TIPExtop: An Exploratory Design Tool for Emergency Planning

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ABSTRACT

Emergency planning is an ongoing activity in which a multidisciplinary group of experts intermittently collaborate to define the most appropriate response to risks. One of the most important tasks of emergency planning is risk reduction. Such a task compiles the analysis of capabilities to face an emergency, the prioritizing of activities, and the definition of procedures and strategies. It is therefore a reflection process based on exchanging information between planners and exploring alternatives.

Despite the exploration of alternatives is an especially relevant activity to design better plans, recent research on computer-mediated collaborative tools for planning do not usually offer support for this activity. Thus, with the purpose of supporting reflection during the development of risk reduction tasks, this paper presents an exploratory design tool that allow planners to assess the space of alternatives and the underlying information related those alternatives. This planning tool will help planners to examine and contextualize information, allowing them to define more suitable response strategies.

Keywords

Emergency planning, risk reduction, collaborative decision-making, tabletop exercises, interactive system

INTRODUCTION

Emergency management is an ongoing process that starts "*long before and emergency occurs, and often continues long after the immediate consequences of the emergency have been resolved*" (Schafer, Carroll, Haynes and Abrams, 2008). Effective emergency management is thus rather a strategic task than a tactical effort, whose performance relies on the coordination and integration of all the activities necessary to ensure the continuance of the community within their planned lifetime (Haddow, Bullock, and Coppola, 2010). This strategic task is essentially achieved by the elaboration of emergency plans at all levels of the community. As a result, emergency planning is one of the most significant activities of the emergency management field.

As activity dealing with natural hazards and human-made disasters, emergency planning is driven by two main objectives: risk assessment and risk reduction (Perry and Lindell, 2003). Firstly, risk assessment involves not only stocktaking all the threats that have previously affected the community in a similar event or situation but also estimating new or potential threats. Once threats are identified, it is necessary to assess their risks in order to evaluate the probability of occurrence as well as the magnitude of the undesirable consequences. Risk assessment can be therefore seen as a set of procedures through which threats can be classified, measured, and evaluated; while risk reduction may be viewed as the development and implementation of activities aimed at mitigation, preparedness, response, and recovery (Mileti, 1999). Secondly, risk reduction involves an examination of the actions required to decrease the detected or projected levels of danger and to identify the resources required for implementing those actions (Perry and Lindell, 2003). Risk reduction is so based on exploring solutions, analyzing alternatives, and making choices. Being prepared requires thus the definition of a series of actions conducted in a certain manner during the emergency as a way of facing with and resolving it.

The study of emergency planning lead us to depict emergency planning as a reason-centric activity (Ralph, 2010), in which knowledge comes from the reflective conversation between the planners and the emergency plan to define. Such reflection mainly relies on the exploration and discussion on the space of alternatives integrating environmental and contextual information with their knowledge into a justification for decision-making. Recent research on computer-mediated collaborative tools for planning usually support the activity by basically providing pooling of knowledge, leaving aside the exploration of the space of alternatives. With the purpose of supporting reflection during the development of risk reduction tasks, we propose an exploratory design tool that allows planners to assess the space of alternatives and the underlying information related to alternatives. Design premises and specifications for emergency planning support previously identified by Turoff et al. (Turoff, Chumer, Van de Walle, and Yao, 2004; Turoff, Hiltz, White, Plotnick, Hendela, and Yao, 2011; Van de Walle, Turoff, and Hiltz, 2009) has been taken as a base for designing the proposed system, and complemented with the analysis of a two-years case study of the emergency planning practice (Tena, Díez, Aedo, and Díaz, 2014)

The rest of the paper is organized as follows. Next section focuses on highlighting that emergency planning as a decision-making process relies on the integration of knowledge from different experts. In addition, different software tools oriented to support this task through the use of digital representations are reviewed. Section 3 collects the design goals and system requirements that drove the development of our solution. The solution, called TIPEXtop, has been conceived as a computer-based collaborative tool aimed to support the exploration of alternatives. The exploration of alternatives is based on the use of geospatial representation that allows planners to build a mutual agreed-upon location. Section 4 describes the main technical features of such a solution. Finally, the discussion about the solution and recommendations for future work are drawn in the last section.

RELATED WORKS

Though "*there is a tendency on the part of officials to see disaster planning as a product, not a process*" (Wenger, Faupel, and James, 1980), emergency planning is more than the definition of written documentation. Planning is an intellectual process that is concerned with deciding in advance what, when, why, how, and who shall do the work, while the plan itself represents a snapshot of that process at a specific point in time (Perry and Lindell, 2003). Specifically, emergency planning may be defined as "*the development, refinement, and maintenance of a predefined set of procedures oriented to prevent, reduce, and cope with critical incidents and emergency situations*" (Díez, Tena, Romero-Gomez, Díaz, and Aedo, 2013). As far as the way of performing emergency planning is concerned, emergency planning is commonly view as a decision-making activity, "*as a group activity involving many people in decision-making and coordination between different groups*" (Rathwell and Burns, 1985). Emergency planning can be therefore regarded as the systematic process of collectively thinking about and establishing all the activities required to face with different incidents, crisis, and disasters. This process of thinking mainly relies on integrating knowledge from different experts in order to make novel decisions.

Since decision-making is the cognitive process resulting in the selection of a course of action among several alternatives, it is often thought that decision-making is just an analytical process. Faced with a decision situation, the task is to think through the options and choose the one that meets the best with the objectives. This view, though, is incomplete and denies the creative side of decision-making (Meredith, 2006). An active decision maker will search for decision opportunities and try to create them whenever possible. Focusing on emergency planning, as an activity oriented to face with unexpected situations, in spite of being driven by standards, it should be carried out to build and expand relationships that help bring new response alternatives. Effective emergency planning must be conducted to explore and make novel connections between knowledge and experiences from emergency planners that lead to creative solutions. According to this approach, emergency planning can be depicted as a forecasting action-centric process (Ralph, 2010), based on the reflective conversation between planners and the critical situation to advance.

Following this perspective, Tufekci (Tufekci, 1995) designed a decision support system for emergency planning that integrates six different modules: communication, GIS, damage assessment, emergency management control, prediction and tracking, and emergency planning. Each module provides different and relevant information for planning activities in hurricane emergencies. Also oriented to support decision-making, a web-based prototype based on emergency planning activities by using maps is presented in (Wu, Zhang, Convertino, and Carroll, 2009). This system prototype was developed to support map-based decision-making by pooling domain-specific knowledge, synthesizing relevant information, and keeping track of collaborators activities.

Since maps externalize geospatial data and help to process both spatial information and the discourse of the group, maps and GIS have been extensively employed within emergency management to support decision-making activities (Johansson, Trnka, and Granlund, 2007). Initially, Geographical Information Systems (GIS) were mainly used to support emergency response during disasters, such as World Trade center attacks (Thomas, Cutter, Hodgson, Gutekunst, and Jones, 2002), hurricane Katrina (Roper, Weiss, and Wheeler, 2006), and many others. More recently, the usage of GIS has become increasingly in a potential tool to also support decision-making activities in emergency planning. Carrol et al. (Carroll, Mentis, Convertino, Rosson, Ganoe, Sinha, and Zhao, 2007) conducted experiments and paper prototypes in order to elicit the main requirements of a geospatial information system for collaborative distributed planning of emergency response. Through the paper prototype, authors highlight the relevance of making notes, using icons to represent objects, and the use of individual and shared maps. Later, authors developed a software prototype to explore its impact on the construction of common ground in emergency planning tasks (Convertino, Zhao, Ganoe, Carroll, and Rosson, 2007; Convertino, Wu, Zhang, Ganoe, Hoffman, and Carroll, 2008). As a way of providing a high-level of interactivity, other works combine the use of GIS with interactive tabletops. Paelke et al. (Paelke, Nebe, Geiger, Klompmaker, and Fischer, 2012) presented a map-based tabletop system for disaster management scenarios. The system supports information sharing via touch input, tangibles, and digital pens. Users can navigate through geographical information and create annotations on the map with pens. Similarly to this system, Qin et al. (Qin, Liu, Wu, and Shi, 2012) designed uEmergency. uEmergency is a collaborative system displayed on a very large tabletop that allows users to browse on maps for accessing to information and making annotations on the map. One additional feature of this system is a time slider that allows users to change the time point on the local map. Finally, there are other works, based on providing map-based systems for emergency management by using large displays, which put the focus on the use of different interactive techniques. Rauschert et al. (Rauschert, Agrawal, Sharma, Fuhrmann, Brewer, and MacEachren, 2002) developed a multimodal, multi-user GIS interface that supports collaborative work on large screen displays in emergency management. The developed prototype replaces the traditional keyboard and mouse with free-hand gestures and natural language recognition to browse maps. On the contrary, Bader et al. (Bader, Meissner, and Tscherney, 2008) integrated gesture based interaction techniques with the use of other interaction devices as a exchange information process.

Aforementioned works focused on supporting the activity by basically providing pooling of knowledge and supporting discussion on maps. However, they left aside two relevant issues in decision-making activities: the discussion of proposed alternatives and the achievement of a consensus about decision. Thus, our work is focused on not only supporting pooling of relevant information during the process, but also the discussion of several proposed alternatives for reaching a decision.

SCOPING THE SOLUTION

The rationale of our solution is that collaborative decision-making is a situation faced when individuals collectively make a choice from the alternatives before them. This decision is the consequence of the exchange of information between participants. Due to the potential of information and communication technologies for fostering social interactions (Hilmer and Dennis, 2000), a computer-based collaborative tool that supports the exploration of alternatives has been designed. The design of the environment takes as a base design premises of Emergency Management Information Systems (EMIS) (Turoff et al., 2004; Turoff et al., 2011; Van de Walle, Turoff, and Hiltz, 2009) and a two-year case study developed in the local level (Tena et al., 2014). The next subsections present the design goals and the system requirements that address the development of this computer-supported collaborative environment.

Design Goals

Making effective decisions requires the generation of alternatives and new solutions, which in turn depends on supporting free flows of information, unstructured discussion, and divergent thinking as a way of increasing grounding and iteration of ideas (Farooq, Carroll, and Ganoe, 2008). In keeping with these statements, the following design goals should be achieved:

G1. Building shared understanding. Shared understanding plays a key role within the emergency-planning context to successfully develop emergency plans (Convertino, Mentis, Rosson, Slavkovic, and Carroll, 2009). Particularly in face-to-face meetings, such a shared understanding is required to make appropriate decisions about risk reduction. The progress of planning will depend on a shared understanding among planners about goals, requirement and criteria. With the purpose of improving shared understanding, it is necessary to design tools that allow team members to keep track of the discussion.

G2. Supporting divergent thinking. Emergency planning is oriented to refining and improving responses by exploring possibilities and generating alternatives. This kind of creative production is often characterized by the divergent nature of human thought and action. Accordingly, support divergent thinking should be an essential design goal of the system. Divergent thinking is the ability to generate a set of possible responses, ideas, options, or alternatives in response to an open-ended question, task, or challenge (Butterfield, 2009). Divergent thinking typically occurs spontaneously; in a way that ideas are generated in an emergent cognitive fashion.

G3. Facilitating information pooling. Emergency planning review is based on exchanging professional experiences and domain-knowledge as a manner of developing shared objectives about the plan and its implementation. This exchange of knowledge and experiences is regarded as information pooling. Information pooling refers to a member of the group mentioning information to another group member (Winquist and Larson, 1998). If groups are primarily concerned with finding a mutually acceptable view, they may avoid focusing on unique items and emphasize common information in their discussion; nevertheless, if they are focused on promoting novel or singular points of view, the effective pooling of unique information should be facilitated (Stasser and Birchmeier, 2003). According to Parks and Cowlin (Parks and Cowlin, 1995), initial contributions to discussion are most likely to be common information, common information that is constantly reducing as discussion continues. Thus, supporting long-term discussion and collective recall of information improves information pooling (Wittenbaum, Hollingshead, and Botero, 2004).

System Requirements

Emergency planning is a collaborative activity usually carried out by a multidisciplinary group of experts. Such multidisciplinary team get together from time to time in face-to-face meetings in which participants exchange ideas and opinions in order to define effective response strategies. Accordingly, and with the purpose of meeting the aforementioned design goals, the following system requirements have been defined:

R1. *Role-based collaboration*. (G1, G3) The multidisciplinary of emergency planning implies that different planners, even representing the same service, can make different contributions depending on their responsibility, background, or involvement level. Consequently, autonomy and free flows of information should not be confused with uncontrolled interaction with the system. The permissions to perform certain operations as well as the information to exchange and the way of pooling must be assigned to specific roles. With the purpose of easing the involvement of different backgrounds, the system should also support role-based interaction (Convertino, Neale, Hobby, Carroll and Rosson, 2004) of specific digital knowledge representations. The usage of role-based interaction allows each reviewer to get customized information related to his/her field.

R2. *Around-the-table interaction*. (G3) Tabletop exercises are commonly understood as brainstorming or group discussions that take place around a physical table (Trnka and Jenvald, 2006). Particularly, within the emergency-planning context, 'tabletop' exercises allow discussing strategies and constraints in order to design emergency plans (Carroll et. al, 2008). To that end, participants gather around a table bring different and often controversial points of view, allowing them to create a shared understanding about the problem. The around-the-table interaction metaphor allows supporting co-located collaboration and face-to-face conversation in a social setting through the usage of rich interaction technologies.

R3. *Geo-spatial representation*. (G1) Collaborative decision-making can be regarded as an activity driven by communicative practices and knowledge representations for mediating ideas (Artman, Ramberg, Sundholm and Cerratto-Pargman, 2005). By digital knowledge representations we refer to interactive simulations, visualizations, maps, and models of phenomena that help reviewers to contextualize and examine information. The application of an information-driven decision-making practice based on mediating with digital knowledge representations will foster the exchange of information as well as the integration of such information. These collaborative mediators will be used as a common collaborative area.

R4. *Annotated design*. (G3) An effective emergency plan can be regarded as a complex artifacts developed over long periods of time (Tena et al., 2014). Due to the limited capabilities of human beings, a longer process entails a loss of information that avoids maintaining a connected whole. In order to foster this long-term indirect communication between different groups of planners, the usage of annotated design is claimed. Annotated designs allow capturing the reasoning of the design, integrating the argumentation within the design artifact itself. The elaboration of annotated design will help planners to build a common understanding about the requirements, particularities, and criteria applied during the design.

R5. *Design history*. (G2, G3) Exploring and making novel connections between knowledge and experiences from planners require the elaboration of alternatives, the assessment of such alternatives as well as the selection or rejection of a course of action among the defined alternatives (Schafer et al., 2008; Tena et al., 2014). Moreover, emergency planning is an evolutionary process, based on successively refining alternatives and ideas. With the purpose of tracking the design over time and over different designs, there is a need of recording the history of the design, allowing planners to build a shared-understanding of the design process and how the plan has been developed.

TIPEXTOP: AN EXPLORATORY DESIGN TOOL FOR EMERGENCY PLANNING

As an exploratory design tools, we refer to an environment that supports the generation and evaluation of the space of design alternatives. This kind of tool enhances decision-making by fostering the exchange of ideas and the building of share understanding. With the aim of enhancing the risk reduction task, we have developed an exploratory design tool called TIPExtop. TIPExtop is computer-based collaborative tool aimed at supporting: 1) team interaction; and 2) the exploration of response alternatives. The former presents the way in which team members interact with the system to define a plan, while the latter is focused on explaining the mechanism applied to capture the rationale of the design.

Supporting team interaction

Since emergency planning is usually performed as a co-located collaborative activity, TIPExtop has been designed to be deployed on a horizontally placed touch screen (R2). Horizontal orientation has been highly recognized as the most convenient disposition to support collaborative decision-making activities (Mahyar, Sarvhad, and Tory, 2012; Rogers and Lindley, 2004). In the particular case of our solution, the horizontal disposition of the screen does not only ease and foster discussion among planning team members, but also allows them to maintain their common way of interacting (G3). When planners start a session for defining strategies, they usually gather around a table. Using the horizontal touch screen, as shown in figure 1, planners can be similarly positioned around the screen simulating a physical table.

Figure 1. Horizontal orientation for around-the-table interaction:
Left – Common planning meeting / Right – Planning meeting performed by using a horizontal touch screen.

Once planners are positioned around the table, they take a fix position, in front of which a customized toolbar is displayed. This toolbar will be different depending on the role (R1). In our system prototype, we differentiated two different roles: the coordinator of the emergency plan and the remaining participants. The coordinator of the plan will be the person who is in charge of the definition of the plan. Consequently, the coordinator commonly leads and moderates the discussion. This role shares common tools with the rest of the participants –like annotations mechanisms, resources palette, and drawing tools-, and has available a set of specific tools for editing and saving alternatives. Additionally, independently of the user's role, each toolbar is colored depending on the service that its user is representing to. Figures 2-a and 2-b show an example of both toolbars. Figure 2-a represents the role of the coordinator with the common tools and the specific tools of his/her role. As an example, if the coordinator role was played by the police service, the coordinator toolbar would be colored in blue. On the other hand, figure 2-b represents the toolbar of a common participant: in this case, the representative of the civil protection service –colored in brown.

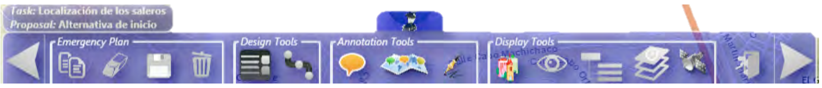

Figure 2-a. Coordinator toolbar

Figure 2-b. Common participant toolbar

For supporting team discussion, the system provides digital knowledge representations such as maps (R3). These maps present geo-spatial information as a way of easing the understanding of the situation (G1, G3). Maps allow planners to contextualize and integrate such information that will be analyzed and discussed, as well as to bring different and often controversial points. By using maps, participants have the chance of allocating resources, defining routes, and highlighting elements of interest for the plan. Additionally, with the aim of providing specific and relevant information for planning, we decided to include different views of the map: the street view and the satellite view. Each view will provide different useful information depending on the task and its context. The street view, including highways and street data, might be helpful to get relevant information such as driving directions; while, the satellite view might be useful to get detailed area conditions. Switching between these two different views would be done by the coordinator of the meeting. Figure 3 shows how the same area can be displayed with different views.

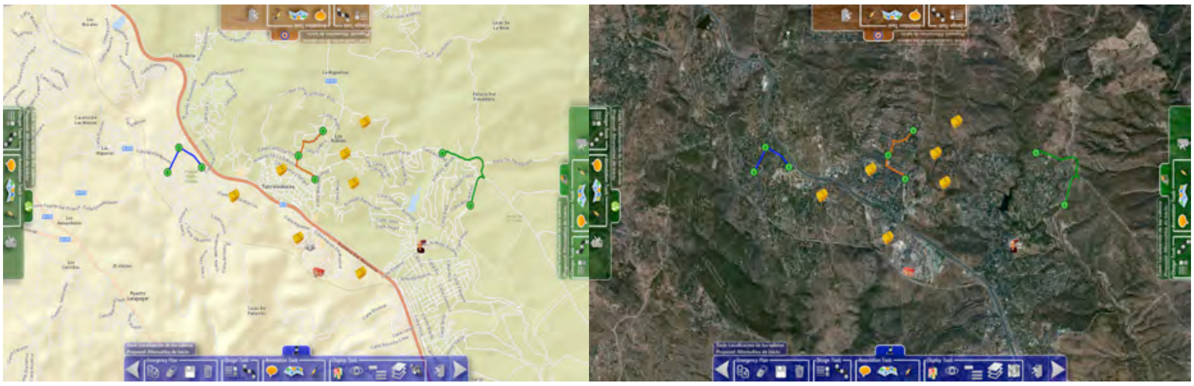

Figure 3. Geo-spatial representation

Supporting the exploration of response alternatives.

While planners are discussing, they usually work on different design alternatives. With the purpose of tracking the design of the plan over time, TIPExtop is intended to record the history of the design (R5, G2, G3). To create alternatives the system provides two different methods: create a new alternative without any previous element or creating a new alternative taking as a basis a previous one. For creating a new alternative without any previous element, planners will start a new alternative without any planning element in the map (resource, route, etc.). However, sometimes alternatives are different in just a few things. Duplicating elements can allow planners to create a new alternative using a previous one as a basis, and modify on it those elements that are needed. In both cases, the participants are allowed to compare the alternatives by digitally overlapping them, easing the comparison of alternatives to determine which one is "the best solution". Figure 4 shows the comparison of two routes. Differentiation of alternatives in case of routes is made by dotted lines, while resources are displayed with a different opacity.

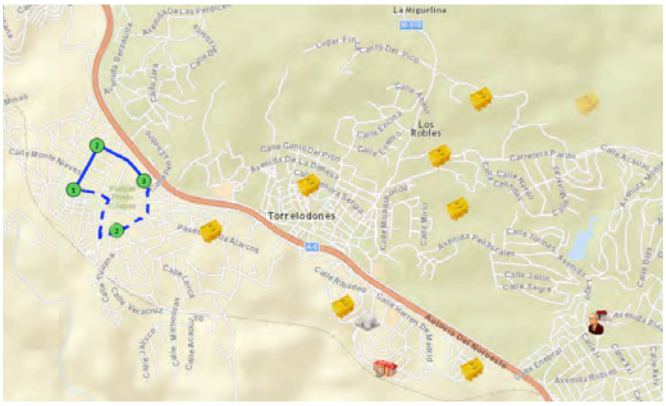

Figure 4. Overlapped comparison of two different alternatives

As a way of complementing the exploration of alternatives, the underlying reasoning of each alternative is captured through annotations and integrated within the plan itself (R4). Planners are able to add annotations linked to specific positions of the map to highlight something relevant in the map, linked to resources to leave knowledge about an specific decision, and linked to an alternative for arguing about a decision. Such annotations can be added by typing or by recording the voice and will store relevant information for the process: the participant that made the annotation, the date in which such annotation was made, and the content of the annotation. Figure 5 shows a screenshot of the widget for annotating the plan.

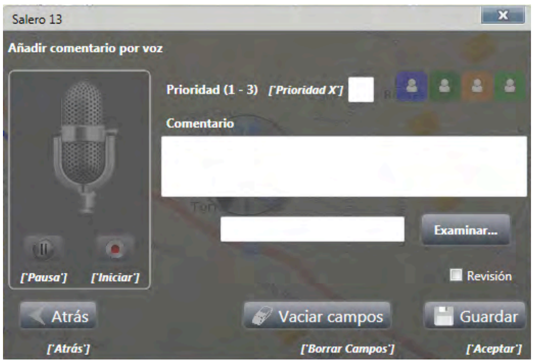

Figure 5. Resource linked annotation tool

CONCLUSION AND FURTHER WORK

Emergency planning can be described as a reflective activity in which a group of experts gather with the aim of discussing and making decisions by exploring a set of alternatives. During reflection, planners collect and accumulate knowledge and experiences from previous plans to create and explore response solutions that consider the range of possibilities and constraints that affect in a response. As a way of supporting such reflection, we suggest to design collaborative technologies that assist team interaction and the exploration of the space of design alternatives. Thus, our software prototype fulfills a set of system requirements: role-based collaboration, around-the-table interaction, geo-spatial representation, annotated design and a design history for exploring alternatives. Especially important in the idea of integrating relevant information for fostering discussion and assessing design alternatives is the use of horizontal placed touch screens. The use of such touch screens horizontally oriented with digital geo-spatial representations will enhance planners to share and exchange different view points.

Further works will be oriented to evaluate the utility and effectiveness of the proposed solution to reflect during risk reduction tasks. Once the utility and effectiveness of this solution for supporting reflection is tested, next steps will be aimed at corroborating if accumulated knowledge is maintained over time for future analysis of alternatives.

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