Designing for Continuity: Assisting Emergency Planning Practice Through Computer-Supported Collaborative Technologies

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Abstract Emergency planning is an on-going process in which a group of experts collaborate for ensuring that a community has the necessary resources and procedures for facing an emergency situation. It is a sustaining pattern of analysis and decision, based on the unstable collaboration over time of heterogeneous groups of planners. With the purpose of understanding the challenges of supporting technologically a long-term collaborative activity such as the emergency planning, a two-year descriptive case study in a real work setting has been carried out. The analysis of its results has shown the necessity of providing a sense of continuity both in the reasoning of planners and the history of the practice. The final aim of the work is to identify a set of claims that addresses the design of such computer-based technologies that effectively assist emergency planning.

1 Introduction

The occurrence of an emergency situation can cause damages in people and properties. Hence, the organization of material and human resources to face emergency situations should not be left to improvisation. Emergency planning is concerned with ensuring that a community has the necessary people, equipment, and procedures to respond effectively to emergencies [1]. Though "*there is a tendency on the part of officials to see disaster planning as a product*" [2],

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emergency planning is more than the definition of written documentation. The written plan itself represents a snapshot at a specific point in time [3]; while emergency planning is actually an intellectual process which is concerned with deciding in advance what, when, why, how, and who shall do the work.

Emergency planning may be depicted as a long-time horizon activity in the sense that defining an optimal response requires the elaboration and implementation of succeeding plans. Moreover, emergency plans are not designed once and for all. During the elaboration of an emergency plan, the planning team usually meets several times in order to both exchange information and discuss about risks and resources assignments. This deliberation process is mainly based on the knowledge, experience, and lessons learned from previous plans. Similarly, emergency plans must evolve over time. An increase in population, the creation of a new road, or even the change of the flow of a river, could bring new threats and, consequently, the redesign of a plan. In this case, planners must joint their efforts to continuously analysis and review of previous emergency plans [4]. This process should be based on using the experience as a key to reflect about new threats and updates. Thus, defining an effective, flexible and timely response is based on creating a link during the definition of plans, on gathering a continuity that allows planners to bind past events and discussions with present situations and decisions.

So far, different authors have proved the feasibility and usefulness of applying computer-supported collaborative technologies so as to improve emergency planning [5, 6]. However, these authors have focused on supporting the collaboration in different spaces or among different backgrounds [5–8], leaving aside the implications of collaborating over time. In order to get a set of claims that address designing for continuity, this paper presents a descriptive case study carried out for 2 years. In keeping with the results of this case study, the achievement of continuity requires providing enough information to let planners to know what decisions were made, who made those decisions, and why they made them. Accordingly, designing computer-based collaborative technologies that effectively assist the emergency planning practice must be focused on capturing the rationale of the design as well as the underlying information that wrap decisions.

The structure of the remaining paper is as follows. Section 2 describes a two-year case study in the emergency-planning context. The results of such case study are presented in Sect. 3. These results show the necessity of creating a virtual link between planning periods during the definition of plans. The Sect. 4 presents a discussion of the necessity of designing for continuity, as well as a set of claims that guides the design of such computer-supported collaborative technologies that enrich emergency planning. Finally, conclusions and further work are presented.

2 A Descriptive Case Study

Emergency planning has been commonly recognized as a professional activity that can be improved through the use of collaborative technologies [5, 8]. With the purpose of understanding emergency planning and developing suitable

collaborative technologies that assist such an activity, different empirical studies and fieldworks have been performed [5–8]. As an example, Carroll et al. [7] studied the support of tabletop exercises by using geospatial collaborative software. Similarly, Convertino [8–10] has been focused on assisting the development of common understanding through the use of annotated design tools. In succeeding works, thanks to the realization of a mid-term case study, Schafer et al. [5] have studied the community perspective of emergency planning, focusing on identifying the main collective tasks of the emergency-planning process and the way of supporting them. Despite their significance to understand the emergency planning practice, none of these works makes enough emphasis on studying the relevance of time to develop suitable emergency plans. In order to overcome this existing gap, a two-year descriptive case study was conducted.

This descriptive case study was divided into two main phases. The initial phase compiled exploratory efforts aimed at reaching a deep understanding of the emergency-planning activity. Second phase was focused on analyzing the implications of emergency planning as a long-term activity. In this second phase, the inquiry team conducted an empirical study in a real work setting. Following subsections are intended to explain the development of both phases.

2.1 Phase 1: Overview of the Emergency-Planning Activity

A knowledge base on emergency planning was initially obtained from the review of literature and the analysis of real emergency plans. Such review provided us knowledge about the main goals and tasks of the emergency-planning process, an overview of how emergency plans are designed, and understanding about which information is treated and documented during the process. With the aim of confirming these insights and deepening our knowledge about the emergency-planning activity, six interviews with emergency planning experts were conducted. Such experts work as emergency management coordinators in Spanish municipalities whose population is between 20,000 and 200,000 habitants—the Spanish legislation defines like a 'municipality' those neighborhoods whose population is within such a range. As emergency management coordinators of their respective municipalities, these experts are responsible of the definition of local plans that address the risks within the municipality.

The collection of information from the experts was based on the performance of semi-structured interviews. These interviews, with duration of approximately one hour per respondent, included a total of three closed questions and nine open questions. Closed questions were related to the background of the experts, while opened questions were focused on getting information about the performance of the activity: the number and profile of planning team members, the regular tasks

carried out during the activity, the kind of resources used by the participants, or the type of communication channels that they utilize. Additionally, experts were questioned about the average time taken to define and develop an emergency plan.

2.1.1 Data Collection

As way of developing a mutual trust partnership with experts, the interviews were not digitally recorded. As an alternative, the researchers decided to handwrite notes during the interviews. Following the investigator triangulation technique [11], and in order to avoid sampling bias, the notes were taken by two researchers. These two researchers were focused on summarizing information, for which they quickly and consistently collect relevant aspects of the different issues of the interview. Additionally, key phrases and exact quotes were captured to highlight those aspects in which the responders make special emphasis. Once interviews were finished, all collected and registered data was transcribed for later analysis.

2.1.2 Data Analysis

Once the information was transcribed, the first task was to make sense of the collected information. To that end, it was necessary to use some encoding process that allowed developing a manageable classification or coding system [12]. This coding forced researchers to make judgments about the underlying sense of the interviews in order to determine which information was meaningful.

Initially, by the open coding process, the inquiry team developed a set of codes that included predefined and emergent codes. Predefined codes were categories and themes that they expected to see based on their prior knowledge about literature in emergency planning. Codes such as 'collaborative', 'multidisciplinary' or 'on-going' are included in this group. On the other hand, codes like 'experience' or 'long-term' came up as the data from the case study was reviewed. After that, the inquiry team closely reviewed and re-coded data creating a resulting coding scheme presented in Table 1. This coding scheme includes four macro-level codes, each comprising several micro-level codes.

The analysis of data showed a significant fact: during the interviews, experts made constant reference to the temporal aspects of the emergency planning activity. Most of the interviewees pointed out that the development of emergency plans is a long-term activity, usually distributed over weeks or months, rather than days. Moreover, they highlighted that emergency planning is not once and for all, but it is an ongoing process. An ongoing process based on the knowledge, experience, and lessons learned from previous plans. In this sense, effective emergency planning is a long-term activity extended over lengthy periods of time. The consequence should be the consideration of time as a key element in the structuring of the emergency planning activity.

Table 1 Coding scheme used to analysis the transcriptions of interviews

Code	Description
Practitioners	
Experience	Knowledge or skill acquired by such means over a period of time
Knowledge	Facts, information, and skills acquired by a person through experience or education
Background	A person's education, experience, and social circumstances
Process	
Collaborative	Produced or conducted by two or more parties working together
Multidisciplinary	Combining or involving several academic disciplines or professional specializations in an approach to a topic or problem
On-going	Still in progress
Long-term	Occurring over or relating to a long period of time
Interaction mode	
Co-located	Sharing a location or facility with someone
Distributed	Occur throughout different locations
Tasks	
Principal	Main tasks relevant in the emergency-planning process
Secondary	Less important task in the emergency-planning process

2.2 Phase 2: Identification of the Implications of the Long-Term

Once we became aware of the importance of temporal aspects to design plans, we decided to focus on examining the role of time in the performance of emergency planning. With this aim, a two-year case study was carried out in the local level. Local level, commonly referred as municipalities, is the base or reference level of emergency planning. Whilst state, national, or international levels are typically focused on coordination activities, planning activities lie in municipal governments [13, 14]. That means that the success of an emergency management operation will probably depend on the effectiveness of local emergency plans, including the quality of local resources and their deployment in emergency situations.

For conducting the study within the municipality, the emergency plan for winter (Winter Plan) was selected. The 'Winter Plan' is aimed to minimize the effects of snow and to restore the roads with the aim of not paralyzing the city and ensuring the restoration of local services as soon as possible. As consequence, this plan involves many local services and first responders such as police, civil protection service, civil guard, social service, environmental service, public construction service and a cleaning service company. In addition, the 'Winter Plan' was selected because of its validity period of four months. Every emergency plan has a validity period—the active lifespan for the plan. Once the validity period ends, emergency plans must be revised to accommodate existing changes in the legal framework, changes in the environment, and the lessons learnt from experience.

To give planners the opportunity of adapting plans during a two-year period, the validity period of the plan should not be longer than six months or be redesigned every year.

Once selected the emergency plan, the exploration was made through the use of the observation technique. This technique provided the opportunity to deepen in the understanding of who the practitioners are, how they work on a day-to-day basis, and how emergency planning is developed in the long-term. In keeping with methods triangulation technique [11], it was used a combination of direct and indirect observation. Direct observation was aimed to study the behavior of participants during planning meetings: their social relationships and group dynamics. Meanwhile, indirect observation allowed collecting data about the information exchanging between meetings, as well as the actions performed by planners to prepare such meetings.

2.2.1 Data Collection

The study of a complex activity such as emergency planning revealed us the need to combine different techniques of collecting data in order to achieve additional findings and to develop knowledge on the emergency-planning activity. Hence, based on the data triangulation idea [11] of using different data collection strategies to verify trends detected over a set of observations, information was collected through the use of field notes, video and audio records, and diaries. Field notes were used during the observations to compile key phrases, exact quotes with indications of emphasis and tone, sketches of the location, the history, steps, and context of any activity, and details that would be essential to study. Since capturing every moment and every word could be in some cases probably unneeded, the inquiry team focused on identifying patterns and phenomena within the activities [15]. Patterns are actions or ideas that keeps recurring—patterns of behavior, patterns in stories or patterns of responses to a question. For instance, a recurring action such as using drawings for expressing ideas could be considered a pattern of behavior. They could emerge during the case study when something is done repeatedly, but also during the analysis of data. Instead, phenomena are unusual behaviors—especially unusual methods of working—that could be interesting and whose consideration could benefit to people in their work. As an example, the unusual fact of comparing data during the meetings could be a phenomenon that provides a different perspective over data in meetings. With the aim of identifying patters and phenomena, field notes used to start recording the name of the person doing the research, the day, the time, and the place. Then, they include the facts and history of the activities using pseudonyms instead of real names to preserve the anonymity of the subjects. Similarly to the methodology used in the first phase, the notes were taken by two researchers [11]. As a complement, researchers video and audio recorded the meetings.

Additionally to field notes and video records taken by the inquiry team, we asked participants to make diaries [16] for recording events, items of behaviour,

informal meetings as they occurred. With such an aim, participants recorded the date, the people involved, the goal of the meeting, and a description of how facts occurred. This information compiled all the facts, meetings, and discussions that took place between the meetings and in which researchers were unable to attend.

2.2.2 Data Analysis

One of the main challenges in case studies lies in the analysis phase, where ideas and findings emerge from fieldwork data. Raw data needs to be turned into a form that can be easily understood. To that end, two different data analysis techniques were used: affinity diagram and short vignettes. The former was focused on highlighting and categorizing information for identifying patterns, while the latter was focused on describing special issues identified during the observation.

Using affinity diagram for categorizing and organize data in groups to establish relationship among them [17], the first step followed by the inquiry team was to make things physical and visible. This would allow drawing connections across various pieces of data, adding them up to a conclusion, or creating something new that could came up by existing pieces of data [15]. With such a purpose, the inquiry team wrote data, quotes, and ideas on a post-it note and stuck them on a wall. Then, team members move and organize notes in groups, establishing relationships, and partnerships among different data. In this case, the team for constructing affinity diagrams consists of three people: the researchers that attend to the interviews and the meetings, and an external person. The external person, with experience in the design of emergency-management system, was included for providing a different perspective of the emergency-planning activity, during the categorization step.

In order to organize and compare data, this technique was applied after each year of planning, getting a total of two affinity diagrams. Figure 1 shows an example of the affinity diagrams obtained.

Since affinity diagram technique resulted very useful for identifying patterns, short vignettes [18] were used to depict phenomena. They consist on a brief description of a recurrent action or a special situation, and the consequences of them. In such descriptions, following the philosophy of other design artifacts such as persona, the names used in the short vignettes are not real. Examples of two short vignettes are presented below:

> During the definition of the routes, Pedro, the coordinator of civil protection realized that two routes was overlapped. The two routes were defined for cleaning the same zone of the city but with different snowplows. Therefore, they decided to change one of the routes and optimize the usage of the available resources
>
> While the planning team was discussing a task, civil protection members have to leave the meeting immediately for attending a fire emergency. Then, the rest of the members continue the meeting without being able to take into consideration the knowledge and experience of the civil protection members. It makes that, in the next meeting, civil protection members have to review what the planning team decided.

Fig. 1 Example of an
affinity diagram

2.3 Results

Emergency planning is an activity distributed in time. Not only during the defi-
nition of the plan, based on meeting several times in a long period of time, but also
throughout the life of the plan, due to the periodically performance of drilling and
review meetings oriented to update and refine the plan. Following paragraphs
explain different issues related to the long-term character of emergency planning.

2.3.1 Sustaining Pattern of Analysis and Decision

The first result to be established is the existence of a well-defined pattern of
practice. Both years, the planning team follows a similar scheme: planners meet
several times over a period of one month, starting approximately two months
before the beginning of the winter session. The first of these meetings is oriented to
finally establish the planning team, define a meeting schedule for the period,
review internal plans and policies, and create a common understanding about
previous winter sessions. Subsequently, the team meets several times to develop
the plan. Once the development of the plan is finished, two team members—
designed at the beginning of the process as annotators—write the emergency plan.
This written document, considered as the main result of the emergency planning
process, compiles all the information managed during meetings. Nevertheless, the
emergency-planning process does not finish with the elaboration and delivery of
the emergency plan. When the winter session ends, the planning team conduct a
reviewing meeting, in which planners tracking down the implementation of the
plan, identifying drawbacks and strong points. The second year of the study, due to
the occurrence of a relevant snowstorm, the planning team conduct an additional
reviewing meeting to analyse the performance during this emergency situation. In

all cases, the result of the reviewing meeting is a written report that collects all relevant issues and problems discussed during the meeting.

2.3.2 Scattered Tasks

Emergency planning is a complex process that involves three main tasks: risk assessment, resources identification, and strategy definition [19]. Such description of the process can lead to think that emergency planning is a waterfall process. Nevertheless, the case study reveals that emergency planning is an iterative process in which planning tasks are scattered over time. As Fig. 2 shows, the risk assessment task is developed in meeting 1, 2, 3, and 4. Similarly, the resources identification task is carried out in meeting 2, 3, and 4. Therefore, planning tasks are not developed in just one meeting, but through several meetings scattered over time.

2.3.3 Emerging Constraints

Data analysis allowed identifying a pattern that is recurrent in emergency-planning practice. There are constraints that arise throughout the planning process and that have an influence in the development of the activity. As the below short vignette describes, during planning meetings some issues remain unresolved. This fact leads planners to resume tasks previously treated during the process.

> In reviewing the 'Winter Plan', after the response phase, they realized that some issues remain unresolved from the planning phase; they did not considered a risk derived from the locality characteristics. One of the streets has a slope too high that provokes cars sliding through the asphalt and crashing into walls when the street is snowy. Consequently, they need to analyse again and include some risks not previously considered for planning.

Therefore, emergency planning tasks are not performed successively, but in a non-linear way. After considering a task as completed, planners could return to it for including or refining things.

2.3.4 Temporal Gap

Aforementioned, the emergency planning process is developed into several meetings extended over time. The time between such meetings, in some cases, is only a few days or weeks, but in other cases the temporal gap is longer than four months. This fact makes that shared experiences, knowledge, and decisions from each meeting tend to be lost across the meetings and regenerated each time. During the observation of the planning process, the inquiry team have the opportunity of attending to a total of sixteen meetings distributed over time, in which participants lost useful information for the definition of the emergency plan.
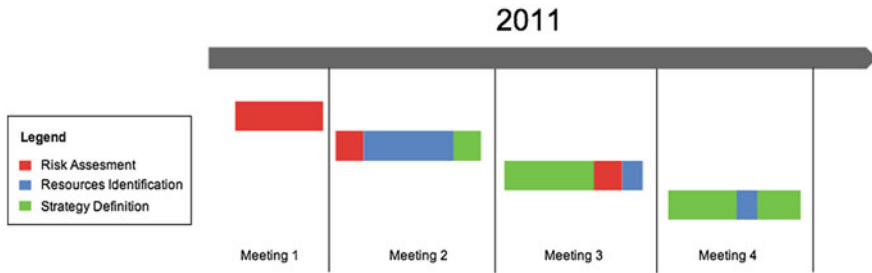
Fig. 2 Scattered tasks over time in the development of the emergency planning process

2.3.5 Unstable Participation

Emergency planning is an activity that takes place over long periods of time. Emergency plans are defined through different meetings extended over time. This causes that planning teams vary between such meetings, because of two different reasons: (1) their daily responsibilities. As professionals, team members have to meet their daily tasks and not always can attend to all the meetings. (2) the unpredictability of the context. Emergency planning is a critical context in which emergencies can arise anytime and, consequently, participants have to suddenly leave the meetings to assist them.

The variation of the participants directly impact on decisions during the definition of the emergency plans. Decisions are based on the background, knowledge, and experience of the participants. But, planning teams are not always composed by all the roles that should be involved in the definition of the plan and, therefore, the knowledge and experience is not the same through the whole process. As a result, the information shared, judgments, and decisions would depend not only on the role, but to the participant that is playing such role. Table 2 shows how the number of participants varies throughout the process, from initially 10 participants to 6 in the second meeting, 5 in the third meeting, and 8 in the fourth meeting.

2.3.6 Referring Backward

During the development of the plan, team members identify challenges and prioritize activities, analyse capabilities and hazards, exchange information about previous experience, and define procedures and strategies. This deliberation process is mainly based on the knowledge, experience, and lessons learned from previous plans. This makes them to continuously refer backward during meetings. They based on their on memory for recalling why they decide something and learn from their own decisions. For instance, during the second year of the study, participants recall to decisions made through the first year of planning:

Table 2 Meetings performed during 2011

Session	Date	No. Participants	Roles
1	05/09/2011	10	Security councilman (1), Civil protection (2), Civil guard (1), Social service (1), Environmental service (1), Police (2), Public construction Service (1), Cleaning service company (1)
2	12/09/2011	6	Civil protection (2), Environmental service (1) Police (1), Cleaning service company (1), Public construction service (1)
3	11/10/2011	5	Civil protection (2), Environmental service (1), Police (1), Cleaning service company (1)
4	07/11/2011	8	Security councilman (1), Civil protection (2), Environmental service (1), Police (2), Public construction service (1), Cleaning service company (1)

Last year we estimated 30 tonnes of melting products and it remained many kilos. This year we will try to save on melting products to avoid damaging the environment.

Tom: -Did you remember why we established a route through the 'Señora Sergia' street?

Anthony: -Yes, the last year we realized that the bus route needed to pass through this street for arriving to the school.

3 Discussion

Many activities in our society have a strong influence of time to achieve an optimal solution. Such long-term activities are characterized by the progressive refinement of the solution, covering a relatively long period of time. As our case study reveals, emergency planning may be regarded in this manner. Defining an effective, flexible and timely response to an emergency situation requires the continuous review, update and improvement of emergency plans. This ongoing process leads to the accumulation of reasoning, experiences, and knowledge; building a continuous understanding of planning that must be considered as foundations for further refinements.

Unfortunately, the limited capabilities of human beings as information processors hinder the maintenance of that understanding of planning. The unstable participation, the existence of long temporal gaps or the performance of scattered tasks disrupt the necessary continuity throughout the practice, hindering the reference to past experiences and the management of emergent constraints. As a consequence, the effectiveness of the activity is reduced. With the purpose of overcoming this limitation, emergency planners resort to create reports and dossiers than compile information about the emergency situation, the response, and the design process itself. Although these external artifacts are good enough to

create a structured based of knowledge, not to support the reflection of planners, the referring backward, or the sustaining pattern of analysis and decision. As an alternative, computer-supported collaborative technologies could be a suitable mechanism to extend human limits and provide a necessary sense of continuity.

Time has been an important research issue in the Computer-Supported Collaborative Work (CSCW) community for more than two decades. And in the first conceptualizations of CSCW systems, time was considered as one of the basic dimensions that determine the way of collaborating, making a difference between synchronous and asynchronous collaboration [20]. This basic idea has been extended by several authors [21, 22], giving rise to the concept referred by Fischer et al. as "*long-term indirect collaboration*" [21]. By focusing on long-term, these authors explore technologies that support the intentions and actions of other who cannot be seen and contacted personally. In this way, supporting long-term indirect collaboration directly links up with the literature on design rationale [23–25] and group memory [26]. Computer-supported technologies that foster long-term collaboration must support not only the evolution of artifacts—in our case, emergency plans—but also the maintenance of the background context and rationale about the artifacts. Achieving continuity during the emergency planning practice is therefore based on providing enough information to let planner to know what decisions were made and why, who made those decisions, as well as what was the context in which the decisions were made. Taking this idea as a basis for designing for continuity, subsequent subsections present a set of claims that should address the design of those computer-based collaborative technologies that assist the emergency planning practice.

3.1 Capturing Collaborative Design Rationale

Empirical experiments have shown the benefits and improvements of collaboration in decision-making by documenting design decisions [27]. Design rationale helps to consider different perspectives, to detect conflicts between decisions, and to establish relationships between alternatives. In long-term processes such as emergency planning, where participants can change over time—team members may go away and new members arrive, capturing design rationale can help team members to maintain continuity in the reasoning. Being aware of what and why was decided would allow planners to understand the line of reasoning even if they could not attend to one or more meetings.

One of the main design challenges of capturing design rationale relies on overcoming the view of designers of design rationale as an "extra" step [22]. It would be difficult to encourage planners to capture their rationale if they felt such capture as additional work. As consequence, capturing rationale should be just made when it is strictly necessary. According to Schneider's approach [23], capturing rationale should be made for those specific tasks where rationale is expected to occur. Regarding the emergency-planning process, not all the planning

tasks imply a design decision; instead reasoning is concentrated on the definition of response strategies in order to reduce risks. Similarly, efficiently capturing design decisions requires that the documentation of such reasoning must be embedded in the practice, without disrupting the planning process.

The use of digital knowledge representations—such as interactive maps or graphic representations—as exploratory design tools should be considered as a key mechanism to capturing the rationale of the design. On the one hand, this kind of tools will help planners to visualize the implications of choices and refine their ideas; on the other hand, they will allow automatically capturing strategies and alternatives. As an example, the definition of evacuation routes could be supported through an exploratory design tool that records requirements, alternatives routes, and even evacuation simulations. Automatic capturing techniques are essential mechanisms to capture rationale without interrupting the activity; however, these techniques usually record raw data what makes difficult the information retrieval process. The alternative will be a balance between user intervention and automatic capturing tools. Automatic-capturing techniques should be restricted to recording design decisions that can be supported through digital knowledge representations – e.g. evacuation routes, relocation points, elements of interest, location of resources, etc. This information should be additionally enriched with manual annotations provided by planners. The use of digital annotated designs will allow capturing the reasoning of planning in a semi-structured way [25], integrating the argumentation within the design artifact.

This reasoning of planning should be considered and treated as a collaborative effort; however, specific argumentations should be analyzed as individual contributions. 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. Hence, comments, opinions and judgments cannot be considered as anonymous, but personal identifiable. Logging user argumentation will allow further tracking of reasoning. Moreover, as a professional activity, emergency planning may be depicted as a procedural labor in the sense that many of the decisions are based on rules, legislation, and prescriptions. Divergent thinking, reflection and communication with artifacts are, of course, key elements to explore solutions; however, the reasoning resulting from this process is often based on declarative knowledge. In keeping with this idea, and in order to foster the capturing of rationale, it would be recommended the creation of rationale as a by-product [23] by attaching predefined rationale to a set of choices from which that the planners could choose.

3.2 Providing the History of the Practice

Being aware of the course of reasoning is an essential but not sufficient element for achieving continuity. The rationale of the design is commonly influenced and determined by the surrounding circumstances. Focusing on emergency planning,

the definition of emergency plans is a collective effort distributed over time. As a collective activity, what a planning team defines is shaped by the composition of the group. Different participants exchange different experiences and judgments, providing a different understanding about situations. Hence, due to the unstable participation and the unpredictability of the context, the analysis of a previous decision requires knowing who was involved during the reasoning process. Moreover, emergency planning can be considered as a context-dependent activity that takes different forms in different areas or circumstances. As an example, law and legislation usually construct an implicit rationale that it is not specifically expressed by planners during meetings, but that determines their final decisions. In this case, using regular rationale-capturing techniques is not enough to be aware over time of this reasoning. Achieving continuity in emergency-planning practice therefore requires getting enough knowledge about the history in which the practice takes place. This history of the practice implies being aware not only of the reasoning of the design decisions, but also of the underlying information that wrap a decision.

As a way of providing relevant information of the history of the practice, approaches such as *group memory* go beyond capturing design rationale. Defined as "*the means by which knowledge from the past is brought to bear on present activities*" [26], group memory focus on providing not only the decisions made during the design process, but also the knowledge and experiences of the groups in the context of decision-making. However, this approach does no make emphasis either the context of the decisions, the people who made such decisions, or information related to the way in which the activity takes place over time. Consequently, our approach for providing the history of the practice relies in the distribution of essential information that allow planners to draw in their mind the big picture of how an emergency plan was designed. Drawing this big picture implies to get information related to *who* is the people involved in the process and *when* design takes place. *Who* refers to participants' background—regarding academic background and participants' experience. Regarding *when*, planning members should be aware of the context of design—current laws and regulations, environment, etc.- and the process history—meetings, tasks, steps, etc. Finally, information about the evolution of the plan must be recorded to provide the design history of the artifact.

4 Conclusions

Emergency planning is an activity distributed over time. Not only during the definition of the plan, based on meeting several times in a mid-term period, but also throughout the life of the plan, due to the performance of review meetings oriented to update and refine the plan. Thus, one of the main challenges of emergency planning should be the articulation of those activities distributed in time, creating a link between planning activities that allows planners to bind past

events and discussions with present situations and decisions. Moreover, defining an optimum emergency plan is a long-time horizon issue that must be based on that accumulated knowledge acquired by planners during the practice. Effective emergency planning therefore requires continuity over time.

Maintaining continuity in planning makes it necessary for planners to be aware of the definition of the plan from the beginning of the process, so that there are not breakdowns or disruptions in the practice. It means that planning members should be aware not only of the evolution of the plan, but also of the previous decisions and their rationale, the planning context, the activities carried out to develop the plan, or the participants' background. Designing for continuity requires supporting which artifact has been defined, why the artifact was defined in that way, who was involved in such a definition, as well as when and where the definition took place.

Future work will be aimed at developing collaborative interactive systems that, based on the claims presented in this paper, assist the emergency planning practice. The development of these systems will allow us to evaluate the utility and effectiveness of providing continuity during the development of emergency plans.

References

1. Haynes SR, Wendy AS, Carroll JM (2007) Leveraging and limiting practical drift in emergency response planning. In: System sciences, 2007. HICSS 2007. 40th Hawaii international conference on system sciences, Hawaii, USA, 3–6 Jan 2007
2. Wenger DE, Charles CF, Thomas FJ (1980) Disaster beliefs and emergency planning. Irvington Publishers, New York
3. Perry RW, Lindell MK (2003) Preparedness for emergency response: guidelines for the emergency planning process. Disasters 27:336–350
4. Dynes RR, Drabek TE (1994) The structure of disaster research: its policy and disciplinary implications. Int J Mass Emergencies Disasters 12:5–23
5. Schafer WA, Carroll JM, Haynes SR, Abrams S (2008) Emergency management planning as collaborative community work. J Homel Secur Emerg Manage. doi:10.2202/1547-7355.1396
6. Schafer WA, Ganoe CH, Carroll JM (2007) Supporting community emergency management planning through a geocollaboration software architecture. Comput Support Coop Work (CSCW) 16(4–5):501–537
7. Carroll JM, Mentis M, Convertino G, Rosson MB, Ganoe C, Sinha H, Zhao D (2007) In: Prototyping collaborative geospatial emergency planning. Proceedings of ISCRAM, Delft, The Netherlands, 13–16 May 2007
8. Convertino G, Zhao D, Ganoe CH, Carroll JM, Rosson MB (2007) A role-based multiple view approach to distributed geo-collaboration. In: Human-Computer interaction. HCI applications and services, vol 4553. Springer, Heidelberg, pp 561–570
9. Convertino G, Neale DC, Hobby L, Carroll JM, Rosson MB (2004) A laboratory method for studying activity awareness. In: Proceedings of the third nordic conference on human-computer interaction, New York, USA, 23–27 Oct 2004

10. Convertino G, Wu A, Zhang XL, Ganoe CH, Hoffman B, Carroll JM (2008) Designing group annotations and process visualizations for role-based collaboration. Social computing, behavioral modeling, and prediction, Springer US, p 197–206
11. Blaikie NH (1991) A critique of the use of triangulation in social research. Qual Quant 25(2):115–136
12. Patton MQ (2005) Qualitative research. Wiley Online Library, Hoboken
13. Alexander D (2005) Towards the development of a standard in emergency planning. Disaster Prev Manage 14(2):158–175
14. Wolshon B, Urbina E, Wilmot C, Levitan M (2005) Review of policies and practices for hurricane evacuation. Transportation planning, preparedness, and response. Nat Hazards Rev 6(3):129–142
15. Saffer D (2010) Designing for interaction: creating innovative applications and devices. New Riders Publications
16. Wiseman V, Conteh L, Matovu F (2005) Using diaries to collect data in resource-poor settings: questions on design and implementation. Health Policy Plann 20(6):394–404
17. Beyer H, Holtzblatt K (1998) Contextual design: defining customer-centered systems. Morgan Kaufmann Publishers, Burlington
18. Yin RK (2003) Case study research: design and methods. Sage Publications, Thousand Oaks
19. Haddow G, Bullock J, Coppola DP (2010) Introduction to emergency management. Elsevier Science
20. Johansen R (1988) Groupware: computer support for business teams. The Free Press, New York
21. Fischer G (2004) Social creativity: turning barriers into opportunities for collaborative design. In: Proceedings of the eighth conference on participatory design: artful integration: interweaving media, materials and practices, vol 1. ACM, p 152–161
22. Conklin J, Burgess-Yakemovic K (1996) A process-oriented approach to design rationale. In: Moran T, Carroll J (eds) Design rationale concepts, techniques, and use, Lawrence Erlbaum Associates, 6(3):293–428
23. Schneider K (2006) Rationale as a by-product. In: Dutoit A, McCall R, Mistrik I, Paech B (eds) Rationale management in software engineering. Springer, Heidelberg, pp 91–109
24. Regli WC, Hu X, Atwood M, Sun W (2000) A survey of design rationale systems: approaches, representation, capture and retrieval. Eng Comput 16(3–4):209–235
25. Carroll JM, Moran TP (1991) Introduction to this special issue on design rationale. Hum–Comput Interact 6(3–4):197–200
26. Haseman WD, Nazareth DL, Paul S (2005) Implementation of group decision support system utilizing collective memory. Inf Manag 42(4):591–605
27. Falessi D, Cantone G, Becker M (2006) Documenting design decision rationale to improve individual and team design decision making: an experimental evaluation. In: Proceedings of the 2006 ACM/IEEE international symposium on empirical software engineering, ACM p 134–143