Function	Behaviour	Comments
1	Map Layers Cluster	Checkboxes	Filters information to show on map	
2	Map	Dynamic image	Shows the corresponding information on the map (2)	

Box bars

All windows shown on top of the map, such as the list of layers and the toolbox, are recommended to have the following features, collected in a header bar.



Figure 49 – eDSS box bar

Table 18 – eDSS box bar

No.	Description	Function	Behaviour	Comments
1	Maximize / minimize	Action button	On click the box maximizes or minimizes its size and collapses	
2	Title	Icon and static text	Describes the contents	
3	Search	action buttons	On click a search field opens. On "Enter" a search is performed within the box, and the results are highlighted	

4	3 dots	Action buttons	Optional functions, as options, Close etc.	Optional: Currently, we do not need these features and thus, the 3 dots are not implemented. This is only for future extension of the tool.
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The Control Panel includes the main functionalities of the application.

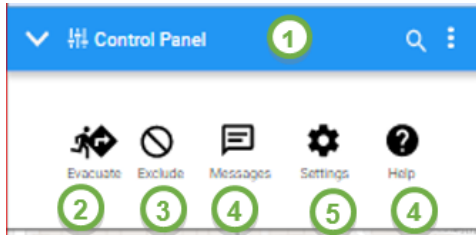


Figure 50 – eDSS control panel

Table 19 – eDSS control panel

	Description	Function	Behaviour
1	Box Bar	action buttons	See Box Bar
2	Evacuate Button	action button	Button that starts the evacuate function (See eDSS evacuate step 1)
3	Exclude Button	action button	Button that starts the Exclude / Include function (See eDSS Exclude 1)
4	Messages Button	action button	Button that starts the messaging function (See eDSS Messages)
5	Settings Button	action button	Button that starts the Settings function (See eDSS Settings .)
6	Help Button	action button	Button that starts the Help function (See eDSS help.)

The Application Bar integrates links to notifications (if any), Log Out, and Help.



Figure 51 – eDSS application bar

Table 20 – eDSS application bar

No.	Description	Function	Behaviour	Comments
1	Title icon	Icon and static text	Static	
2	Notifications button	action buttons	Optional: Opens Notifications	
3	User button	action button	On click , the following option appear: log out	
4	Help button	Action buttons	Shortcut to Help (see eDSS help)	Note: this button

				is available twice, to make it easier to find.
--	--	--	--	--

Evacuate

The Evacuation feature is the most important one in the eDSS. There are two ways to activate this feature. One is from the control panel, by clicking on the “evacuate” button. This opens a wizard, which is described in the following figures and tables. The wizard was implemented because we figured that an evacuation was seldomly occurring and thus, the user needed guidance through the process, even if this would make the process marginally more time-consuming (based on an estimation using KLS-GOMS). For trained users, the difference may be no more than a few seconds, for untrained users the wizard may significantly speed up the process. The wizard is also available by right-clicking on the map (this was introduced as a result of user testing; users reported functional binding to the map and disregarded the control panel from time to time). Pro-users can also start the evacuation by using tools on the map (a circle to select ESSMA users, a node-mode to select start and end-nodes) to do each step when they want to.

Evacuation Step 1

After selecting evacuate, the following window appears.

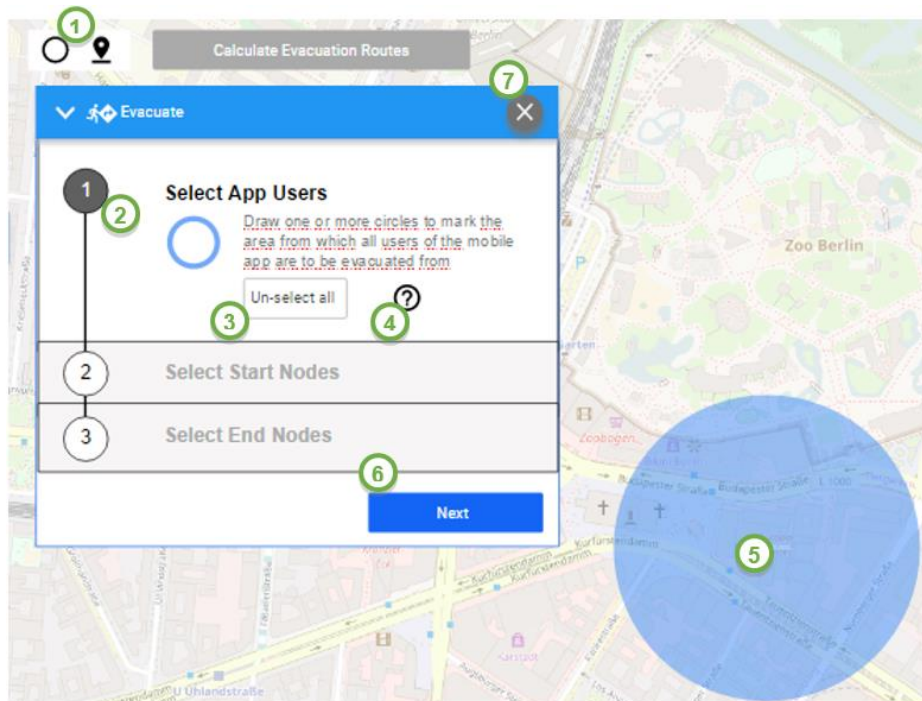


Figure 52 – eDSS evacuate step 1

Table 21 – eDSS evacuate step 1

No.	Description	Function	Behaviour	Comments
1	Circle Power User Button	action button	Shortcut - starts Evacuation	
2	Text	Icon and static text	Static – Displays first step information	

3	Deselect All	action button	On click , deselect selections	
4	Help	Action buttons	On click, displays [Help text: You can remove any circle by right-clicking and selecting „remove“]	
5	Mark on Map	Dynamic image	Clicking on the map selects the requested area to evacuate	
6	Next Button	Action button	On clicking moves to second step	
7	Close button	Action button	On clicking cancels action and closes window	

Evacuation Step 2

Left-clicking on next, step 2 appears.

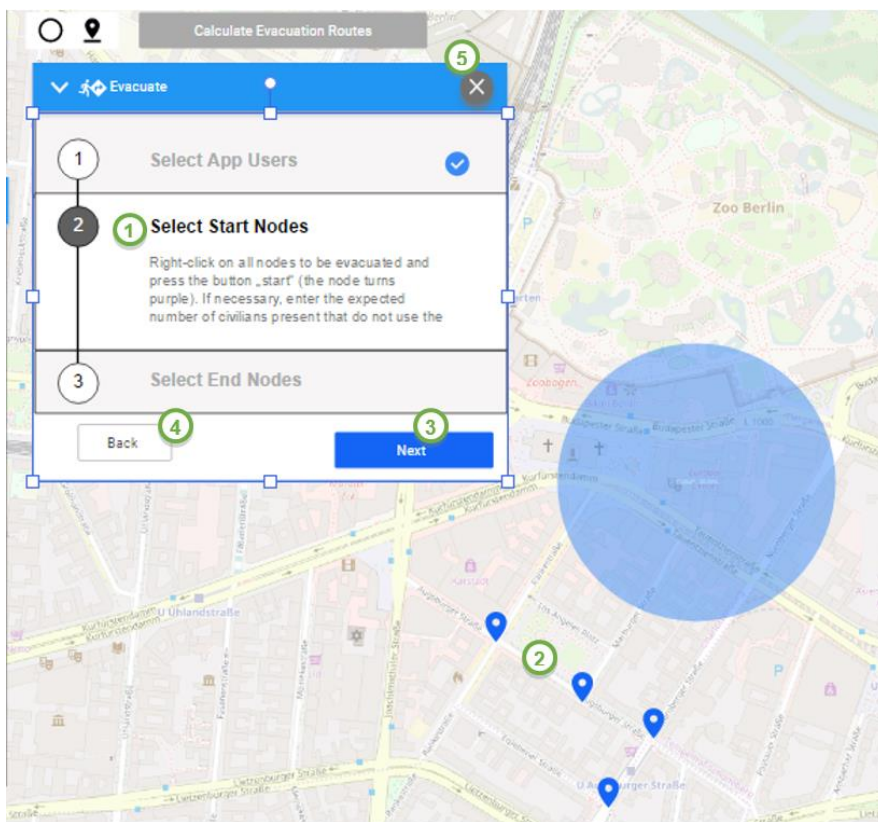


Figure 53 – eDSS evacuate step 2

Table 22 – eDSS evacuate step 2

No.	Description	Function	Behaviour	Comments
1	Text	Icon and static text	Static – Displays step information	
2	Mark on Map	Dynamic image	Clicking on the map selects the requested Start Nodes	
3	Next Button	Action button	On clicking moves to second step	
4	Back button	Action button	On clicking returns to previous step	
5	Close button	Action button	On clicking cancels action and closes window	

Evacuation Step 3

Clicking on “next”, step 3 appears: the user is asked to (left-)click on the nodes that are safe for the civilians to go to and press the button „end“ (the node turns green).

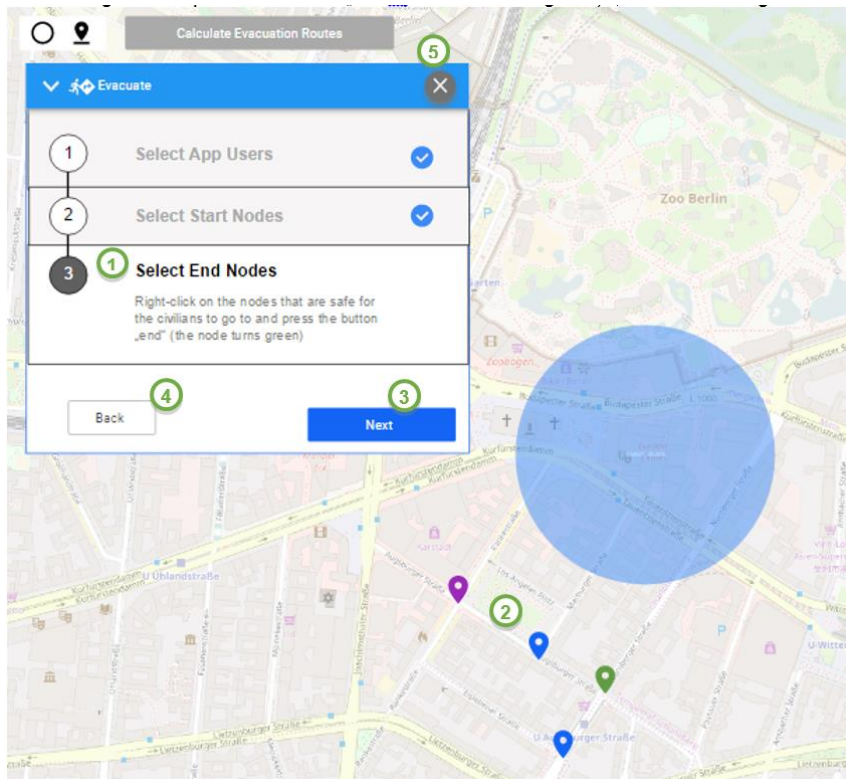


Figure 54 – eDSS evacuate step 3

Table 23 – eDSS evacuate step 3

No.	Description	Function	Behaviour	Comments
1	Text	Icon and static text	Static – Displays step information	
2	Mark on Map	Dynamic image	Clicking on the map selects the requested End Nodes	
3	Next Button	Action button	On clicking moves to second step	
4	Back button	Action button	On clicking returns to previous step	
5	Close button	Action button	On clicking cancels action and closes window	

Evacuation Step 4: waiting for permission

Clicking on next, the following message appears: “Awaiting Permission: the routes have been calculated and a request for permission to start the evacuation has been sent to the Central Decision Maker”. The request is sent through the back-end, via the ESB, and it appears in the Dashboard of the CDM.

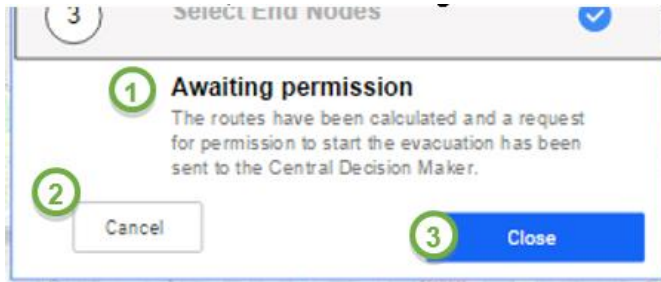


Figure 55 – eDSS evacuate step 4

Table 24 - eDSS – evacuate step 4

No.	Description	Function	Behaviour	Comments
1	Text	Icon and static text	Static – Displays step information	
2	Cancel button	Action button	On clicking it cancels the evacuation request and closes window	
3	Close button	Action button	On click it closes window and does not cancel evacuation request	

Evacuation Authorization Results

Depending on the response given by the CDM, two options are possible:

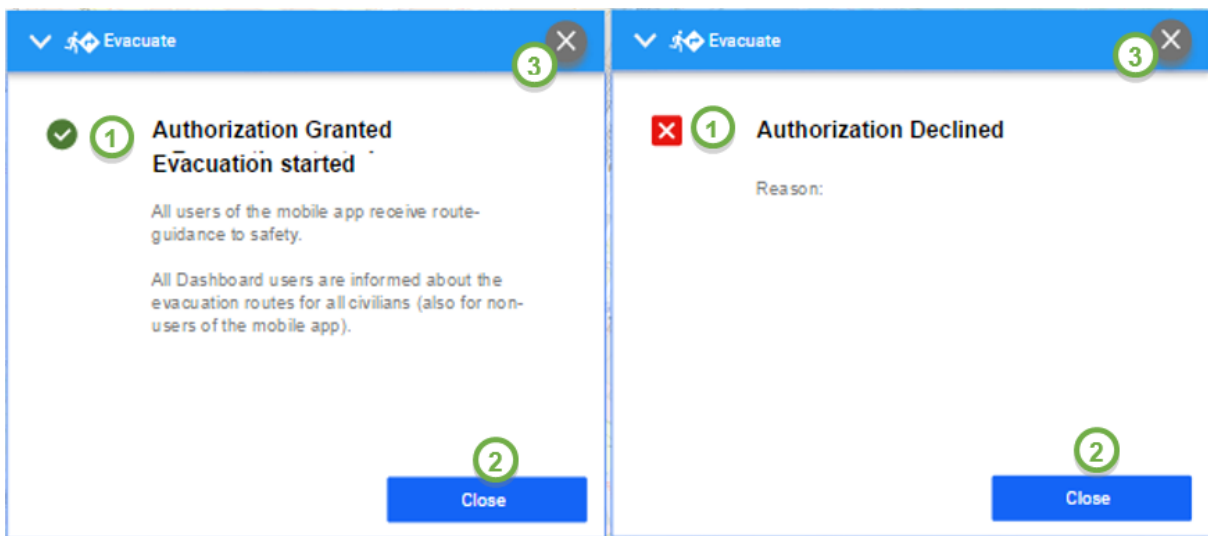


Figure 56 – eDSS evacuate step 4 – authorization result

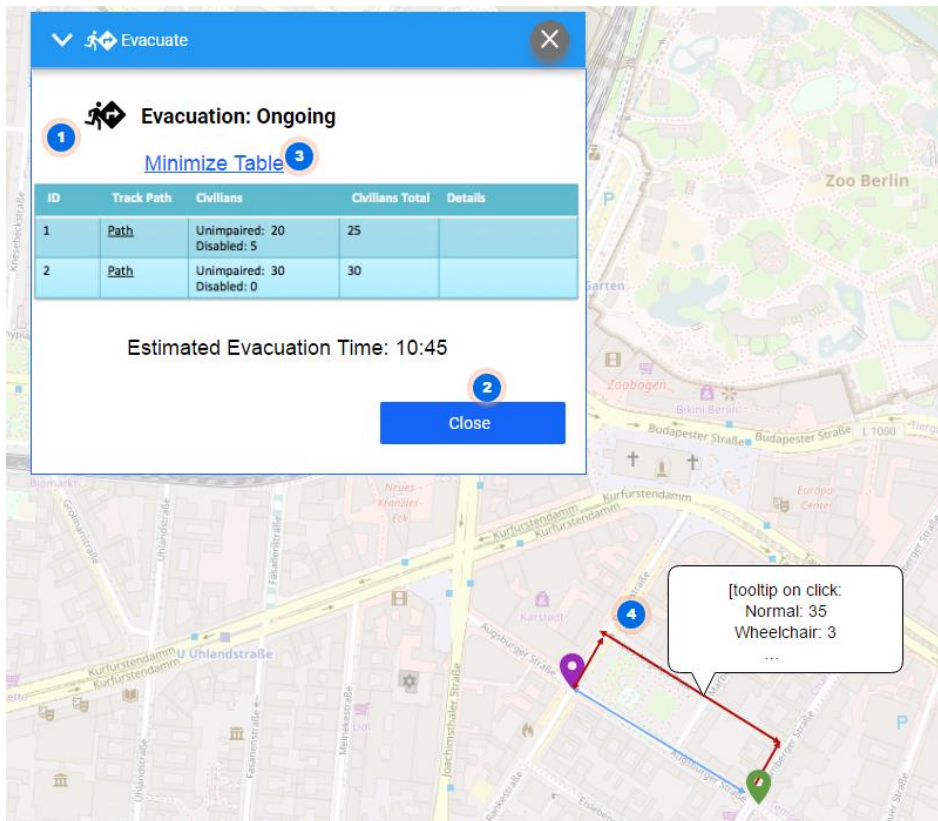
Table 25 – eDSS evacuate step 4 – authorization result

No.	Description	Function	Behaviour	Comments
1	Text	Icon and static text	Static – Displays step information	
2	Close button	Action button	On click it opens Evacuation Ongoing window and does not cancel evacuation request	
3	Close button	Action button	On click it opens Evacuation Ongoing window and does not cancel evacuation request	

If the permission / authorization is granted, then the evacuation is started immediately by the system. This means that the individual evacuation routes are sent to the mobile devices of the ESSMA users. The summary of the evacuation routes is also available to the other operators via the Dashboard. Thus, the police could, for example, use the plan to guide people that do not have the ESSMA.

If the permission / authorization is denied, the configuration of the evacuation is nevertheless maintained. It can be altered by the eDSS operator and a request for permission can be sent again.

Clicking on "Close", the following window appears.



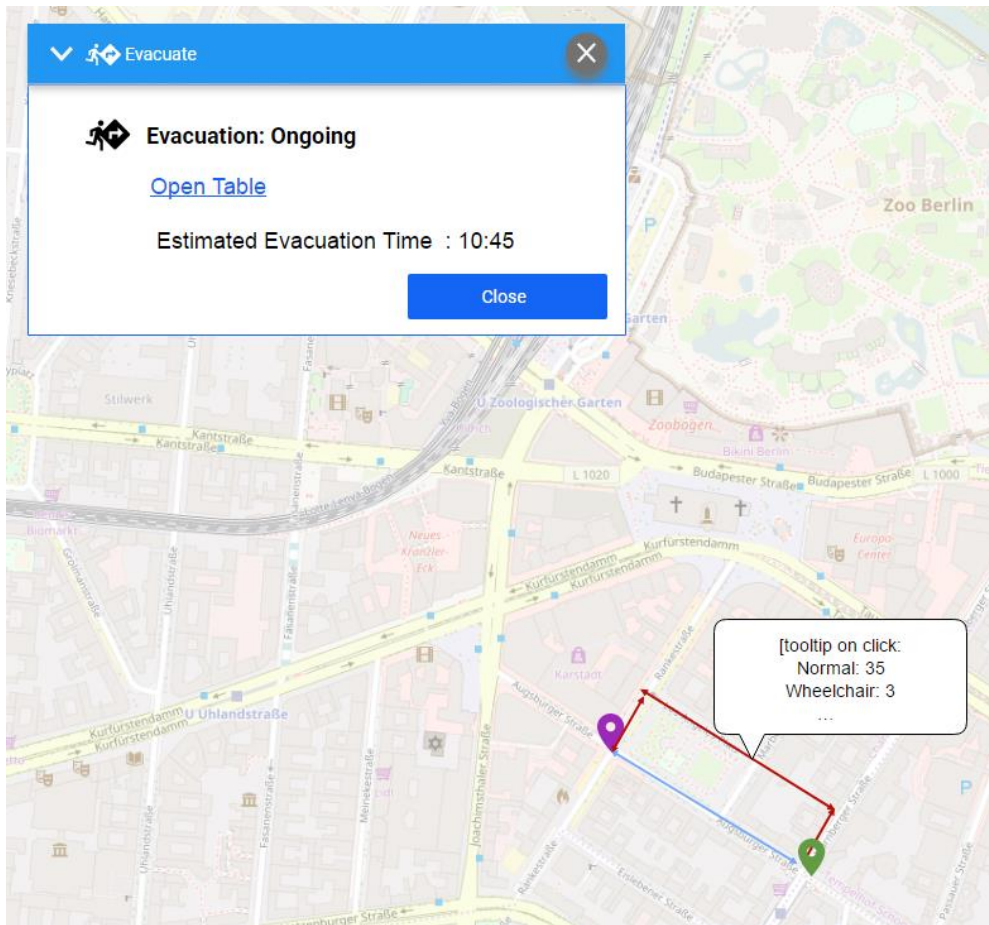


Figure 57 – eDSS evacuation ongoing

Table 26 – eDSS evacuation ongoing

No.	Description	Function	Behaviour	Comments
1	Text	Icon and static text	Static – Displays step information	
2	Close button	Action button	On click it opens Evacuation Ongoing window and does not cancel evacuation request	
3	Open Table	Action button	On click it opens a Table as shown in Figure 58: eDSS evacuation ongoing & table	
4	Route Tooltip	Tooltip	On click it opens a tooltip with information of number of agents as shown	

The table summarizing the different routes may be big or small, depending on the number of routes and their lengths. If the table is sufficiently small, it can be displayed in a window on top of the map, such as in the following example. Otherwise, it could be displayed as a separate tab in the browser.

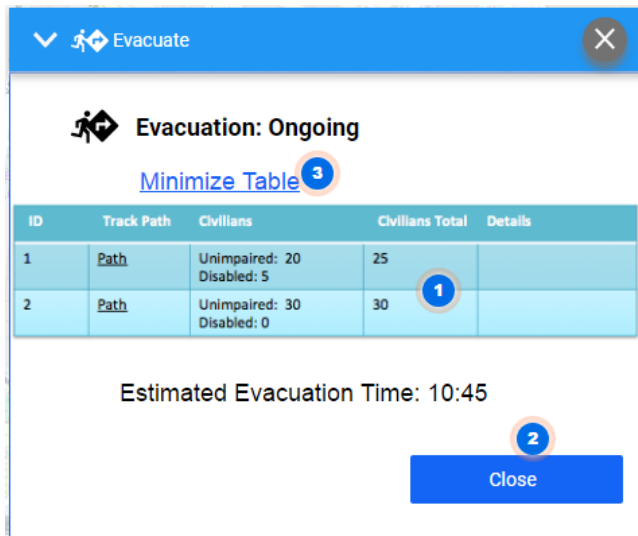


Figure 58 – eDSS evacuation ongoing & table

Table 27 – eDSS evacuation ongoing & table

No.	Description	Function	Behaviour	Comments
1	Text	Icon and static text	Static – Displays routes information	
2	Close button	Action button	On click it opens Evacuation Ongoing window and does not cancel evacuation request	
3	Minimize Table	Action button	On click it minimizes the Table as shown in Figure 57	

Exclude

Excluding streets from the evacuation is assumedly a rare case and thus not of high priority. It is implemented to allow maxing out the efficiency of the tool in the rare case that a street is blocked and that this is known to the operator. It is usually initiated by right-clicking on a street in the map directly, and choosing “exclude” (see Figure 46).

Optional:

To support the user in the best possible manner, we recommend to also create a wizard feature for the exclusion of streets. This Exclude feature would be initiated in the Control Panel by clicking on the Exclude button (see Figure 50, Nr. 3).

Clicking on Exclude, the following window would appear.

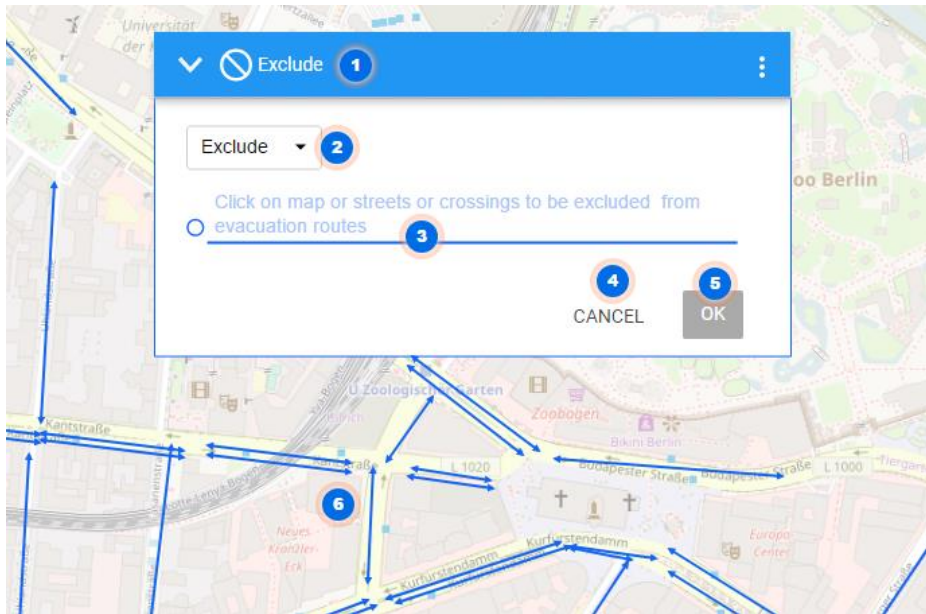


Figure 59 – eDSS Exclude 1

Table 28- eDSS Exclude 1

No.	Description	Function	Behaviour	Comments
1	Box Bar	Action buttons	See 1.3.4.1. Box Bar	Optional
2	Exclude / Include button	Action button	Enables switching to Include / Make Available a certain arc (for evacuation routes). See – Errore. L'origine riferimento non è stata trovata. - eDSS Include 1.	Optional
3	Info Text	static text	Tells users to click on map	Optional
4	Cancel button	Action button	Cancels and closes the window	Optional
5	OK button	Action button	Is grey and inactive – after choosing node(s) it turns blue and enabled, as shown in Figure 60 – eDSS Exclude 2	Optional
6	Nodes On Map	Dynamic image	On (left-)click, they are selected and turn red, and enables the OK button.	Optional

Upon clicking on a node on the map, the following becomes visible.

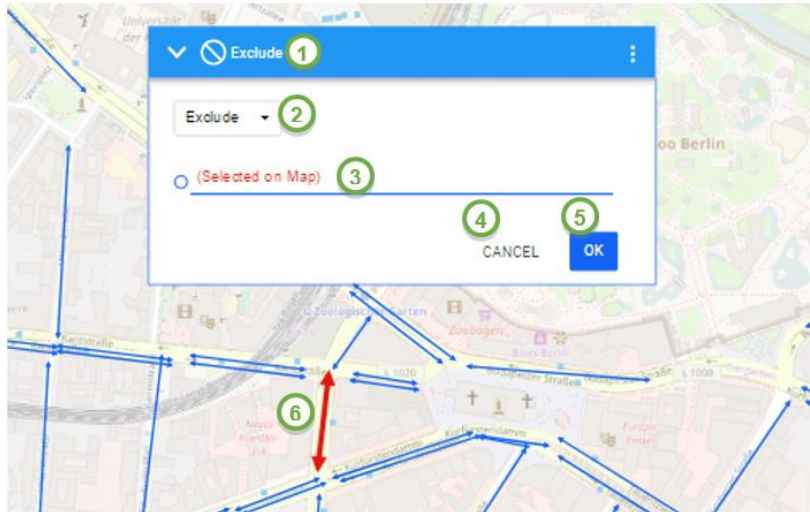


Figure 60 – eDSS Exclude 2

Include

To reverse the effect of excluding a street, the operator needs a feature to re-include it into the calculations (e.g. when the street has been re-opened after being closed previously). The *include* or *make available* feature is also initiated by right-clicking on a street in the map directly, and choosing exclude (see Figure 46), and again, clicking on the Exclude / Include button, and choosing “Make Available”.

Optional: Analogously to *exclude*, the Include / Make Available (for evacuation Routes) feature would benefit from a redundant access via the Exclude feature in the Control Panel. It would be opened by clicking on the Exclude button (see Control Panel Figure 50), and then clicking on the Exclude / Include button, and choosing “Make Available”.

Clicking on “Make Available”, the following window would appear.

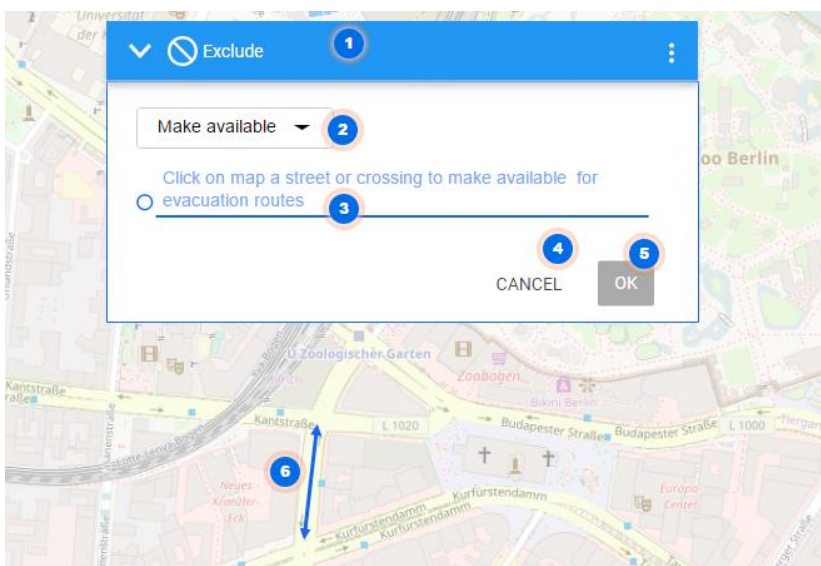


Figure 61 – eDSS Include 1

Table 29 – eDSS Include 1

No.	Description	Function	Behaviour	Comments
1	Box Bar	Action buttons	See Box Bar	Optional
2	Exclude / Include button	Action button	Enables switching between Exclude (see Figure 59 – eDSS Exclude 1; Errore. L'origine riferimento non è stata trovata.) and Include / Make Available (for Evacuation Routes)	Optional
3	Info Text	static text	Tells users to click on map	Optional
4	Cancel button	Action button	Cancels and closes Window	Optional
5	OK button	Action button	Is gray and inactive – after choosing node(s) it turns blue and enabled (analogously to Figure 60 – eDSS Exclude 2.	Optional
6	Nodes On Map	Dynamic image	Only Excluded nodes are shown. On click, they are selected and turn red, and enables the OK button.	Optional

Upon clicking on “OK” , or “cancel”, the nodes disappear (which essentially means that the display mode goes back to normal) and the window closes.

Messages

The messaging function is initiated by the “Messages” button in the Control Panel (see Control Panel, Figure 44).

Upon clicking on “Messages”, the following window appears.

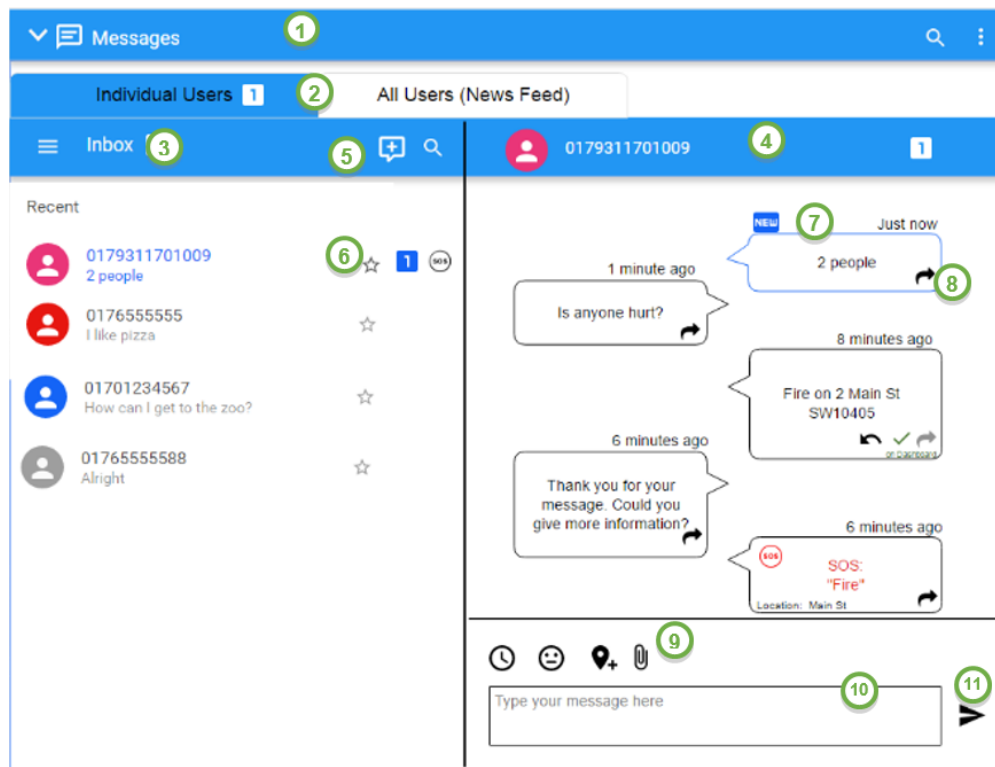


Figure 62 – eDSS Messages

The messaging includes two tabs, one for individual messages to ESSMA users (2), and the other one (3) to all ESSMA users as news update. The messages window is divided into panes, on the left side the different contacts, and on the right pane the conversation messages. It includes the following elements.

Table 30 – eDSS Messages

No.	Description	Function	Behaviour	Comments
1	Box Bar	Action buttons	See Figure 49 – eDSS box bar	
2	Individual / all users tabs	Action button / radio buttons	Enables switching between individual messages to news feed to all users. Shows if there are unread messages in the appropriate tab	
3	Contacts pane	input field	Lists the different sources of the last messages. Includes contact lines	
4	Conversation pane	Action button	Shows all messages for the selected user in the contacts pane	
5	New message	Action button	Allows writing a new message to a new contact	
6	Contact line	Dynamic image	Shows contact number or name, the beginning of last message, and marks it in colour and number, if there are unread messages	
7	message	Static text / image / video	Shows the message in a bubble. Allows images or video attachments too	
8	Forward button	Action button	Allows forwarding a message including the attachments	
9	Message Attachments	Action buttons	Buttons enabling attachments to a new message	
10	New message field	Input field	Input field that allows writing new messages in a conversation. Messages are sent with the send button (11) or by pressing the enter key	
11	Send button	Action buttons	Allows sending new messages, corresponds with the new message field (10)	

The messages to all users, known as the News Feed, is alternatively shown in the following figure.

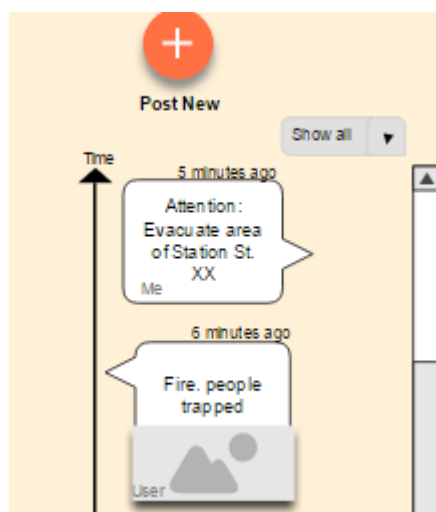


Figure 63 – eDSS News Feed

Settings

The Settings feature is initiated by the “Settings” button in the Control Panel (see Figure 50 – eDSS control panel).

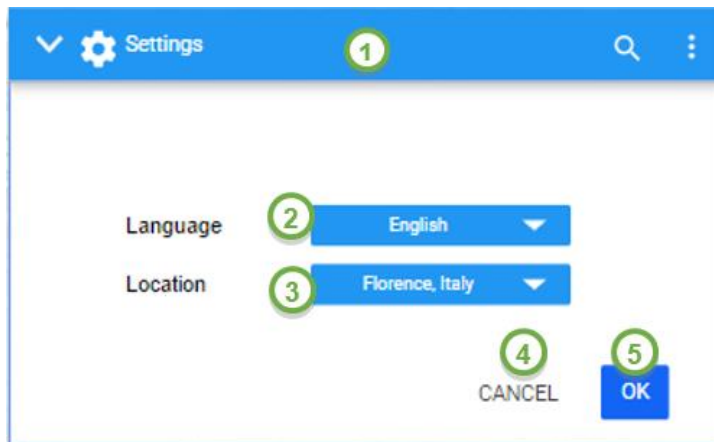


Figure 64 – eDSS Settings

The Settings window includes two main elements: one for changing the language (2), and the other one (3) for changing the location. These are exemplary options, which are not necessarily required for the RESOLUTE pilots. They may be replaced by others, if required.

Table 31 – eDSS Settings

No.	Description	Function	Behaviour	Comments
1	Box Bar	Action buttons	See Figure 49 – eDSS box bar	
2	Language button	Action button / radio buttons	Enables switching between different languages. Any change will change the language of the menus. Currently only English is available.	
3	Location button	input field	Enables switching between different locations.	
4	Cancel button	Action button	Cancel any changes and closes Window	
5	OK button	Action button	Saves any changes and closes window	

Upon Clicking on OK, or cancel, the window closes.

Help

The Help function is initiated by the Help button in the Control Panel (see Figure 50 – eDSS control panel) or at the help button in the Application Bar (Figure 51 – eDSS application bar).

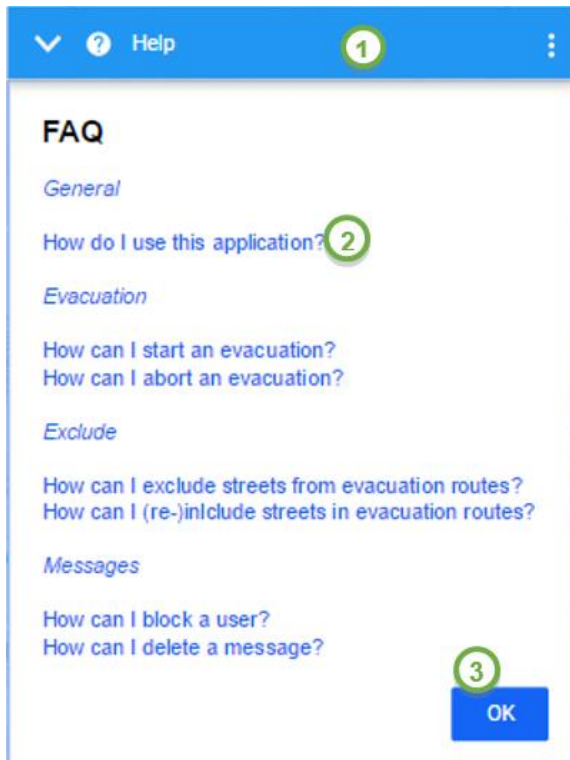


Figure 65 – eDSS Help

The Settings includes one main element: a frequently asked questions (FAQ) links(2), divided into different categories. By clicking on the question, the answer is shown below it.

It includes the following elements.

Table 32 – eDSS Help

No.	Description	Function	Behaviour	Comments
1	Box Bar	Action buttons	See Figure 49 – eDSS box bar	
2	FAQ line	Action button	Upon clicking on a line, the answer appears as a static text below it.	
5	OK button	Action button	Closes window	

Upon clicking on “OK” the window closes.

Log out

The user menu and log out functions are initiated by the user button on the Application Bar.

Upon clicking on the button, in this case “John User”, the user icon or the arrow down (1), the following window appears.

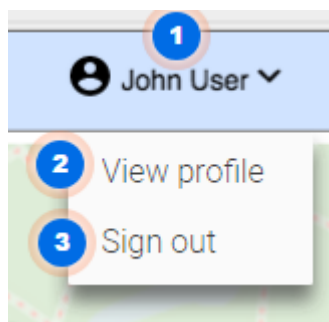


Figure 66 – eDSS Log out

The User Menu and Log out has two main elements: View profile button(2), and Sign out button (3). It includes the following elements.

Table 33 – eDSS Log out

No.	Description	Function	Behaviour	Comments
1	User button	Action button	Opens the window	
2	View Profile button	Action button	Upon clicking on it, it opens the (optional) profile window	
5	Sign out button	Action button	Signs out	

Upon clicking somewhere else the window closes.

User profile

Currently, a user profile is not technically required and thus not implemented. However, at a later stage after the project's end, field use may require such a profile to be created. It could be linked to the section with log out and settings and look like the following.

Figure 67 – eDSS user profile page (only if required)

6 EMERGENCY SUPPORT SMART MOBILE APP

6.1 Introduction

The Emergency Support Smart Mobile App (ESSMA) is meant to be used by professionals, such as rescue teams, and civilians. It turns its users into sensors and active agents of the resilient urban transport system. Thereby, it turns these actors into resources to be managed by the operator of the eDSS. It follows two main purposes: one is to track user movement and behaviour and thus provide the eDSS with data on a level of detail that could not be achieved otherwise. The other is to provide each user with individualized information, aiming to support self-rescue or to divert passenger flow in the UTS in case of a disruption, or to provide guidance to other citizens in need of help.

The ESSMA is, obviously, not a system to substitute other safety-relevant installations, such as exit signs in public buildings. It is meant to provide an added value to users travelling through the city, by making their self-rescue more efficient than it would be relying on static information (such as public signs) only.

6.2 Target users

The target groups meant to make use of the ESSMA are civilian users and rescue professionals; in order to avoid cumbersome registration processes, which would probably hinder the widespread usage of the app, the app only distinguishes between helpers and non-helpers.

Helpers are professionals, such as police, fire brigades, and emergency services. Voluntary helpers, for example civilians with first aid training, also belong to this category. All civilians that are not willing or able to help others in

cases of emergency bid on to the category of non-helpers. Each user can decide on this category in the user profile. The rationale behind this decision is that once an emergency, such as a flooding, has occurred, publishing the positions of people in help does not compose a security threat.

Non-helpers will only receive information relevant for their self-rescue, whilst helpers receive additional information on where they can go to help civilians. Civilian users of the ESSMA and consequently of the GBTA as well, may vary in age from 14 years to old age. Younger users would supposedly need a separate app, which is not foreseen within the context of this project. The civilian helpers represents the “ad-hoc volunteers” (GA, p. 131).

Although rescue professionals can belong to different organizations yet they share common characteristics: A professional training with respect to rescue activities and a more restricted age span (from 18 years of age to retirement age).

Thus, the users of the ESSMA can be summed up as:

1. **Non-helpers**
 - Civilians (from age 14)
2. **Helpers**
 - UTS employees
 - Emergency rescue teams
 - Civil protection agents
 - Civilians (ad-hoc volunteers)

While the rescuers are expected to be proficient at the locally spoken language, some civilians may have a migration background and need a user interface in another language.

6.3 Scope and objectives

The objectives of the ESSMA's users are:

1. Self-rescue in case of disruption/emergency with the support of the ESSMA (all)
2. Follow alternative routing in case of disruption for users that are not (yet) in acute danger due to the disruptive event, as provided by the ESSMA (all)
3. Find the target of rescue or mitigation – i.e. civilians to be rescued – with the support of the ESSMA, including info on exit route(s) (helpers).

6.4 Features

This section provides an overview on the technical features of the application. Some features were relevant for the definition of the UI, although they do not directly (only indirectly) contribute to achieving the user's objectives. An example of this is the locating function of the ESSMA, which helps rescue activities but is (possibly) not directly desired by the user.

With respect to the four cornerstones of resilience, the ESSMA principally supports the cornerstone RESPOND. In the emergency situation, the ESSMA helps speeding up the rescue of travellers by telling them how to escape and rescuers how to find the people to be rescued.

Features:

1. User profile.
 - a. Helper vs. non-helper
 - b. Special requirements.
2. Newsfeed.
 - a. Display information on disruption / emergency (push-message)
 - b. Display “all the relevant information about a problem state and how to [obtain further information required to resolve a problem]” (GA, p. 108).
3. Display the individualized evacuation route provided by the evacuation DSS (“real-time evacuation guidance”, GA, p. 108)
 - a. Realization: Indicate escape route on an outdoor navigation map.
4. Collect the user’s localization data in real-time and send it to the back-end for various purposes.
→ “sensing in background the human movement behaviour” (GA, p. 152)

Features for helpers:

1. Provide localization of people to be rescued; display the individualized route to this position.
2. Then, also provide the route to safety.

6.5 User requirements

General requirements were the fulfilment of established user interaction guidelines, such as Nielsen’s usability heuristics (Nielsen, 1999).

6.5.1 Based on the target user description

1. All users require the ESSMA to be available in their local language. Additional languages would be nice to have; at least an English version for users that are non-proficient in the local languages of the pilot sites is required.
→ **Languages: ENGLISH, GREEK, ITALIAN**
2. The ESSMA must work for different age groups. Younger generations growing up with digital technologies can be expected to be well-accustomed to map-based applications, mobile navigation aids and interaction principles. Less technology-appraising users may have a smartphone yet encounter difficulties with understanding what the application may demand from them in an emergency situation.
→ **Use simplified, commonly known interaction principles.**

6.5.2 Based on the objectives

1. The foremost objective of the ESSMA is self-rescue. Everything is meant to be secondary. Thus, in an emergency situation, the self-rescue should be prompted.
→ **Focus on efficient self-rescue as primary objective**

6.5.3 Based on standards and the ERMG

The ERMG name key standards to be heeded in UI design of the ESSMA:

1. “Applications provided to the users should undergo usability testing to ensure their helpfulness during emergency situations” (D3.5, p. 71). This was addressed by conducting 2 usability tests of the ESSMA.

Additionally, several standard guidelines apply to the design of mobile applications. These guidelines apply to the ESSMA, equally as to the GTBA and are therefore reported in the Annex.

6.5.4 Based on the features

1. A key challenge in the design was in the fact that the most critical feature (self-rescue) of the ESSMA will only be available in an emergency situation. Although there is a training mode for the ESSMA, the ESSMA had to be designed in a way that accounts for a possible lack of such training.
→ **Ensure navigation of the ESSMA is learnable during normal mode. User testing showed that the approach chosen for displaying that self-rescue information was intuitive.**

6.5.5 Based on research and other relevant aspects

1. Based on literature (Zipf & Mohan, 2008) the SAVE ME project (Jiménez Mixco & Evans, 2009) found the following key criteria for designing evacuation maps.
 - a. Completeness: The map needs to contain all information required for finding the way out.
 - b. Flashbulb time: The time the user requires to scan the map and internalize it should be short.
 - c. Visual clutter / perceptual quality: Potentially distracting graphical content should be avoided, as it also implies a high flashbulb time.
 - d. Symbol clarity: Symbols should be self-explicatory or generally well-known. Iconicity is expected to be helpful.
 - e. Consistency: Particularly, the same symbols found by the user along the way should be easily recognizable as the same.

If a map is used for explaining the escape route to the user, these principles need to be heeded. While this requirement principally refers to the passive role users, it would supposedly be wise to apply the same to maps provided to rescuers.

→ **Make maps complete and consistent with the environment, with low flashbulb time, low visual clutter, and clear symbols. We used well-known standards for outdoor navigation.**

2. According to the SAVE ME stakeholder research (A1.2 stakeholders report), rescuers need complete information, which rather means rich than more information. Rescuers should have access to different sources of information and verify themselves where. Access to first-hand information should be provided directly, to ensure this.
→ **Rescuers should get access to rich information relevant for their purposes. Such additional information was not available in the project. However, future adaptations should take this into account.**
3. A basic approach to way finding processes is given by Downs and Stea (1977; c.f. SAVE ME A1.2 Stakeholders report), who differentiate the following four sub-tasks of a person trying to find an exit:
 - a. Orientation, i.e. determining one's position in an environment,
 - b. Choosing the route, i.e. planning one's route to the destination,
 - c. Keeping on the right track,
 - d. Discovering the destination.

Depending on the navigation concept to be implemented, different combinations of these sub-tasks may become particularly relevant for the HMI design. In a landmarks-based approach, the minimum requirement is for the user to identify the direction, landmark, door, etc. to move towards from the current position; getting there, the next landmark. An approach without landmarks requires other methods for insuring that the user keeps on track (and knows that she remains on track) until reaching the exit.

→ **Emergency navigation should help users identify the direction of movement and feedback on the correctness of the escape route chosen. In the end, we used a map-based approach, which doesn't require landmarks. The GPS position gives clear feedback.**

4. Mass panic:

Psychological research (Cocking, Drury & Reicher, 2009) indicates that in emergency situation, people do not tend to panic and thus behave irrationally, simply due to fear. Instead many people have in emergencies been reported to keep their calm and to behave cooperatively, even among strangers. The true danger of so-called "mass panics" is due to bad front-to-back-communication. This means: people pile up as the back of a crowd cannot realize that the front of the crowd has stopped moving, e.g. because of being confronted by a barrier (e.g., the Love Parade disaster of Düsseldorf, Germany, 2010). This requires decision making routines not to send too many persons into the same area. GUIs simply have to be designed in a way that ensures people get clear information about what to do, in order to make them feel capable of rescuing themselves and others. Additionally, it is known that people sometimes disregard orders given by station personnel or even police; the system needs to take disobedience into account and phrase self-rescue orders in a way that transports the authority of the sender.

→ **Avoid mass panic by carefully dispersing people across exits or areas and ensure that self-rescue information is clearly stated. The authority of the sender should be transmitted. This is done by the evacuation DSS.**

6.6 Technical restrictions

The app was developed for two mobile platforms: Android OS and iOS. The resulting restrictions are:

- **Interaction is limited to**
 - Touch-screen interaction
 - Single clicks
 - Gestures
 - Sensor input
 - Locomotion (location sensor)
- **Limited screen size**
 - Reference: iPhone 4 (3.5 inch; 960 × 640 pixels)
 - Reference: Android phone: reference device not yet defined.

6.7 Development process

The development process included a closed loop with the development team and was enriched by two design iterations based on usability tests.

6.7.1 First user test

Objective

The first usability study for the ESSMA app concentrated on the iterative process of developing and optimizing the UI Design of the ESSMA. It tested the preliminary UI design and its features and aimed to gather as much information as possible from users regarding which features to improve, add, or remove as well as any general reactions or judgments by users. Therefore, the test was of explorative nature in early – mid development.

The resulting data gained by user's interactions with the mock-ups were analysed to develop an improved mock-up with clearly defined functions and specifications of the ESSMA's UI design.

Methods

Sample. 10 (9 German and 1 Italian) participants (2 female, 8 male) took part in this UX study. Recruitment took place via social media networks and private contacts of the researchers. All were frequent smartphone users.

Click dummy (stimulus). Clickable PDF-based mock-ups of the ESSMA were developed based on the features defined in D5.1. Screens were linked on a basic level so that users could click through the different screens to create a natural feeling of interacting with a mobile app. However, it was only possible to view the screens of the main features and not a comprehensive screen flow with all screens possible. The mock-ups were presented on a smartphone and participants could interact with it via its touchscreen.

The mock-up provided simulated access to the following features:

- *Login.* At the present state of the development users had to login first before using the app. The login screen of the test mock-up asked for the user's email address and password. They could proceed by clicking 'login'.
- *Profile.* In the profile area, users could view their profile page on which they could see the icons to indicate personal characteristics ('Characteristics') and biographical information ('Bio'). It was not possible to indicate this actively with the present click dummy.
- *Data sharing.* At the data sharing section, participants could either navigate to a page that displays shared data or to a Live Updates page. The Shared Data page provided an overview of all contacts with whom data was shared at any point in the past. The Live Updates page displayed important messages by officials and private users to inform citizens about acute incidents or important messages. The mock-up showed participants a news feed with posts by private users in form of a tweet feed with which they could not interact further.
- *Navigation.* The navigation feature provides users with a way to navigate them to safe areas. In the present study, a screen displayed a map with the personal position, a destination, and a route. Furthermore, a navigation directive indicated to participants when the next turn comes and when they will reach the destination.
- *Communication.* The communication feature allows citizens using the ESSMA to write messages to officials and private contacts, including the upload of media content (e.g. pictures). This feature supports the resilience approach by allowing operators to receive fast updated information on relevant incidents, which is an additional resource of information and helps distributing resources in the transport system. In the present study, participants saw a chat history with text fields and shared pictures.

Procedure. Participants were invited to the Fraunhofer offices in Berlin and greeted by the research staff. They signed the informed consent, the nondisclosure form, and were told that they would take part in a study to test a mobile app and asked to think aloud while using the app. They were reassured that the test was about the app and not their performance. The study was video recorded for later analysis.

During the test, different tasks were given to the participants which they had to work on using the app. The app was introduced as an emergency app and users were asked to indicate their age, profession, and a recent first aid training and were asked if they could think of any other information that would be useful to indicate here. Then, they had to use the app for navigation to reach a certain address in Berlin on a normal day and were asked if they could think of a feature of the navigation that would make them prefer it to other navigation apps available.

Afterwards, participants were asked to imagine a situation in which their city was subject to a heavy storm and a subsequent flood. They were asked how the app could help them in this situation and then to initiate the emergency navigation feature. Again, the interviewee asked if they would use this feature in such a situation and what they expect from a safety navigation feature.

Participants were then asked to send a picture to officials with the app and if they would use this or another way to communicate.

Subsequently, participants were asked to get an overview of the present emergency by using the app to see if users would use the news feed. The interviewee also asked if they would use this feature, if it was easy to find, and what they would like to see on such a feed during emergencies. They then had to contact a spouse with the ESSMA and were asked if they would use this app or another to do so.

Afterwards, they were asked follow-up questions about whether the app was easy to use, how the design could be improved in their opinion, what they understood under Shared Data, and Communication, and if they missed a certain feature.

Measures. We used the *AttrakDiff* (www.attrakdiff.de) questionnaire as this instrument measures user experience, and thus hedonistic criteria of possible future use. This is relevant for an app that needs to be installed voluntarily by its users, compared to the Dashboard, which will be part of its users' workplace equipment.

Results

Analysis. The thinking-aloud remarks of the users as well as their behaviour while interacting with the ESSMA mobile app were analysed qualitatively during the study and afterwards with the videos.

Based on participants' most common reactions to the app, we derived several interaction criteria. We assume these the most important interaction criteria, which need improvement if users showed problems while using them. The criteria and their respective descriptions and results are displayed in the following table.

Table 34 – Usability test results – ESSMA test 1

Criteria	Description	Metric	Result
'Bio' understood.	Participant understands that 'Bio' stands for 'Biography' and would use it to edit personal data.	Proportion of participants displaying this behaviour.	40,0 % (4 Participants)
'Characteristics' understood.	Participant understands that 'Characteristics' is the section where to add personal characteristics (i.e. profession, 1 st Aid training)	Proportion of participants displaying this behaviour.	20,0 % (2 Participants)
Navigation normal day use.	Participant indicates that he or she would use the app for navigation on a normal day.	Proportion of participants displaying this behaviour.	70,0 % (7 Participants)
Understands how to use navigation during emergency	Participant knows how he or she would use the navigation to be guided to the closest safe are.	Proportion of participants displaying this behaviour.	80 % (8 Participants)
Would use emergency	Participant would use the	Proportion of participants	100%

navigation.	emergency navigation feature in acute dangerous situations.	indicating 'yes'.	
Understood data sharing.	Participant understood what 'data sharing' stands for and what to do with it.	Proportion of participants indicating 'yes'.	20,0 % (2 Participants)
Data sharing - Communication confusion.	Participant goes to communication to share a picture when supposed to use 'Data sharing' instead.	Proportion of participants displaying this behaviour.	60,0% (6 Participants)
Would use data sharing.	Participant would use the function to share data in acute situations.	Proportion of participants indicating 'yes'.	50,0 % (5 Participants)
Problems finding live updates.	Participant has problems/ does not find the section where to view live updates.	Proportion of participants displaying this behaviour.	80,0 % (8 Participants)
Would use live-updates.	Participant would use the live-update function to gather information in emergencies.	Proportion of participants indicating 'yes'.	50,0 % (5 Participants)
Problems to contact private contact.	Participant has problems to go to 'Contacts' to send a message to a fictive spouse.	Proportion of participants displaying this behaviour.	20,0% (2 Participants)
Would rather use different app for communication.	Participant would rather use a different app to reach private contacts.	Proportion of participants indicating different app.	Phone: 50,0 % WhatsApp: 40,0 % ESSMA: 10,0 %
Usability rating.	Participant where asked to rate the app's usability between easy, hard, or mixed.	Proportion of participants indicating usability level.	Mixed: 60,0 % Easy: 10,0 % Easy-Mixed: 20,0% No rating: 10,0 %
Misses a SOS button.	Participant indicates that a SOS button to call for help is missing.	Proportion of participants indicating this.	30,0 % (3 Participants)
Misses push messages.	Participant says that the app should provide a push message system to send warnings when user is not using the phone.	Proportion of participants indicating this.	60,0% (6 Participants)

The usability test identified several shortcomings of the present UI design. The general UI design and flow was adequate but several features' purpose or meaning was unclear to users, some were too difficult to find, and some desired features were missing.

There was a general confusion about the meaning and purpose of some features of the ESSMA. Several users did not know what 'Bio' and 'Characteristics' stand for and subsequently did not know where exactly to indicate age, profession, and the first aid training. There was also confusion regarding the data sharing page since users were uncertain what kind of data to share and with whom. The folder structure depicted on the screen was also bewildering. Moreover, there was a general confusion between data sharing and communication, since users were expecting to share data in the respective chats within the communication page. In accord, many users went to the communication page when asked to share a picture. Thus, data sharing, communication, and some aspects of the personal profile lacked clarity regarding their functions.

Furthermore, the live update feed was too difficult to find. Since the information from a newsfeed was deemed quite important in emergencies, users criticized that it was too hidden as a separate screen under data sharing. It was also unclear why it was located under data sharing in the first place. This problem relates to the previous point that the data sharing function appears too nebulous to users in general.

Apart from the present features, some users missed features they thought to be important for an emergency app. Users wished that the app would warn them about incidents also when they are not using their mobile device with pop-ups and warning sounds or vibrations since a timely warning can make the difference. Additionally, several users asked for a SOS function, with which they could send a signal to call for help and share their GPS location. The respective SOS button should be very easy to find and use since attention and concentration during emergencies might be limited due to stress.

There also was a general scepticism if the app can provide what other apps cannot and why users would install it at all. This was rooted in the communication and navigation feature. For communication, 90% of users indicated they would use the regular phone or another more prominent messaging app, where they are certain that the recipient has the app installed as well. For the news feed, some users articulated worries about possible spam and informational overload if private users could upload data in an unregulated fashion. If they would use ESSMA over other, more prominent newsfeed apps would then depend on the algorithms used. The navigation feature was also compared to other navigation apps and it became clear that the most important feature for users would be the display of safe and unsafe areas and a route that takes this and irregularities in public transport into account. Otherwise, they might use other apps for navigation.

Implemented changes

Clarify functions. To improve the confusion about some of ESSMA's functions, they were structured or named differently.

1. On the profile page, 'Bio' and 'Characteristics' was changed into submenus named 'Account', 'Personal Data', and 'Settings'. Under 'Account', users can view and edit account information, i.e. their name, number and email address they used for their account. Under 'Personal Data', users can indicate their address, profession, demographics or any medical info. Under 'Settings', users can change global settings of the app, such as turning on vibration signals.

2. The Data sharing function was removed as a main feature. It was partly integrated into communication and the SOS feature, where users can send pictures, videos or files in the chat interface or together with the SOS message. It was also decided that private users are not able to upload files to the news feed and only do so within communication.

Aim attention at the news feed. 'Live Updates' was renamed to 'News Feed' and got an own main screen that is easily navigated to from the lower icon bar. The news feed is now the start page of ESSMA when opening it. Information displayed on the feed is only from officials to prevent irrelevant information or the need to filter private posts by urgency and practical significance. Users can click on the messages to see more information on a bigger screen that pops up.

Adding SOS feature. Since some users asked for a SOS button and it was generally considered a useful idea by the researchers, a SOS button was added. It is one of the main pages from the lower icon bar and is labelled 'SOS' there. At the SOS screen, users can press and hold a red SOS button for 500ms to send a message to officials and share the own GPS location. They can subsequently attach further information to the message by

choosing from a predefined list of situations such as 'I'm injured', 'I'm trapped', or 'Others are injured' or attach pictures, videos, or a voicemail.

Defining ESSMA's main purpose. To define the purpose of the ESSMA and differentiate it from other apps with similar functions, the overall functionality was streamlined. Communication with private users was cut, since most users indicated they would use other apps for this anyway. The ESSMA is then an app with navigation with safe/unsafe input, provides acute and specific warnings, a way to communicate with officials, and a way to call for help (SOS).

Conclusion

The first usability study of the ESSMA integrated an explorative and an evaluative approach to the system, shed light on some of the most central weaknesses of the app, and provided important input and suggestions from users how to improve it. Some functions were clarified regarding their meaning and purpose by renaming and rearranging it. Data sharing was integrated to communication and the news feed was emphasized by making it the start page and easier to find. A SOS feature was added so users can easily send a call for help and attach data to it. This could generate a considerable amount of data from citizens within the CRAMSS framework. Moreover, it supports the resilience approach by allowing citizens to function as a sensor for information on the streets. Furthermore, the overall app was streamlined by removing the redundant feature of communication with private contacts and emphasizing the main functions – a navigation system that processes and displays information about the degree of safety, a news system, a system to directly communicate with officials, and a way to send a SOS message.

6.7.2 Second user test

The integrated changes to the ESSMA were tested in the second user test.

Objective

The second Usability study for the ESSMA continued the iterative process of developing and optimizing the UI Design of the ESSMA mobile app. It tested the UI design and the functions based on the previous usability study's findings in regards to users' reactions and judgments of it. The resulting data gained by user's interaction with the mock-ups were analysed to develop the final version of the ESSMA's UI design.

Methods

Sample. Eight (5 German and 3 Italian) participants (4 female, 4 male) took part in this UX study. Recruitment took place via social media networks and private contacts of the researchers. Age was between 20 and 40 years, all were frequent smartphone users.

Click dummy (Stimulus). Clickable Balsamiq-based mock-ups of the ESSMA mobile app were developed based on the definitions and the findings of the last UX test. Screens were linked so that users could click through the different screens to create a natural feeling of interacting with a mobile app. The mock-ups were presented on a computer screen and participants could interact with it via mouse clicks.

The mock-up provided simulated access to the following features:

- **News Feed.** The news feed displays important messages by officials to inform citizens about critical incidents or important messages. The mock-up showed participants a news feed in form of a tweet feed and users could click on a message to display more information.

- *Navigation.* The navigation feature provides users with a way to navigate them to safe areas. In the present study, users were able to look at the normal map, to choose a destination and a route, and to see the path to the destination displayed on the map. Furthermore, there was a map screen and function in case the operator has called out an emergency - an evacuation button, which displays the route to the next safe area.
- *Communication.* The communication feature allows citizens using the ESSMA to write messages to operators, including the upload of media content (e.g. photos). This feature supports the resilience approach by allowing operators to receive fast updated information on relevant incidents, which is an additional resource of information and also helps distributing resources in the transport system. In the present study, participants were able to write a message or to send a picture to the police or the ambulance.
- *Profile.* In the profile area, users could indicate their respective personal information, change global settings of the app, and change account information. The present mock-up provided participants with a feature to edit account data such as email-address, phone number or name, indicate profession, address, age, gender, and medical information such as blood group or disabilities and intolerances. Moreover, they could change notifications settings such as vibration and noise notifications, or sharing the own GPS position.
- *SOS.* The SOS function is a fast way to send an SOS signal through the ESSMA mobile app. Other ESSMA users will thus be enabled to come to help. The user could hold an SOS button for 3 seconds to send an SOS signal. Subsequently, they could indicate details, by selecting from more information of the acute emergency such as their physical condition, their mobility status (if they can still move or not) or if others are injured or immobile. This SOS could also be extended by adding a picture, a video, or a voice message. Participants were able to use the SOS function with the present mock-up.

Procedure. Participants were invited to the Fraunhofer offices in Berlin and greeted by the research staff there. They signed the informed consent, the nondisclosure form, and were told that they would take part in a study to test a mobile app and asked to think aloud while using the app. They were reassured that the test was about the app and not their performance. The study was video-recorded for later analysis.

During the test, different tasks were given to the participants, which they had to work on using the app. First, they had to indicate their age, gender, profession, address, and a fictive heart irregularity. Then, they had to use the app for navigation to reach a certain address in Berlin. Subsequently, they were asked to imagine a flood took place in their city and they should use the app to gather news and information about the emergency. Afterwards, they were asked to use the navigation feature to guide them to a safe area, followed by the task to take a picture of a jammed road to send it to the police. In the end, they were asked to use the SOS function to call for help. Afterwards, they had to rate the app with the AttrakDiff survey and were asked follow-up questions about whether the app was easy to use, if the icons were clear, if they disliked anything, and if they would install the app outside of the study.

Analysis. The thinking-aloud remarks of the users as well as their behaviour while interacting with the ESSMA mobile app were analysed qualitatively during the study and afterwards using the video files. Based on the common reactions of participants to the app, several criteria of the interaction were derived.

Results

The criteria and their respective descriptions and results are displayed in the following table.

Table 35 - Usability test results – ESSMA test 2

Criteria	Description	Metric	Result
Problems indicating personal data.	Participant does not manage/ have problems to go to 'Profile' to indicate sex, address, and profession.	Proportion of participants displaying this behaviour.	12,5 % (1 Participant)
Problems indicating medical information.	Participant does not manage/ have problems to go to 'Profile' to indicate medical information.	Proportion of participants displaying this behaviour.	0
Problems finding navigation function.	Participant does not manage/ have problems to go to 'Navigation'.	Proportion of participants displaying this behaviour.	0
Problems using navigation to reach destination.	Participant does not manage/ have problems to enter the destination, choose from the route list, and/or to click on 'start' to begin navigation process.	Proportion of participants displaying this behaviour.	12,5 % (1 Participant)
Dislike for navigation with bird perspective.	Participant indicates to dislike the 'bird' point of view during navigation.	Proportion of participants indicating 'yes'.	0
Lack of emergency information.	Participant thinks that the 'News' function does not display enough information about the emergency.	Proportion of participants indicating 'yes'.	0
Emergency navigation – SOS confusion.	When asked to use the navigation to safety, participant uses the SOS function instead.	Proportion of participants displaying this behaviour.	62,5 % (5 Participants)
Use of 'Evacuate' button on map.	Participant perceives and uses the 'Evacuate' button on the navigation screen during emergency.	Proportion of participants displaying this behaviour.	37,5 % (3 Participants)
Problems sending picture file.	Participant does not know how to send a picture to the police when asked to do so.	Proportion of participants displaying this behaviour.	62,5 % (5 Participants)
Use of SOS function.	Participant uses the SOS function when asked to find help with the app.	Proportion of participants displaying this behaviour.	75,0 % (6 Participants)
Would use SOS button in acute emergency.	Participant indicates he or she would use the SOS function in an actual emergency when he/she had the app.	Proportion of participants indicating 'yes'.	100% (8 Participants)
Trust in SOS message.	Participant trusts that the SOS message will be processed and lead to help.	Proportion of participants indicating 'yes'.	75,0 % (3 out of 4 Participants)
Clear Icons.	Participant indicates that all icons of the app are clear to understand and easy to perceive visually.	Proportion of participants indicating 'yes'.	75,0 % (6 Participants)

Would install the app.	Participant indicates he or she would install the app when published.	Proportion of participants indicating 'yes'.	62,5 % (5 Participants)
AttrakDiff Score		Score on AttrakDiff questionnaire (Range: 1 – 7)	5.1 (SD = 0.78)

Considering the results, it becomes apparent that users had issues with distinguishing between the evacuation navigation and the SOS message (Criterion: Emergency navigation – SOS confusion). The purpose of the evacuation navigation function is to display the safest and fastest route to the next safe area, assuming the user is still mobile. In contrast, the SOS function serves to send a SOS signal to officials in case the user cannot move or has observed an incident. Thus, evacuation navigation and SOS message are practically distinct functions. Nonetheless, 62.5 % of participants confused them, indicating that the functions have to be defined and contrasted against each other more clearly.

Another central and related issue was the lack of using the evacuation navigation at all when being asked to move to a safe area (Criterion: Use of the 'Evacuate' button on map). Only 37.5% of participants found and used the button. In the present mock-up, the 'Evacuate' button is displayed in the lower centre of the navigation screen during an emergency (i.e. the operator has defined a dangerous and safe area and thus enabled the function). A majority of participants missed this button and hence did not use the function at all. Instead, they oftentimes used the SOS message. Therefore, the presence and the way to start this function has to be more salient.

Other issues that came up during the tests were more specific and not experienced or mentioned by a majority of participants. Therefore, they are not listed in table 1. Two participants indicated that some icons were not clear, especially the '!' symbol for the newsfeed. Furthermore, the menu for 'special requirements' was not clear to some users, because they did not know what it means. We attribute this to a language barrier since no participant was speaking English as mother tongue and should not have problems with the translated app.

Implemented changes

Improve evacuation – SOS confusion. To clarify the difference between emergency navigation and SOS message, several changes were made. The SOS screen now has a list of options specifying the possible issue the user might have prior to sending the SOS message. Therefore, the user can specify beforehand what the SOS message shall convey. During emergencies, one option is 'Bring me to safety', which will lead the user to the evacuation navigation without sending an actual SOS. If the user does send a SOS, he is afterwards directed to the evacuation navigation automatically. Furthermore, a pop-up message asking 'Do you want to be guided to the nearest safe point?' was added whenever the evacuate button is pressed to improve clarity. These changes add redundancy and help the user to discriminate between evacuation navigation and SOS and make the emergency navigation function more present and easy to initiate.

Other changes. Some other minor changes were made based on remarks that are not part of the criterion table. Text descriptions of the functions in the lower case icon bar were added: 'News', 'Map', 'Chat', 'Settings', and 'SOS'. This adds redundancy by adding text form to symbol form and improves general clarity of the main functions. Furthermore, the profile start page does not display the postal address anymore, since some participants thought that they could edit this information by clicking on the text.

Some of the changes resulted either from discussions with the developers (updated requirements) or from insights that some more features may be able to provide added value. This refers to the following features that were added at this stage:

- Social media
- Profile concept: voluntary helper
- Language selection
- Topic selection (communication)
- NoGPS warning
- 'Profile' renamed to 'Settings'. Icon changed from mannequin to gear

Conclusion

Generally, participants displayed a positive impression of the app's usability. They were able to work on the tasks quickly and intuitively for the most part, did not display grave confusions or errors by using the app, and rated the app's usability reasonably well. However, it became salient that the app did not differentiated well enough between emergency navigation/ evacuation and the SOS button functions. Since these are two major functions with quite different practical objectives, they have to be discriminated quickly and intuitively by users to use them in potential emergencies. Thus, we made the difference more clear in our final mock-up by linking the SOS message with the navigation.

6.8 Final UI blueprint

The final ESSMA's UI structure is the following:

6.8.1 Final structure

This is the summary of the app's final structure:

1. Newsfeed:
 - a. The information about critical events
 - b. Link to map: Start self-rescue
 - c. Link to map: Start guidance to help others
2. Map
 - a. Navigate and find points of interest
 - b. Start self-rescue
 - c. Start guidance to help others
3. Messages
 - a. Exchange messages with the operator
 - b. Upload photos, videos
 - c. Call or Send SMS to Authorities
4. Settings
 - a. Notifications
 - b. User profile
 - c. Language
 - d. Information about the app
5. Start an SOS call

6.8.2 Information Design of the self-rescue navigation

The approach chosen to represent the self-rescue information or route-guidance to the safe point is a street or network-based navigation. Current position, destination, and route are displayed on a map. This corresponds to the first of several route guidance methods proposed in D5.1. Figure 68 Depicts what this looks like.

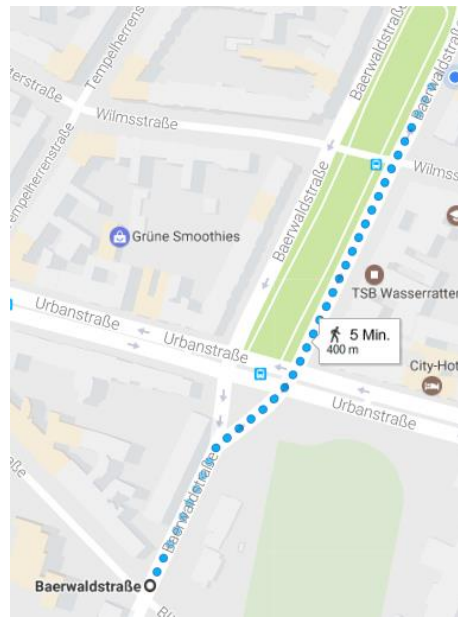


Figure 68 – Street- or network-based navigation

6.8.3 Storybook

The following storybook shows the final blueprint. It served as an orientation for the developers, with respect to the layout and structure, wordings and icons. In the implementation, this blueprint was to be translated into the specific visual language of the targeted operating system.



Figure 69: ESSMA – lock screen with newsfeed update

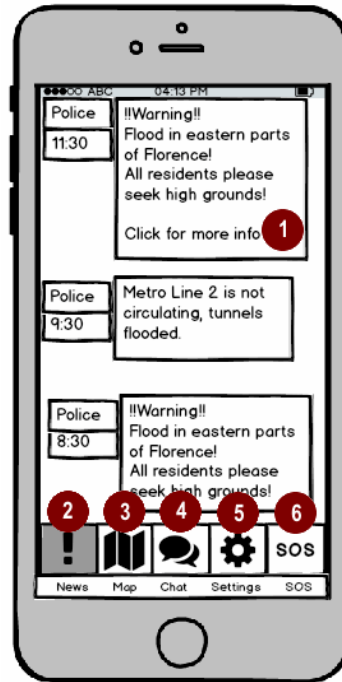


Figure 70: ESSMA – newsfeed & base navigation

Table 36 – ESSMA – lock screen with newsfeed update

No.	Description	Function	Behaviour	Comments
1	unlock	unlock	In the shown scenario, the user has received an evacuation order while the phone was locked. The user needs to activate the phone's in-built unlocking mechanism before accessing the notification. After unlocking, the user can click on the notification to access the ESSMA.	

Table 37 – ESSMA – newsfeed & base navigation

No.	Description	Function	Behaviour	Comments
1	message	Text element	Contains a message from the eDSS operator to all or to a sub-group of ESSMA users.	
2	News	Custom tab navigation (OS-based)	Opens module News	Same behaviour on all pages
3	Map	Custom tab navigation (OS-based)	Opens module Map	Same behaviour on all pages
4	Chat	Custom tab navigation (OS-based)	Opens module Chat	Same behaviour on all pages
5	Settings	Custom tab navigation	Opens module Settings	Same behaviour on all pages

		(OS-based)		
6	SOS	Custom tab navigation (OS-based)	Opens module SOS	Same behaviour on all pages

One of the following pop-ups (depending on the respective user’s profile) is displayed every time that operator has selected your area as an area in danger that needs to be evacuated. Independently on the current view, the message will be shown. **ESSMA – escape order – helpers** is shown to voluntary helpers, while **ESSMA – escape order non-helpers** is shown to civilians that declare in their profile they do not want to engage in rescuing others.



Figure 71: ESSMA – escape order - helpers

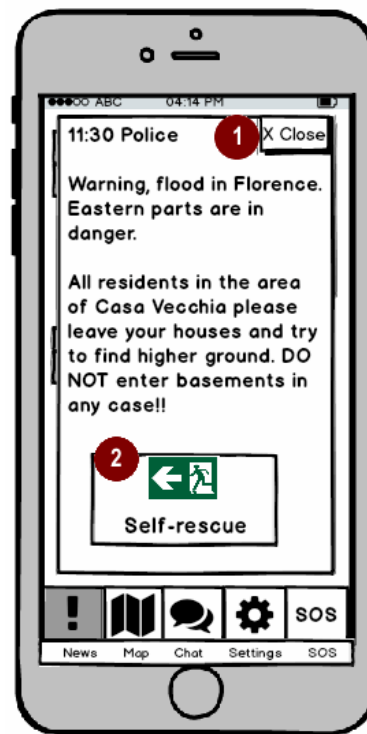


Figure 72: ESSMA –escape order non-helpers

Table 38 – ESSMA – escape order - helpers

No.	Description	Function	Behaviour	Comments
1	close	Action button	Closes the popup and	In the shown scenario, the user has received an evacuation order.
2	Self-rescue	Action button	Downloads the escape route from the eDSS; opens view: ESSMA – confirm self-rescue	
3	Help others	Action button	Downloads the route to the position of the SOS-call from the eDSS; opens view: ESSMA – confirm rescue	

Table 39 – ESSMA –escape order non-helpers

No.	Description	Function	Behaviour	Comments
1	close	Action button	Closes the popup and	In the shown scenario, the user has received an evacuation order.
2	Self-rescue	Action button	opens view: ESSMA – confirm self-rescue.	



Figure 73: ESSMA – confirm self-rescue

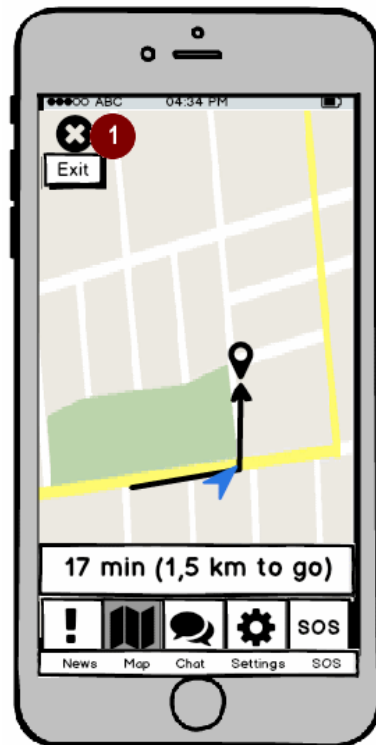


Figure 74: ESSMA – map evac – display route (1)

Table 40 – ESSMA – confirm self-rescue

No.	Description	Function	Behaviour	Comments
1	No	Action button	Returns to the previous page. On the map, a button for starting the self-rescue is now available: ESSMA – map with evacuate option	
2	Yes	Action button	Downloads the escape route from the eDSS; Navigation to: ESSMA – map evac – display route (1)	

Table 41 – ESSMA – map evac – display route (1)

No.	Description	Function	Behaviour	Comments
1	exit	Action button	Aborts the evacuation guidance but keeps a button alive on the map to restart it if necessary: ESSMA – map with evacuate option	Evacuation guidance is closed automatically once reaching a safe point.



Figure 75: ESSMA – map with evacuate option



Figure 76: ESSMA – confirm rescue

Table 42 - ESSMA – map with evacuate option

No.	Description	Function	Behaviour	Comments
1	evacuate	Action button	Restarts the evacuation guidance: ESSMA – map evac – display route (1)	
2	search	Text input field	For searching addresses or points of interest. Available so that the ESSMA can be used for everyday navigation. On click: see – ESSMA – map no evac (2)	

Table 43 – ESSMA – confirm rescue

No.	Description	Function	Behaviour	Comments
1	No	Action button	Starts the evacuation.	
2	Yes	Action button	Downloads the rescue route from the eDSS; Navigation to: ESSMA – map evac – display route (1)	

When a voluntary-helper accepts to be guided to a person the navigation will start automatically. In the case, that they change their opinion, and they want to be self-rescued, the can click on the Self-rescue button as shown here and the view of Figure 73 will appear.

ESSMA – self-rescue & SOS shows a variant that is available when a helper starts his self-rescue and an SOS-call has been sent by a person nearby. By clicking on the SOS-icon, the user can change to a navigation that takes him to the SOS-call location instead. This results in Figure 78.

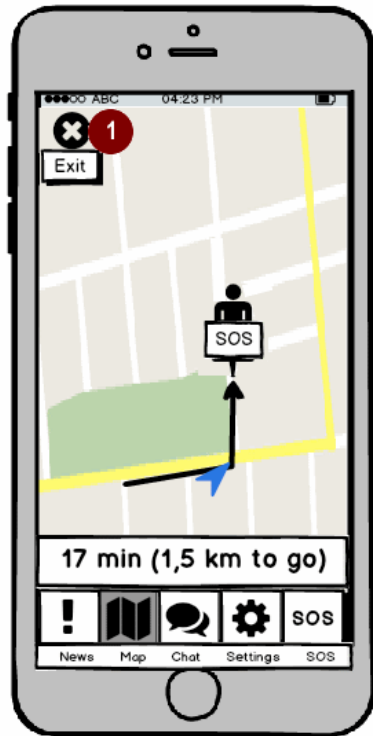


Figure 77: ESSMA – navigate to SOS

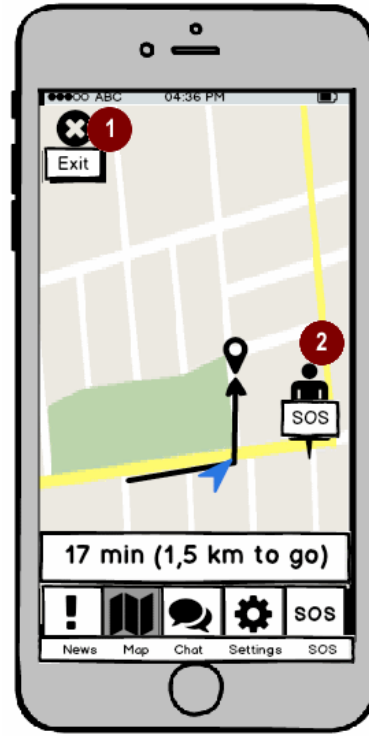


Figure 78: ESSMA – self-rescue & SOS

Table 44 - ESSMA – navigate to SOS (1)

No.	Description	Function	Behaviour	Comments
1	exit	Action button	Aborts the evacuation guidance but keeps a button alive on the map to restart it if necessary: ESSMA – map with evacuate option	Evacuation guidance is closed automatically once reaching a safe point.

Table 45 – ESSMA – self-rescue & SOS

No.	Description	Function	Behaviour	Comments
1	exit	Action button	Aborts the evacuation guidance but keeps a button alive on the map to restart it if necessary: ESSMA – map with evacuate option	
2	SOS	Action button	Discards the route and selects the location of the SOS-call as a new destination. Opens the popup: ESSMA –	

			confirm rescue	
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The following features may be made available when no evacuation has been requested by the eDSS operator.



Figure 79: ESSMA – map no evac (1)



Figure 80: ESSMA – map no evac (2)

Table 46 – ESSMA – map no evac (1)

No.	Description	Function	Behaviour	Comments
1	search	Text input field	For searching addresses or points of interest. Available so that the ESSMA can be used for everyday navigation. On click: see – ESSMA – map no evac (1)	
2	map	Interactive element	Allows for zooming, panning (e.g. such as google maps) by using device-specific gestures	

Table 47 – ESSMA – map no evac (2)

No.	Description	Function	Behaviour	Comments
1	search	Text input field	Text field is focused. If available, a list of likely options is displayed to select from by clicking.	
2	cancel	Action button	Removes the focus from (1); deletes content in (1); hides keyboard (3).	
3	keyboard	Device's custom	Standard. Disappears on hitting "return". On "return", the route to the entered	

		keyboard	destination from the current location is calculated. → ESSMA – map evac – display route (1)	
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The following images and tables describe the the other features that are not directly related to self-rescue.

The topic selection is optional, it is mostly meant to show the users what they should use the feature for – and hopefully helps avoid the sending of messages that are not helpful for the operator. Alternatively, a pop-up can be displayed stating: “please do not send messages not related to one of the following topics: emergency; traffic incident or risk; public safety incident or risk.”

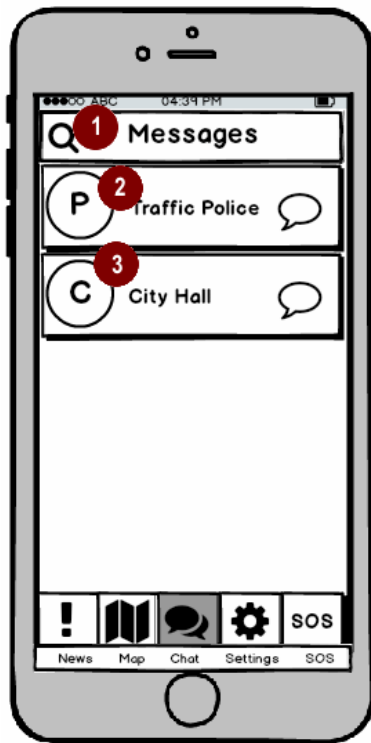


Figure 81: ESSMA – messages main

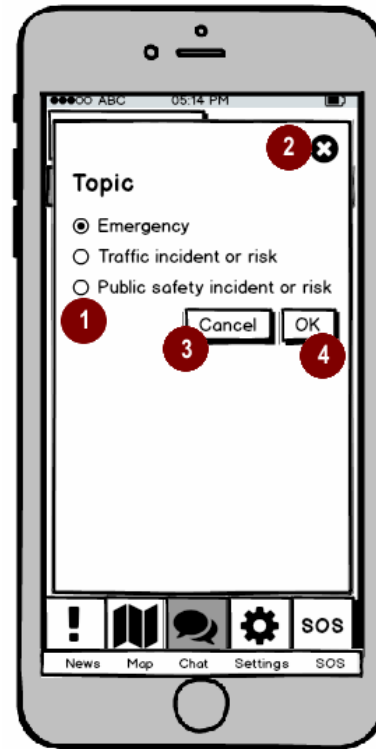


Figure 82: ESSMA – messages – select topic

Table 48 ESSMA – messages main

No.	Description	Function	Behaviour	Comments
1	start	search	Opens a text entry field. On “return”, the app searches for the input in the text field in all messages: ESSMA – messages - search	
2	[contact 1]	Action button	Opens the chat with [contact 1]. Starting with ESSMA – messages – select topic.	This serves to minimize off-topic messages received by the eDSS operator.
3	[contact 2]	Action button	Opens the chat with [contact 2]. Starting with ESSMA – messages – select topic.	

Table 49 – ESSMA – messages – select topic

No.	Description	Function	Behaviour	Comments
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1	selection	List + radio buttons	Contains three topics: emergency; traffic incident or risk; public safety incident or risk.	(List selection is optional)
2	(x) "close"	Action button	Closes the topic selection. Back to ESSMA – messages main	
3	Cancel	Action button	Closes the topic selection. Back to ESSMA – messages main	
4	OK	Action button	Forwards the selected topic to the chat; opens the chat:	

The message search feature is optional, as supposedly, civilians are not meant to send many messages, or to come back to messages sent a long time ago. Messages should always reflect the current issue.



Figure 83: ESSMA – messages – chat with contact 1

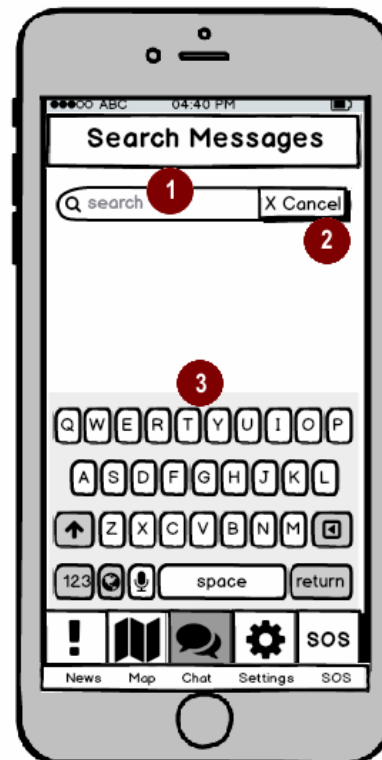


Figure 84: ESSMA – messages - search

Table 50 - ESSMA – messages – chat with contact 1

No.	Description	Function	Behaviour	Comments
1	cancel	Action button	Closes the chat. Back to ESSMA – messages main	
2	picture	Action button	Opens the camera. Once a picture is taken or selected from the gallery, it can be inserted here.	
3	Text input	Text input field	Accepts all characters	
4	send	Action button	Forwards the message to the eDSS.	

Table 51 - ESSMA – messages - search

No.	Description	Function	Behaviour	Comments
1	Search	Text input field	Accepts all characters.	(optional view)
2	(x) cancel	Action button	Navigates to ESSMA – messages main.	(optional view)
3	Keyboard	Custom keyboard	Use to enter input into (1). On return, this is started based on the entered characters in (1).	(optional view)



Figure 85: ESSMA – settings

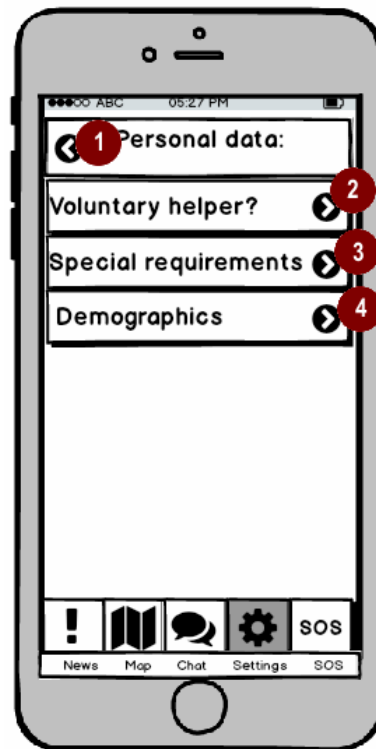


Figure 86 ESSMA – settings – personal data

Table 52 – ESSMA – settings

No.	Description	Function	Behaviour	Comments
1	Personal data	Action button	Opens: ESSMA – settings – personal data	
2	Settings	Action button	Opens: ESSMA – settings – settings	

Table 53– ESSMA – settings – personal data

No.	Description	Function	Behaviour	Comments
1	Voluntary helper	Navigation element	Navigation to ESSMA – settings – personal data – voluntary helper	
2	Special requirements	Navigation element	Navigation to ESSMA – settings – personal data – special requirements	
3	Demographics	Navigation element	Navigation to ESSMA – settings – personal data – demographics	

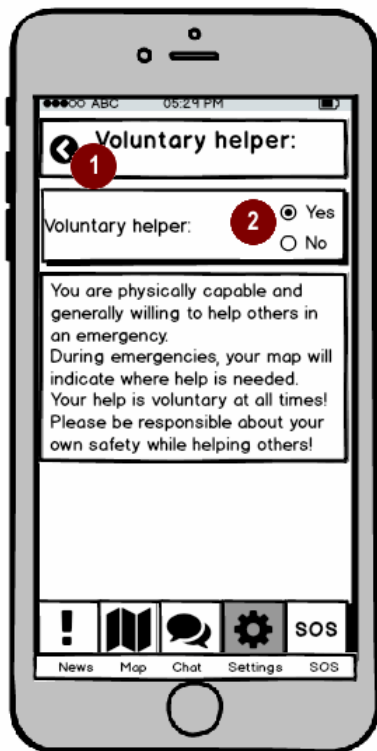


Figure 87: ESSMA – settings – persona data – voluntary helper

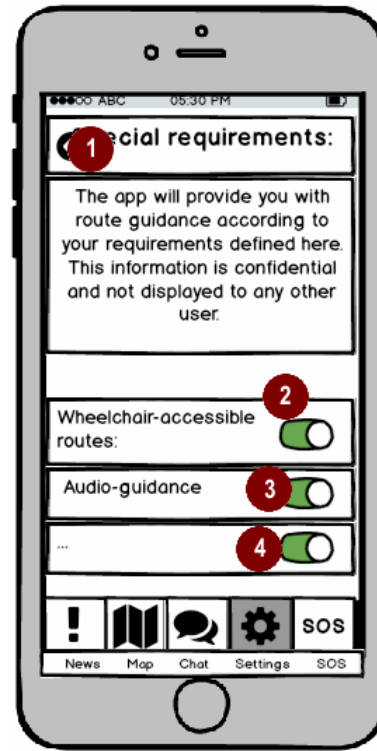


Figure 88: ESSMA – settings –personal data – special requirements

Table 54 - ESSMA – settings – persona data – voluntary helper

No.	Description	Function	Behaviour	Comments
1	back	Navigation element	Navigation to ESSMA – settings – personal data	
2	Voluntary helper	List & radio buttons	The selected option will be saved in the user profile and sent to the eDSS.	

Table 55 – ESSMA – settings –personal data – special requirements

No.	Description	Function	Behaviour	Comments
1	back	Navigation element	Navigation to ESSMA – settings – personal data	
2	Wheelchair-accessible routes	On/off switch	When on, the app sends the info to the eDSS that the user is a wheelchair user. This influences the estimated velocity.	
3	Audio-guidance	On/off switch	When on, the app enables speech output.	
4	...	On/off switch	[other possible profile variables]	

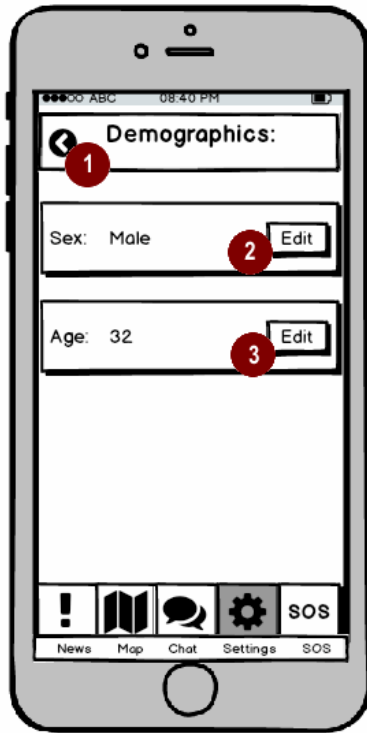


Figure 89: ESSMA – settings – persona data – demographics

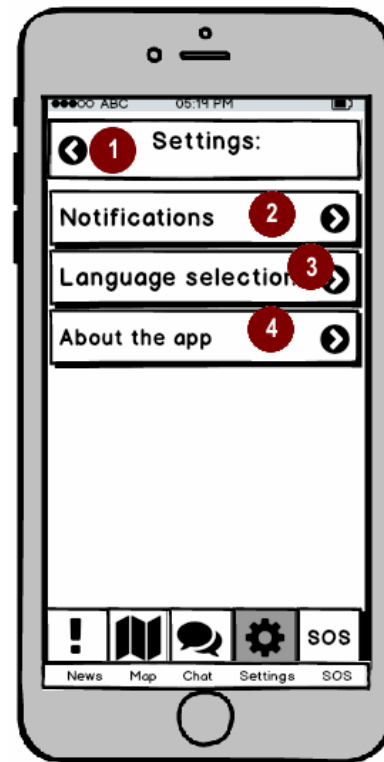


Figure 90: ESSMA – settings - settings

Table 56 – ESSMA – settings – persona data – demographics

No.	Description	Function	Behaviour	Comments
1	back	Navigation element	Navigation to ESSMA – settings – personal data	
2	Sex (or “gender”)	Action button	Opens a custom selector of the phone’s OS to indicate the gender. Closing the selector will save the change to the profile, which is published on sending an SOS call.	
3	Age	Action button	Opens a custom selector of the phone’s OS to indicate the age. Closing the selector will save the change to the profile, which is published on sending an SOS call.	

Table 57 – ESSMA – settings - settings

No.	Description	Function	Behaviour	Comments
1	back	Navigation element	Navigation to ESSMA – settings	
2	Notifications	Navigation element	Navigation to ESSMA – settings – settings – notifications	
3	Language selection	Navigation element	Navigation to ESSMA – settings – settings – language selection	
4	About the app	Navigation element	Navigation to ESSMA – settings – settings – about the app	

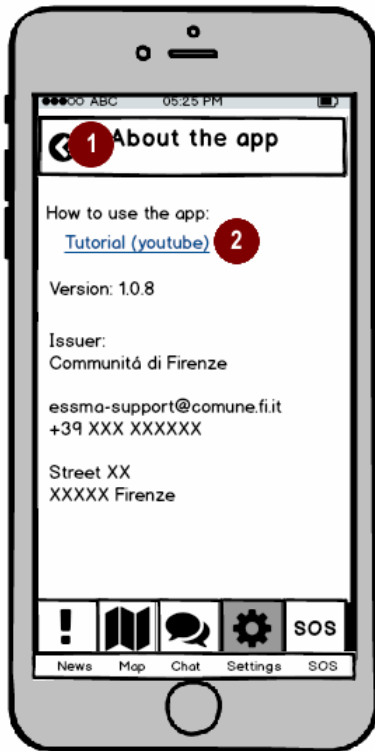


Figure 91: ESSMA – settings – settings – about the app

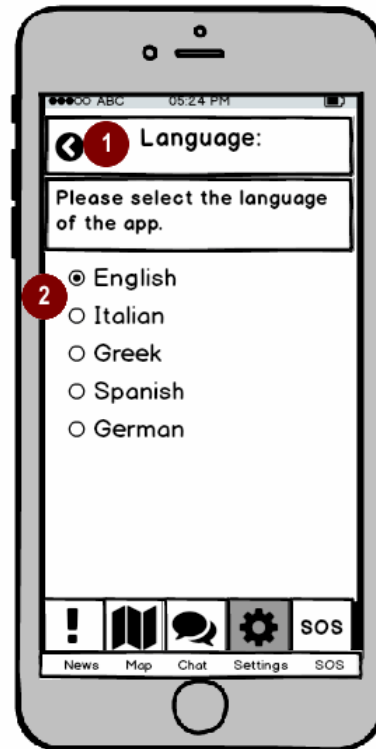


Figure 92: ESSMA – settings – settings– language selection

Table 58 – ESSMA – settings – settings – about the app

No.	Description	Function	Behaviour	Comments
1	back	Navigation element	Navigation to ESSMA – settings – settings	
2	Tutorial (YouTube)	hyperlink	Opens the default browser on the webpage of the tutorial video.	

Table 59 – ESSMA – settings – settings– language selection

No.	Description	Function	Behaviour	Comments
1	back	Navigation element	Navigation to ESSMA – settings – settings	
2	Select language	List + radio buttons	Select language. Language is applied instantly.	

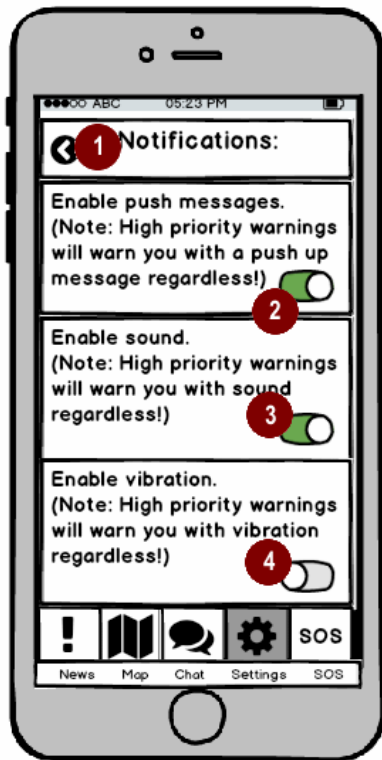


Figure 93: ESSMA – settings – settings – notifications

Table 60 – ESSMA – settings – settings – notifications

No.	Description	Function	Behaviour	Comments
1	back	Navigation element	Navigation to: ESSMA – settings – settings	
2	Enable push messages	On-/off switch	When on, the ESSMA shows new newsfeed messages in the phone's notifications.	
3	Enable sound	On-/off switch	When on, the ESSMA makes a sound when receiving new newsfeed messages.	
4	Enable vibration	On-/off switch	When on, the ESSMA vibrates when receiving new newsfeed messages.	

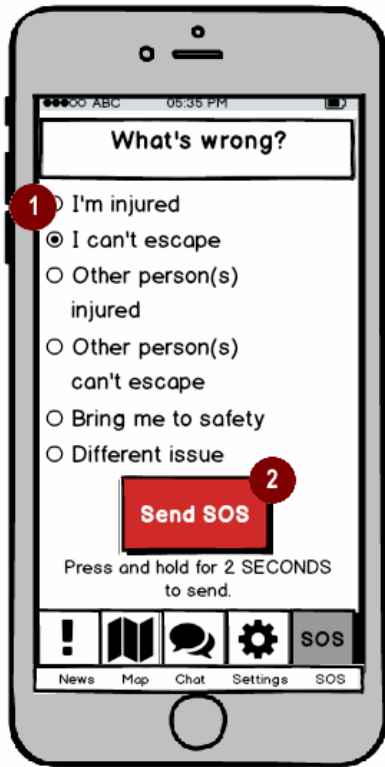


Figure 94: ESSMA – SOS (1)

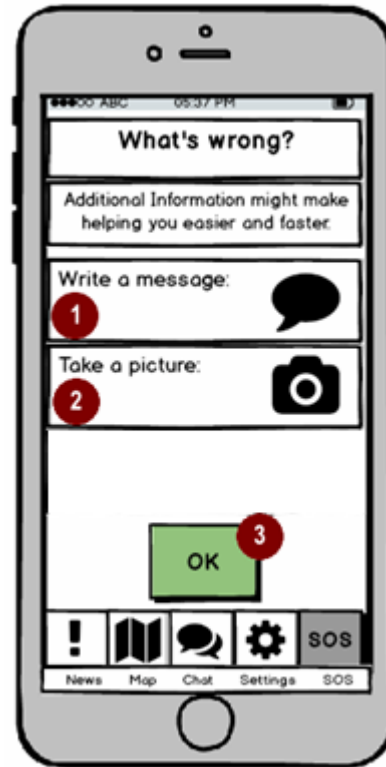


Figure 95: ESSMA – SOS (2)

Table 61 - ESSMA SOS (1)

No.	Description	Function	Behaviour	Comments
1	Select issue	List + Radio buttons	Select issue category to be sent to the system	
2	SOS call	Action button	Sends the SOS call to the system; Navigation to SOS (2)	

Table 62 - -ESSMA SOS (2)

No.	Description	Function	Behaviour	Comments
1	Write a message	Action button	Opens a messaging feature (like ...)	
2	Take a picture	Action button	Opens the camera. Offers a send-button after taking a picture.	
3	OK	Action button	Navigation to ESSMA SOS (3)	

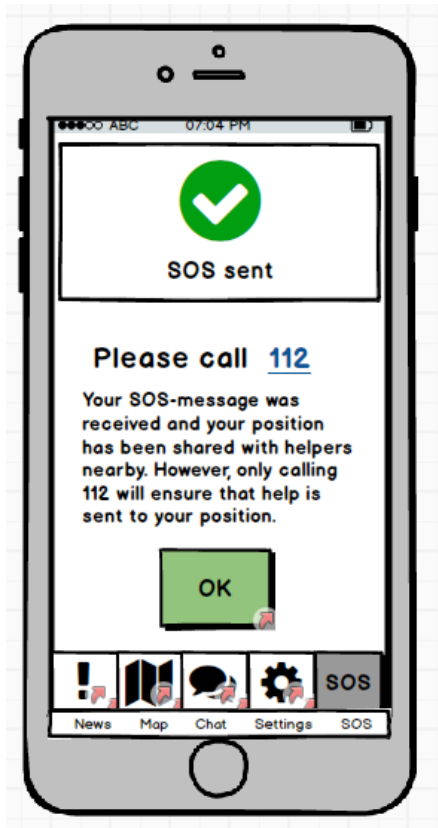


Figure 96: ESSMA – SOS (3)

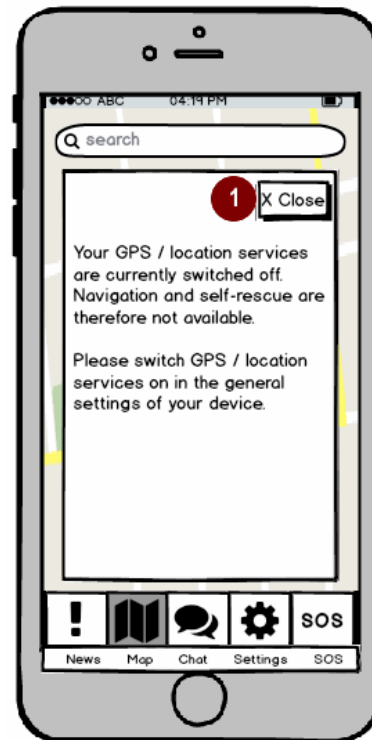


Figure 97: ESSMA – NoGPS

Table 63 -ESSMA SOS (3)

No.	Description	Function	Behaviour	Comments
1	112	Hyperlink	Starts a phone-call to 112	
2	OK	Action button	Closes the SOS feature.	

Table 64 - ESSMA – NoGPS

No.	Description	Function	Behaviour	Comments
1	close	Action button	Closes the popup.	Shown when GPS is switched off. Users need to enable GPS in the device's native controls. (Assumedly only available on Android OS)

7 GAME-BASED TRAINING APP

The Game Based Training App (GBTA) is a smartphone-based application, which allows the user to learn how to behave in certain critical in situations. In the RESOLUTE project, the GBTA was filled with learning contents that

refer to flooding scenarios. However, the development consists in a framework that can easily be used to host any other learning content as well.

The app has a very simple user interaction concept, which has borrowed from an already existing app: CLINICAL SENSE.

In summary, the course of the game follows a tree structure. The user clicks through a story, which consists of a general storytelling, interrupted by decision points. Depending on the decision taken, the star it proceeds in a different manner. The challenge is to take the right decision at all decision points.

7.1 Target users

The target users are civilians from the age of 14 years. It and Consequently, the same restrictions as mentioned in the chapter 3 will also apply here.

7.2 Scope and objectives

From a user's perspective, the game-based training app is meant to be a fun activity and to prepare the user for serious situations in real life. The users should be motivated to complete all scenarios with success and thus test or improve their knowledge about what to do. The detailed objectives depend on the contents, which are reported in deliverable 5.5.

7.3 Features

With respect to the four cornerstones of resilience, the GBTA supports the cornerstone ANTICIPATE: Through providing training to its users before disruptive events happen, the GBTA aids in preparing the UTS and its users for such events.

The GBTA will, from a system point of view, include the following features:

1. Select scenario
2. Proceed through story
3. Choose one of several decision options
4. Receive rewards

7.4 User requirements

Deliverable 5.1 reported a collection of usability standards and requirements to be heeded in the development of the GBTA. However, as the app follows a really simple usability approach, which only consists in clicking forward during story mode and clicking one of several buttons that represents a decision once decision points are reached, usability testing was not necessary. Checking the original app, clinical sense, we did not find any usability issues.

User requirements thus rather refer to the contents, which should be interesting, challenging, and trustworthy.

7.5 Technical restrictions

The same technical restrictions applied as reported above for the ESSMA. Due to the simple design, there were no issues concerning technical restrictions of smartphones.

7.6 Work plan: user requirements analysis

The main challenge was in the design of the training contents, not the app itself. This was achieved by researching necessary contents in interviews with civil protection officials in Florence and carefully creating the correct decision tree structures.

7.7 Blueprint of user interaction & experience

Here, we show simple examples of the app clinical sense, from which the interaction concept was taken over.

The start screen offers four key options: opening the scenarios, editing the profile, inviting friends [social media], and setting the language. For the GBTA, only the first and last are relevant.

On the page for scenario selection, the user can go back to the previous page by pressing the arrow in the upper left corner. He can also choose one of the scenarios to play. Starting a scenario leads to the story mode.

In story mode, the user can leave the scenario by pressing the arrow in the upper left corner. He can go forth and back in the story, using the arrows at the bottom left and right. Sometimes, hyperlinks are available in the story, which open a pop up window with additional information (help topic).

The help topic can be closed by pressing the X in the upper right corner.

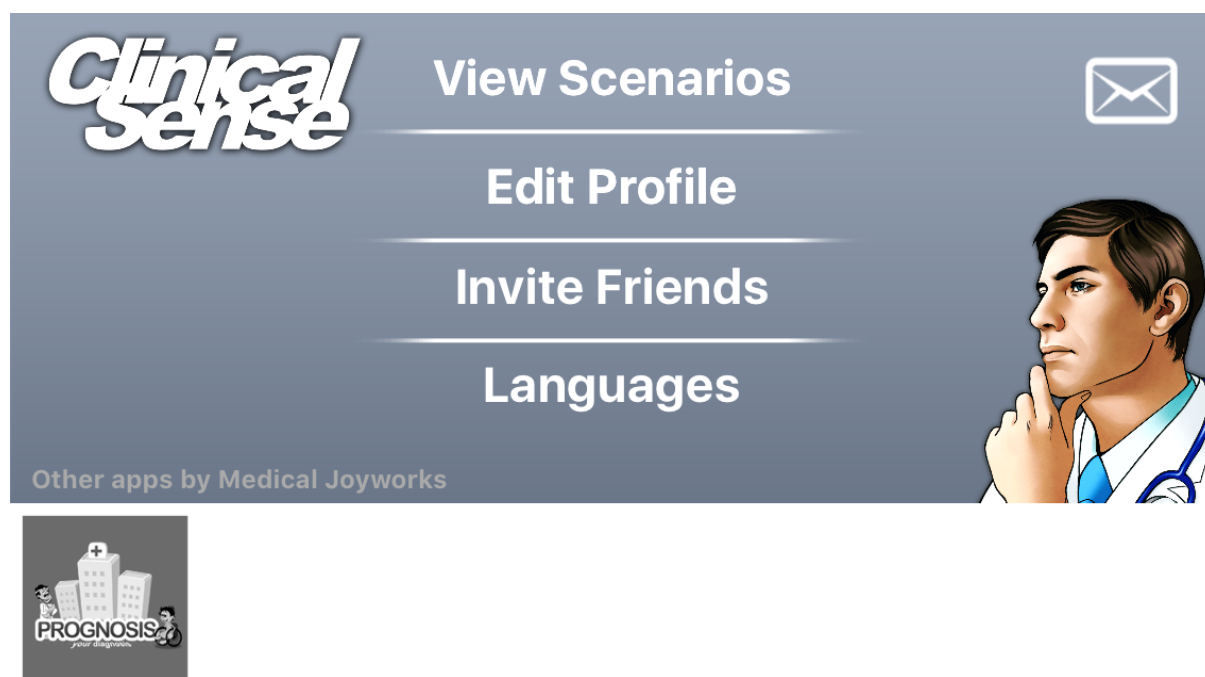


Figure 98 – Clinical sense – start screen

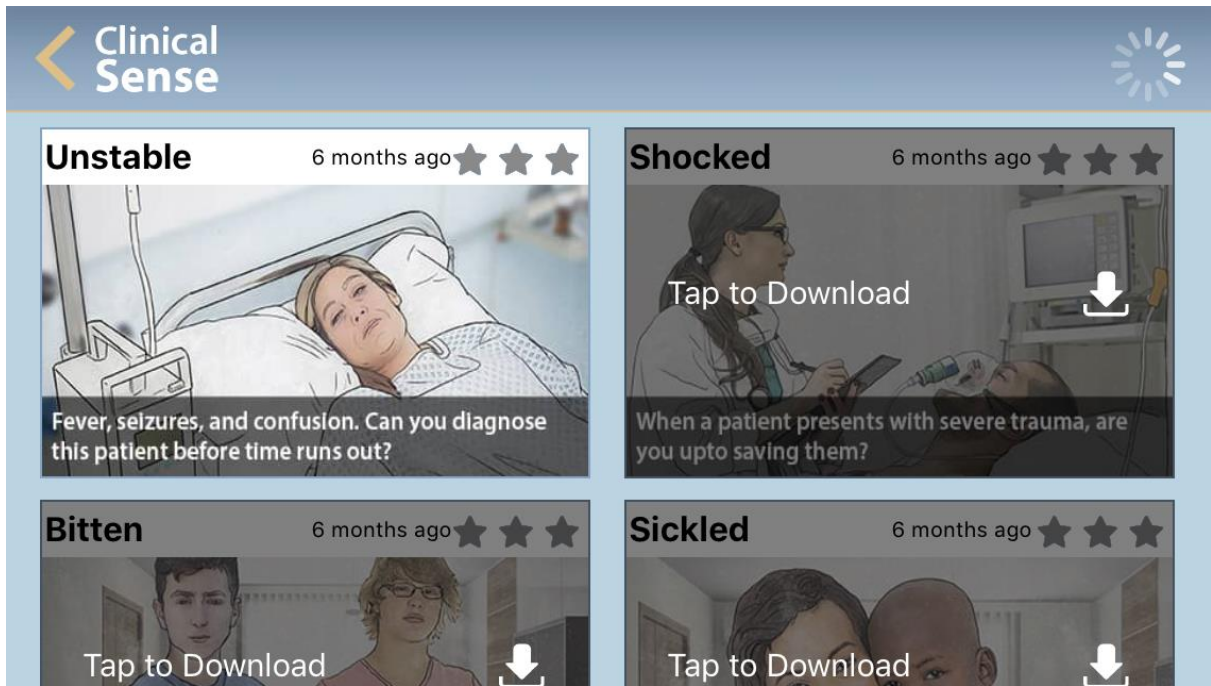


Figure 99 – Clinical sense – scenario selection

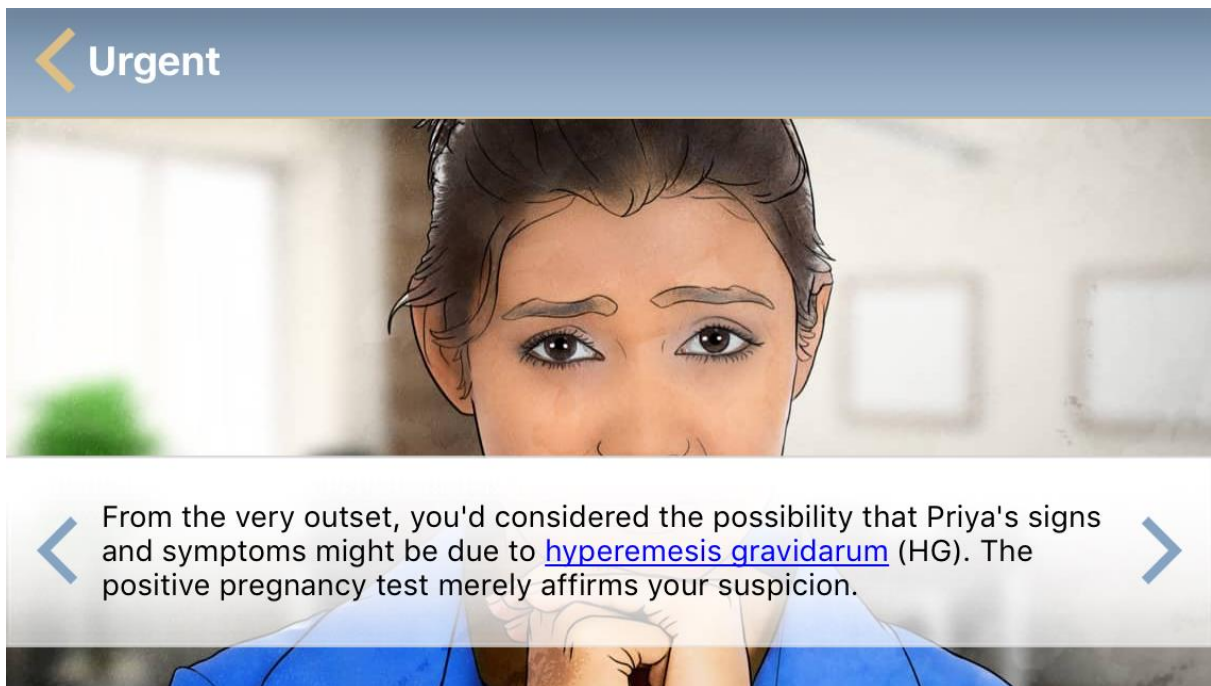


Figure 100 - Clinical sense – story mode (with help topic)

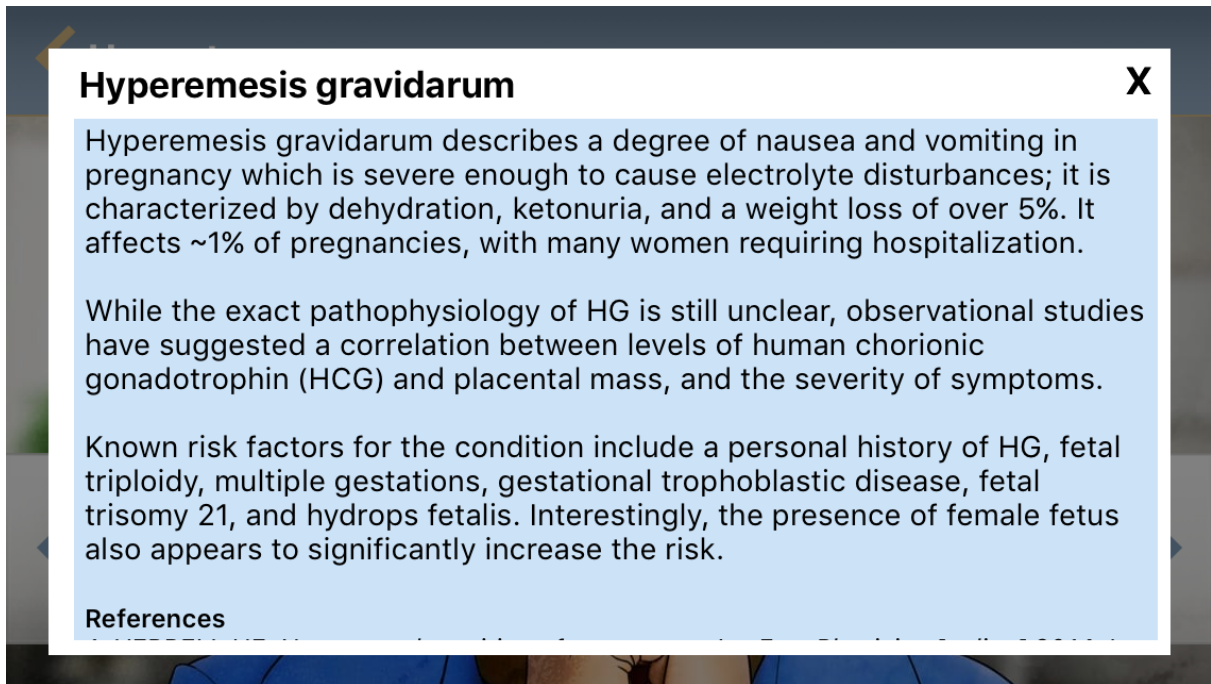


Figure 101 – Clinical sense – help topic

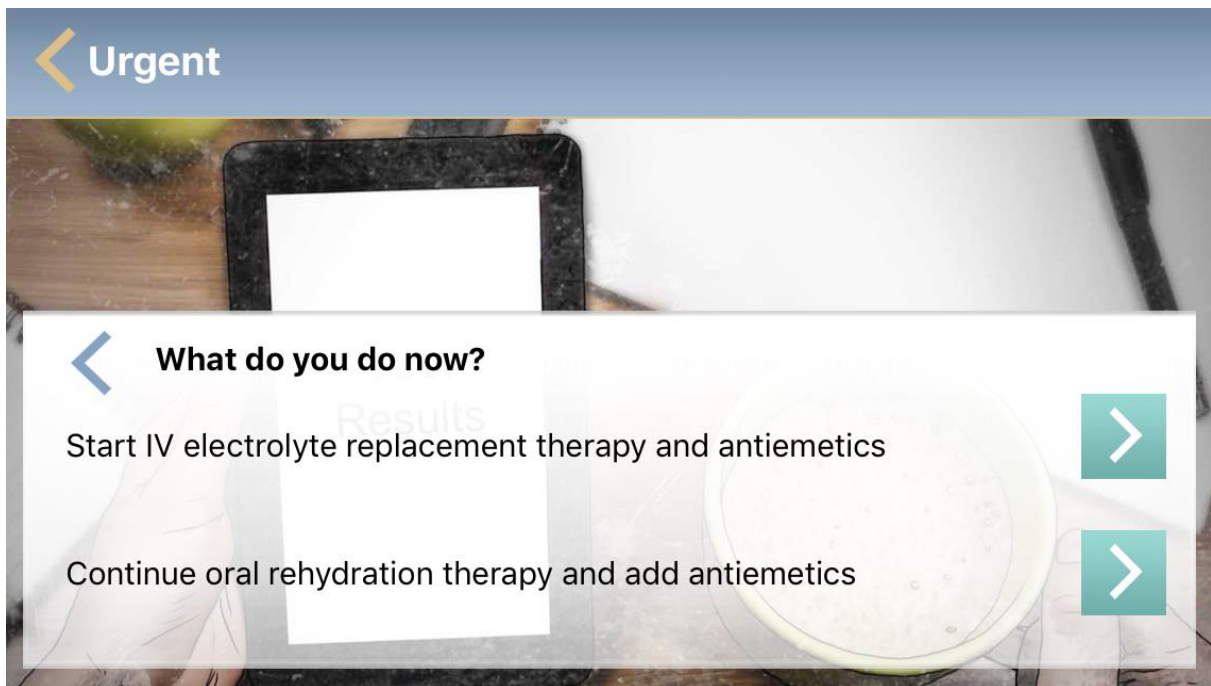


Figure 102 - Clinical sense – decision point

In decision points, there are several errors to the right, each representing a different decision. The rest resembles the story mode.

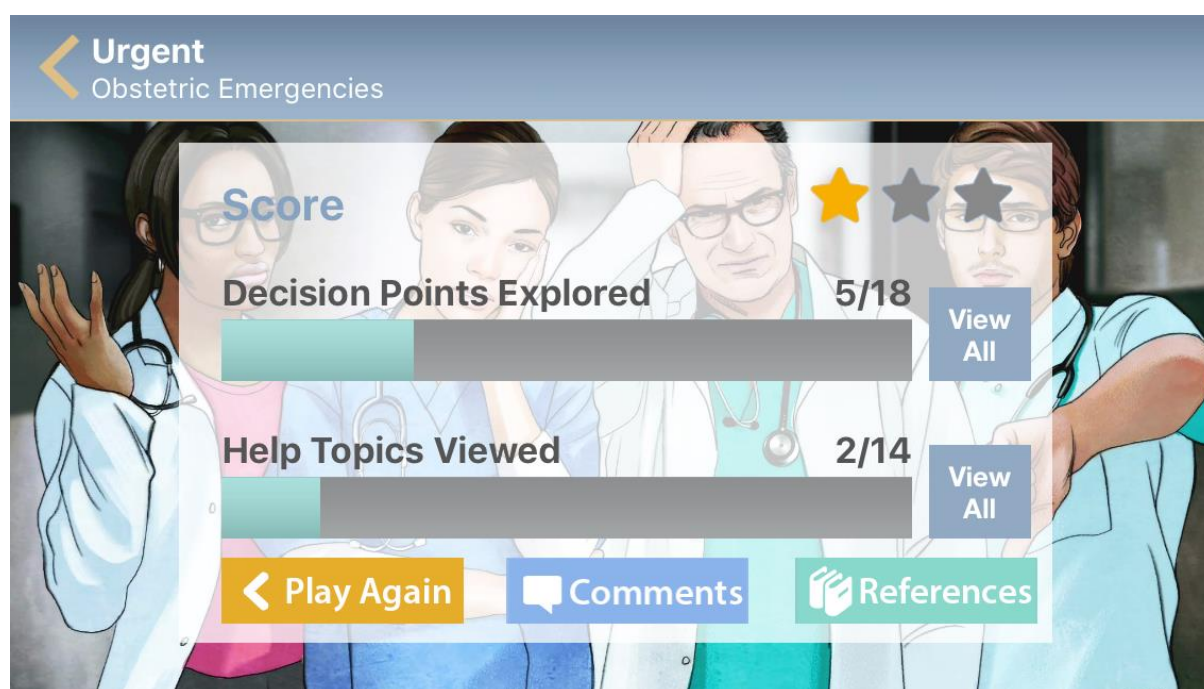


Figure 103 – Clinical sense – closing page

By the end, the app presents a summary of the users success and activity. Four scoring categories [0 to 3 stars] are available. Additionally, the app shows how many decision points and help topics were touched.

8 ESSMA TRAINING APP

8.1 Introduction

The ESSMA is the application that will be developed in task 5.3 and its main aim is to provide an assistance and support to the citizens that use it. For this reason based on ESSMA app, a training app that familiarizes the citizens with the real ESSMA app was developed as contribution of CERTH to the task 5.4.

8.2 Interaction Assistance

The ESSMA training app uses a number of techniques, which are common in many applications, in order to assist users in learning the features of an app. One of these is the ng-walkthrough that is shown in Figure 104, using this the user will get information about how to use each of the application components. As the ESSMA is an application for smartphones with touch screens, the information that users get is a hand that shows the exact interaction with the phone. For instance, when the user needs to tap on a specific button for an action, then the respective message will be shown in the training app.

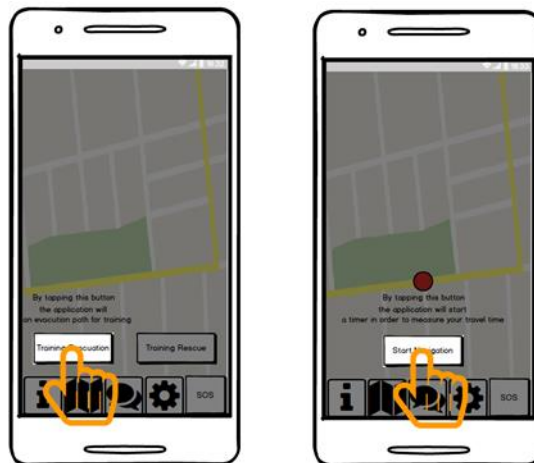


Figure 104 – Walkthrough Examples

8.3 Gamification feature

Additionally, the ESSMA training app does not only familiarize users with the features of app in order to use them easily; it also contains a kind of gamification that will incentivate users to continuously use the application. This gamification feature works with points that user acquires by using the application and every time they reach a number of points, the application upgrades the level of the user. The ESSMA training app contains four basic games that correspond to the main features of the app, the Training Evacuation, the Training Rescue, the Communication Task and the SOS Alert. All the four games are described by the ng-walkthrough and they are triggered by the user. The procedure that gives points and upgrades the level of user is started and managed automatically by the application.



Figure 105 – Gamification Example

In Figure 105, an example of the training evacuation is shown. More specifically, at first the user taps the *Training Evacuation* button. This action generates a random path and draws it to the map. By tapping on the *Start Navigation* button, the application starts a timer that records the time needed to reach the safe point. When the user reaches the destination, the application gives a number of points to the user. In this example, the user surpass the 5000 points threshold and ascends to Level 1. In another section of the application, the user is able to view their points and their levels.

9 CONCLUSIONS

This deliverable presents the results of the user centred design approach undertaken to develop the user interaction concepts for the resolute work package 5 applications. The main aim of the work was supporting the implementation of these applications, which was successful as the implementation is almost complete by this time. The interaction concepts have proven useful in user testing with representative participants.

The presented applications are key outcomes of the RESOLUTE project. Based on the other projects on resilience guidelines presented at DSM our workshop in Berlin, Germany, on the 4th April 2017, it seems that RESOLUTE is special in the sense that it provides both, guidelines, which are there other strategic instrument, and the work package 5 applications, which serve for strategic, tactical as well as operational purposes. The evacuation DSS for example is an operational or tactical instrument when it is used for evacuation in a crisis scenario. Similarly, the Dashboard can support tactical operations, for example by showing UTM DSS strategies in place. However, the tools are helpful for long time monitoring of the city, leading to insights about recurrent problems and possibly improving the anticipation capacities of the urban transport system. This complements the guidelines (ERMG, D3.1). Additionally, the FRAM tool creates a link between the guidelines and the activities of individual operators.

10 REFERENCES

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