Understanding End-User Needs for an Efficient Multi-Hazard Emergency Management Service Platform Design

Javier Mulero Chaves
German Aerospace Center (DLR)
Institute for Communication and Navigation
Javier.MuleroChaves@dlr.de

Maria Antonietta Marchitti
German Aerospace Center (DLR)
Institute for Communication and Navigation
Maria-Antonietta.Marchitti@dlr.de

Ulrich Raape
German Aerospace Center (DLR)
Institute for Communication and Navigation
Ulrich.Raape@dlr.de

Helena Ballart
Pau Costa Foundation
Helena@paucostafoundation.org

ABSTRACT

A deep analysis and understanding of real life end users' procedures and needs is a basic requirement for designing and providing useful tools that can be applied during risk and emergency management operations. Human-centered tools can help to achieve this necessary understanding and to support the complete design and implementation process for newly developed tools. The paper describes the approach that has been followed in order to interact with end users during the XX project, intended to develop a multi-hazard open service platform for risk and emergency management. The paper focuses on the techniques used during a dedicated end user workshop for requirements gathering and refining and its corresponding results.

Keywords

Fire management, risk monitoring, requirements, risk assessment

INTRODUCTION

Understanding the needs and requirements of end users is a critical issue when designing and implementing risk and emergency management tools. On one hand, the process gets complex when considering the wide range of interdisciplinary factors which play a role. On the other hand, understanding the limits of the user domain, the roles which end users may adopt, their needs in terms of information and communication structures and their everyday operation protocols is crucial for providing a service platform for risk and emergency management. Therefore, the adaptability of the provided tools to the current emergency management procedures and protocols will determine the success of the tool as well as their adoption for regular use.

The design and provision of a multi-hazard open service platform for risk and emergency management must take into account the current and foreseeable state of suitable technologies and tools to be provided, the characteristics of the different hazards to be managed, the existing operational procedures, the

demanding psychological conditions that end users must stand during emergency situations, their level of familiarity with IT systems and many other technological, social and psychological factors. While the technological aspects might be easily evaluated from an engineering perspective, a dedicated user-centered methodology must be devised in order to bridge the gap between user needs and expectations and what technology and research can provide them with.

The paper aims at describing and analyzing the interactive approach planned and implemented within the XX project in order to assess user needs and tailor the design and implementation of an open service platform for risk and emergency management. Firstly, the paper describes the general interaction approach planned within the project as well as the different end user profiles which are involved in the overall process. Thereafter, a description of the particular methodology used during the second dedicated end user workshop is provided together with its results. Finally, conclusions are derived.

END USER INTERACTION APPROACH

Interaction with end users is one of the pillars on which the XX project is based. This interaction process is intended to close the gap between the real world problems that end users and practitioners face during their everyday tasks and the risk and emergency management tools which are or can be available in the short and medium term. Within XX, participation of end users is granted thanks to the establishment of an End User Advisory Board, which is a group of appointed international experts, with end user profile, who work in the area of civil protection and disaster management related to different hazards and whose role in the project is to provide advice to the project team from an end user perspective. This allows tailoring strategic decisions to achieve relevant and efficient services from the perspective of end users.

The interaction strategy to be followed during the project is divided in two main activities:

- On one hand, they are consulted regularly through a set of four workshops distributed over the project duration. Through these dedicated workshops, the project team can present the advances which have been achieved at the different project phases and gather immediate feedback from the participants. The focus of the first two workshops has been to understand current operational procedures and to identify room for improvement in order to gather and refine user and system requirements, so to avoid omitting important conceptual and technical aspects related to the development of the system. The third and fourth workshops are mainly related to the development and the presentation of a pre-operational system. A first implementation of the system will be presented to the Advisory Board during the third workshop. This will be followed by the demonstration of a pilot (i.e., fourth workshop) in a real context for a forest fire scenario. The proposed technological concepts will be challenged and their performance demonstrated. The involvement of end users in organizing the pilot, using the provided platform during the pilot and evaluating its performance will ensure the real assessment of its features and benefits to improve the detection, monitoring and management of an emergency situation, including alerting the population.
- On the other hand, a second round of feedback is collected by creating ad-hoc questionnaires relative to aspects that could not be investigated during each of the meetings.

Although the pilot phase of the project is based on a forest fire scenario, the multi-hazard nature of the service platform to be provided makes it necessary to involve a wide range of end user profiles in the system design and implementation. Therefore, a series of local end users are invited to the different workshops, in addition to the Advisory Board members. The end user profiles which are involved in the project development are professionals working in senior positions in agencies involved in emergencies, such as Fire Service, Civil Protection Service, Police Service and Traffic Service in the region of Catalonia (Spain).

Regarding the Fire Services, three different profiles can be identified:

- Heads of Extinction or Incident commanders (IC), who are in charge of the overall command of an incident and are the decision-making final authority.
- Wildfire analysts, who are experts on forest fire spread and in optimization of strategies. They give advice to the IC about the fire potential, opportunities

and alternatives, and monitor the evolution of the determining factors of fire along the fire season.

- Head of Technology Development Section, whose main duties are proposing the technological requirements, tools and applications necessary to support emergencies.

Regarding Civil Protection Services profiles, a Head of Logistic Service and Regional operations has been consulted. The main duties of this civil protection profile are supporting the coordination of operating authorities in the territory and of the authorities involved in emergency management, supporting and coordinating actions in emergency logistics and establishing action plans in emergency deployment.

The Police Information Systems Division (a body of the police in charge of protecting the internal computer systems, databases and telecommunications internal body) has been consulted through a Head of projects Area. The main role of this profile is collaborating in the management of the design, definition, implementation, monitoring and evaluation of police information systems.

Finally, the traffic service is represented by a responsible for road safety and mobility. The main tasks of this profile are to propose improvements to the Traffic Accidents Information System to Local Police, to prepare studies, reports and technical papers in the field of traffic and road safety, as well as designing and executing research projects.

END USER WORKSHOP FOR THE REFINEMENT AND IDENTIFICATION OF USER REQUIREMENTS

User Requirement Extraction is a multidimensional knowledge acquisition / engineering challenge (Benyon, 1993). In disaster management and specifically in the area of monitoring, early warning and response, typical activities include:

- A given spatiotemporal context is monitored for signs/indications of a (potential) disaster happening/approaching/evolving,
- Sensor networks, telecommunication (e.g. 112 services), media reports, reports from resources in the field, etc. are used to gather relevant information,
- Available information is compiled into a “picture” of the situation (situation awareness, common operational picture (COP)),
- Information gaps are closed or narrowed down using additional tools, e.g. risk/vulnerability databases, historic information (e.g. about historic emergencies/disasters), simulation/modeling tools (e.g. wildfire simulation, evacuation simulation),
- Different decision options or action plans (if available) are assessed,
- Decisions are taken and implemented, action plans activated,
- Information is shared (with own resources, neighboring centers, higher level authorities, other authorities involved), warnings/alerts are disseminated

Depending on the local/regional legal and organizational frameworks and the available resources, the authorities and decision makers involved, the rules and workflows followed, the methods and tools used can differ a lot, including the way of decision making (centralized vs. decentralized) and the degree of freedom of decision makers. To gather information about such framework requirements is an important part of user requirements identification. In order to fulfil this task, the project has dedicated two end user workshops:

- In the first one, the objective was to introduce the overall objective of the project and to gather feedback on the end users expectations in the form of possible use cases. Since the workshop objective was to obtain a high amount of ideas that would be processed and classified afterwards according to their suitability to the project objectives, a limited amount of information about the project was provided and brainstorming techniques were used for collecting feedback.
- In the second one, the objective was to tailor the preliminary system design to the users’ expectations. Therefore, participants were provided with more detailed information about the system operational principles. Feedback was collected using the methodology described in the following sub-section.

Methodology

The availability of different stakeholders and users during an end user workshop allows using the interaction between the participants as a further source of information. A proven procedure in such an environment is the scenario-based user interaction using historical disaster cases in which the different stakeholders/authorities present in the end user workshop have been involved in (Haumer and Heymans and Pohl, 1998; Haumer and Pohl and Weidenhaupt, 1999). In some cases, participants have even been personally involved in the management of the selected historic disaster, as it was in our case.

Typically, the selected examples should be of medium to high complexity and should contain typical challenges the different roles (e.g. firefighter at headquarter, firefighter in the field, civil protection) may encounter during the disaster. Depending on the experience level of the end users and group dynamics, a sequence of scenarios can be used to address additional (more complex or "exotic") challenges, perhaps using fictitious scenarios.

The scenarios selected for the end user exercise during the second dedicated workshop were tailored to three different end user profiles (firefighter at headquarter, firefighter in the field and civil protection responsible). A forest fire case was presented to participants and summarized in the following way:

- Short textual summary
- Additional information (maps, multimedia) to explain specific facts about the scenario
- Numbered list of key facts (challenges), sorted chronologically

The *numbers of the list of key facts* and different *roles/stakeholders* (in our case *firefighters at headquarter*, *firefighters in the field* and *civil protection*) has been used to create a two-dimensional matrix on a whiteboard to allocate end user feedback during the step-by-step discussion of the scenario.

End users were asked to provide feedback, written on notes to be allocated within the matrix, regarding a specific list of questions. In our case, the questions targeted

- Decision problems/information gaps encountered
- Additional information, technology or function that would help.

During the interactive session, and while the feedback is allocated on the whiteboard and explained to the group, in most cases feedback clusters can be identified in the matrix. Although the feedback focus often becomes obvious, indicating also priority areas, the (nearly) empty fields in the matrix should be cross-checked afterwards with the end user group.

Results

In our case, the outcomes of the exercises can be summarized as follows:

- Depending on role, hazard type and other factors, the focus may vary from improving situation awareness to additional decision support,
- In the wildfire case, focus is on information gathering/information sharing in order to improve situational awareness (no focus on decision support),
- Access to historic incident data is important,
- Interfaces to other systems/legacy systems would be helpful (e.g. to 112 services).

In the specific project setting, it turned out that in the domain of forest fire fighting the level of distributed/on-site decision making is very high compared to other domains where more centralized command-and-control structures are applied.

The expert knowledge involved to cope with a wildfire, both regarding the decision makers at the command and control center/headquarter and the resources in the field, cannot easily be captured and translated into automatic analysis and decision support. Experience, intuition and creativity plays a much greater role compared e.g. with the area of tsunami early warning, where decision options are fewer and standard operating procedures (SOPs) and workflows already capture a considerable fraction of available expert knowledge. In addition, the conversion of a complex operational picture into a structured warning message, containing

individual warning information for a high number of specific warning areas – a typical application for decision support, e.g. in the tsunami early warning case -, is not required in the wildfire context.

Results showed that some areas exist where decision support can nevertheless provide a high added value:

- Alerting support, including public alerting and the provision of relevant incident information to other authorities involved;
- Background analysis against historic disasters; valuable decision support could be provided if the system can compare the current situation with a database of historic disasters and offering the decision maker information about similarities (based on disaster similarity metrics to be defined);

Usually, the requirements gathering/elicitation process is conducted within a certain project context. This imposes time and budget restrictions for implementation efforts as well as a pre-selection of available technologies (sensor systems, simulation/modelling tools) provided by the project partners. Often, the project framework does not allow allocating resources for the integration of legacy systems in operation at users' sites.

Given these constraints, the user requirements that have been gathered need to be checked against the SMART criteria (Specific, Measurable, Achievable, Realistic and Timely) in order to cluster them into different horizons (Mannion and Keepence, 1995):

- Implementation within project (If all SMART conditions are met),
- Conceptual integration within the project (not all SMART conditions are met, implementation within the project framework is not possible),
- "Waiting list" (requirement is relevant, but conceptual integration cannot be prepared within the project)
- "Off-topic"

Of special importance is to agree on a common terminology among the different stakeholders and end users, which is often a difficult task especially when dealing with cross-domain or multi-hazard scenarios. Ambiguous terms shall be clarified in order to avoid misunderstandings. In this specific case, terms like event, incident and common operational picture required special attention.

In the case of wildfire hazards and the cooperation of firefighting and civil protection authorities, the outcome can further be summarized as follows:

- More information would be helpful for firefighters, in the command center as well as in the field, including meteorological information (mentioned often), other sensor information, airborne and satellite information, and additional geographic information (e.g. water resources nearby)
- Valuable information can be provided by geo-located multimedia information about the hazard, e.g. photos or videos (using dedicated apps/channels or public platforms such as Facebook, Twitter or Tumblr)
- Reliability of information is important, e.g.
    - Information from the field
    - Emergency calls (112 system) regarding doubled incidents, misleading/wrong information, overestimation of danger
- Vulnerability and risk information would be helpful (esp. for civil protection), e.g. high-risk facilities (industry, schools, hospitals, isolated houses, …), people affected, population in a specific area, in order to prepare and take appropriate measures (evacuation, road blocks, preparation of shelters, logistics, …)
- Sensor data (esp. meteorological data) and feedback from the field (and perhaps other sources) should be used to update forecasts (simulation)
- For firefighters on their way or in the field,
    - logistical information would help (best available routes, estimated time of arrival of resources/at next location, …)
    - a (geographic) overview of resources, more precise information of current and forecasted weather information, and access to

prediction plans for the next hours would be helpful

- For civil protection, it is important to
    - Provide identical information among the different channels used. Not only evacuate people, but also to prevent people to keep out of the area.

Many contributions refer to a more complete picture of the situation and how the situation may evolve (forecasting), taking into account a much wider range of sensors, multimedia sources (photos/videos), location information and background information (infrastructure, resources/appliances, vulnerability, etc.), for all three target groups in this exercise.

CONCLUSION

High technology is not useful if the human understanding is not able to take advantage from that point, nor the human are trusting in technology that has not been created to their needs and demands. The paper has highlighted the importance of establishing a human-centered approach for the design and implementation of risk and emergency management systems. This approach allows understanding the needs and limitations that end users face during their daily operations and fosters the conception of tools which adapt to already existing processes and protocols. Therefore, the general approach followed during the XX project has been presented as well as the dedicated tools implemented in the second workshop for gathering and refining user requirements.

As an outcome of the mentioned workshop, it has been possible to identify that the focus of fire management operations is generally on information gathering and sharing (for supporting de-centralized decision processes) rather than in automatic decision support techniques, since expert analysis plays an important role that can hardly be supported by using automated tools. However, several activities, such as providing alerting support and analysis against historic disasters, have been pointed as potential use cases where decision support would provide a high added value.

The workshop allowed identifying the different information items which are valuable at the different stages of a forest fire and the intended recipient of the provided information. From this deeper understanding of the procedures and related needs, it has been possible to derive a new set of user requirements and to refine the ones obtained during the previous workshop.

ACKNOWLEDGMENTS (OPTIONAL)

The research leading to these results has received funding from XXX under grant agreement n° [XXX].

REFERENCES

1. Benyon, D. (1993) Adaptive Systems: A Solution to Usability Problems. User Modeling and User-adaptive Interaction (3), pp 65-87.
2. Mannion, M., Keepence B. (1995) SMART Requirements. *Software Engineering Notes*, vol. 20 2, ACM SIGSOFT.
3. Haumer, P., Heymans, P., Pohl, K. (1998) An Integration of Scenario-Based Requirements Elicitation and Validation Techniques. CREWS Report 98-28.
4. Haumer, P., Pohl, K., Weidenhaupt, K. (1999) Requirements elicitation and validation with real world scenes. IEEE Transactions on Software Engineering. 01/1999; DOI: 10.1109/32.738338.