Prototyping Collaborative Geospatial Emergency Planning

John M. Carroll, Helena M. Mentis, Gregorio Convertino, Mary Beth Rosson, Craig H. Ganoe, Hansa Sinha, Dejin Zhao
College of Information Sciences and Technology
The Pennsylvania State University
{jcarroll, hmentis, gconvertino, mrosson, cganoe, hsinha, dzhao}@ist.psu.edu

ABSTRACT

Regional emergency planners use "tabletop" exercises to develop plans, to articulate strategies and constraints, and to practice working together. We conducted an experimental paper prototyping study to identify design requirements for a collaborative system to support distributed tabletop emergency planning exercises. We designed a reference task for geo-collaborative planning by adapting the hidden profile paradigm from social psychology as a model of obstacles to effective coordination in decision making. Our objective was to assess the usefulness and tractability of experimental paper prototyping methods for complex collaborative problem-solving contexts.

Keywords

Collaboration, coordinated multiple views (CMV), emergency planning, geospatial information systems (GIS), paper prototyping, prototyping.

INTRODUCTION

The term "emergency" connotes frantic activity in dire circumstances. But one of the most important determinants of effective performance by emergency responders has nothing to do with speed or courage. Emergency responders spend most of their work time planning and otherwise preparing for emergencies. This is a paradigm case of what Suchman (1986) characterized as planning to create a resource for situated action: Emergency responders do not expect to merely execute a plan; rather, they use plans as a basis for more effective improvisation as they respond to an emergency situation.

Emergency planning is an on-going activity that involves many stakeholders and roles (e.g. rescue services, transportation facilities, weather forecasting services and regional planning authorities), takes into consideration a wide variety of environmental factors (e.g. location of local flood plains, the state-of-repair for bridges), and takes into account an unending variety of "what-if?" risk scenarios.

During the past three years, we have worked with regional emergency managers in Centre County, Pennsylvania, to understand emergency planning activity in a rural/small town context. We found that there is a continuous planning process underway (Schafer, Carroll, Haynes, & Abrams, submitted). However, because the various stakeholders have extensive separate responsibilities, and because all-hands planning exercises require significant coordination and logistic support that itself is not directly funded, these face-to-face meetings are convened only a few times per year.

A central activity we have observed in emergency planning meetings is the "table top exercise" (Schafer, et al., submitted) where a physical table is used for informal planning activities (not specifically related to the design and use of tabletop displays). In these exercises, an emergency response scenario is presented (e.g., a forest fire approaching from the north side of town, landing gear fail in an aircraft arrival) and the planners work through possible responses. These exercises are *not* designed to create a repository of response scripts for later access, but rather to revisit existing options in place and rehearse the interdependencies among personnel and other resources. Table top exercises help emergency personnel to build a planning space for improvisation during actual crises.

Based on this fieldwork, we have begun to investigate how we might support regional emergency planning as a form of remote – only intermittently face-to-face – collaboration. Our aim is to develop a computer-based tool that might be used to support these planning activities. For the tool, we are focusing on the characteristics and management of multiple, coordinated map-based views of an emergency scenario, for instance views that are customized to different responders' expertise (e.g., public works, environmental engineers). To this end, we required a model situation to systematically study specific group processes, such as sharing and managing knowledge (i.e., common ground), coordination of actions, development of decision strategies, as well as their impact on performance (Carroll, Convertino, Ganoe, Rosson, To Appear).

We wanted to build on our fieldwork to develop a more precise analysis of the group process involved in emergency planning problems. Because of their central role in the fieldwork data, we are focusing first on table top exercises. Our initial work has led us to the use of paper-prototypes as a method for testing our reference task, testing our initial conceptual system design, and eliciting specific software design requirements. Thus in this paper we describe a study, in which groups of three participants developed plans for evacuating isolated families to shelters during an emergency. We describe the process followed and some of the initial findings and successes in the use of this empirical paper prototyping methodology. Subsequently, this method will also be used for testing software user interface designs and concepts in a controlled lab environment. We present three sets of findings.

First, we present the feasibility of using experimental methods to complement field-based methods. We designed a focused experiment, incorporating our paper prototype, to investigate an independent variable identified in previous research, namely, the salience of role in a collaborative endeavor that involves information sharing (Stasser & Titus, 2003). One of the key challenges in moving to an experimental paradigm is exerting more control over the task information to which participants have access. One way we overcame this challenge was to use novice participants in place of the domain experts.

Second, we present the efficacy of paper prototyping methods in a complex collaborative problem-solving context. Paper prototyping is a standard method in user interface design, but has generally been applied to simple and non-collaborative software applications (Snyder, 2003). We developed a paper-based reference task modeled on tabletop exercises, yet also incorporating the design concept of role-based views of a situation map. Our research asks whether such a paper prototype can be a useful tool for investigating design concepts for collaborative emergency planning software.

Third, we present the feasibility of leveraging participants' experience with an experimental task for a focus group debriefing. In this study, we asked groups of participants to develop three emergency plans, within the context of our experimental model and using our paper-prototype. We then tried to leverage their, albeit modest, experience with the domain and with the prototype in a focus group exercise designed to inform the design of an interactive system based on the paper prototype.

EXPERIMENTAL REFERENCE TASK

We designed the experiment to study small teams of three members, each playing distinct and stable roles (Public Works, Environmental, or Mass Care expert). Each role contributed distinct expertise and information – all of which was *required* to perform the collective task successfully. Different areas of expertise imply different languages, responsibilities, and priorities (McCarthy & Monk, 1993). This increases the need for members to build common ground in order to communicate, coordinate, and perform well on the group decision-making task.

The three-member teams were asked to build the best plan for evacuating a family from a flooded area to the best shelter available. Identifying the best plan involved consideration of route, shelter, transportation, and rescuee information. All information given to the participants was in one of three forms: individual role-specific maps, information sheets with role-specific information, or shared scenario with background information.

The three members, playing experts' roles, received shared and unshared information to complete the task. Since the participants were not experts we had to impose the beliefs and knowledge that an expert would have. Each participant was given a detailed description about his/her role and role-specific background information. The role description included three parts: (1) a list of items the expert knew about and that were displayed on their role-specific maps (e.g., the Public Works expert knew technical details about roads and bridges and utility lines); (2) problems that typically arise about each of the items s/he was responsible for (e.g., downed power lines: sparks from wires can trigger fires); (3) an example illustrating how, given a problem, the expert would use his/her knowledge to evaluate tradeoffs and find a solution (e.g., Choose a road through the north valley because it is less likely to wash out in the storm).

In order to study the development of coordination in a working team, we had each team create three different plans in three repeated runs; members played the same role in each of the three runs. The task scenarios for each run were similar in that there was a family in need of rescue in a floodplain, there were four possible shelters, only one route to each, and the same amount of information was provided.

A key issue in the design of the study was balancing between ecological validity with respect to field observations of emergency planners (roles they play, information they manage, how they use maps, etc.) and the systematic manipulation or control of factors like access to information in a laboratory setting. The three roles were developed from the FEMA emergency planning roles (DHS-FEMA, 1997) and the Red Cross Rescue Scenario, a notional scenario on a multi-expert evacuation operation by the US Office of Naval Research (www.onr.navy.mil/sci_tech/34/341/cki/overview_notional.asp). Considerable research effort was devoted to the design and specification of the task structure and content through an extensive process of pilot testing (6 pilot groups) and revision.

Task Design

The experimental task we used adapted the "hidden profile" paradigm of Stasser and colleagues (Stasser & Titus, 2003) developed to study information sharing within group decision making. A hidden profile is embedded into the data provided to each participant; that is, an overall superior decision alternative exists but is "hidden" from individual members, each of whom is biased toward suboptimal solutions. The superior alternative can be discovered only if the members effectively pool relevant individual knowledge and reason as a team. This creates a logical dependence of the quality of the team decision on the quality of team sharing. It also allows measuring if (and how often) team members disanchor from their initial preferences to choose the team-level optimal solution.

In our task, the key information items are risks or constraints (cons) pertaining to each of four possible solutions – four shelters to which the family could be evacuated. Example cons are *Garbrick St. goes through a floodplain.* and *The Brown Clinic Shelter holds 30 people and currently has 25 people.* Each member of the team is provided with 9 cons; each individual's set of cons are biased toward choosing one shelter (having only 1 con) and against another shelter (having 4 cons), with the remaining two shelters having an intermediate number of cons (2 cons each) (Table 1). At the individual level, each team member would thus advocate *for* one shelter and *against* another. As shown in Table 1, we allocated cons for three of four shelters (rows A, B and C) according to a 3x3 Latin Square.

The fourth shelter in our task design (row D in Table 1) has the hidden profile: Each team member is given one distinct con for that shelter, and one shared con for that shelter. From each individual's perspective, the fourth shelter has two cons, neither the worst nor the best alternative. But if the team effectively pools relevant information across roles, then that shelter is *clearly* the best choice: it has 4 total cons versus 7 each for the other three shelters.

	Public Works	Environment	Mass Care	Total Cons
A – unshared	a	a a	a a a a	7
B – unshared	b b b b	b	b b	7
C – unshared	c c	c c c c	c	7
D – shared D – unshared	d d	d d	d d	4

Table 1. Con Distribution Matrix

In addition, to the 25 relevant cons distributed to the teams (and schematized in Table 1), each member received 6 irrelevant cons such as *There is a fallen tree obstructing Fisher Fire Rd*., which is irrelevant since Fisher Fire Rd. is not a route to one of the shelter options. Two important assumptions in this task design are: (1) that the 25 relevant cons are judged and used as relevant in the task, and that the 6 irrelevant cons are ignored in the decision, and (2) that all the relevant cons are weighted as equally critical by members for their task.

We addressed this through piloting. We developed a full experimental design, as described above, and then ran 6 pilot groups. In running pilots we asked participants to rate the criticality of each con before they began the task. We analyzed how participants discussed each task and each con during the task. For example, in our original set of cons we had included a tornado possibility near one of the shelters. This was perceived as a show-stopper; the shelter with this con was ruled out prima facie. Thus, we replaced the tornado with a risk of lightning, which was perceived as less severe.

We continued the piloting until we felt that the cons were reliably perceived as evenly relevant and severe. We then created two variant task scenarios by rearranging the cons on two other maps. We then ran one final pilot with the full set of three scenarios to verify that the team would understand the three versions in the way we expected and ultimately refine the materials.

PAPER PROTOTYPE

In devising the paper prototype we tried to strike a balance between purely simulating the tabletop exercises and creating a paper version of our conceptualized software interface. Since we were interested in developing a system with multiple, coordinated map-based views we gave each role an individual role-specific map. The role-specific maps showed features that were specific to their understanding of the area (e.g. the environmental expert had weather information and the public works expert had utility information). For collaboration, a team map was provided which had only the basic, shared map features. For all of the maps we used official map data from Centre County, Pennsylvania (http://www.co.centre.pa.us/gis/), but rotated and relabeled towns and other features to control for prior experience (no participant reported recognizing locations in the maps). For annotation and information sharing, a colored pad of post-its and a colored pen were available for each individual role.

For the study, our laboratory was configured with three tables at right angles to one another. This provided an individual working area for each participant (role-specific map and written materials) as well as a common tabletop working area at the intersection of the three tables (team map).

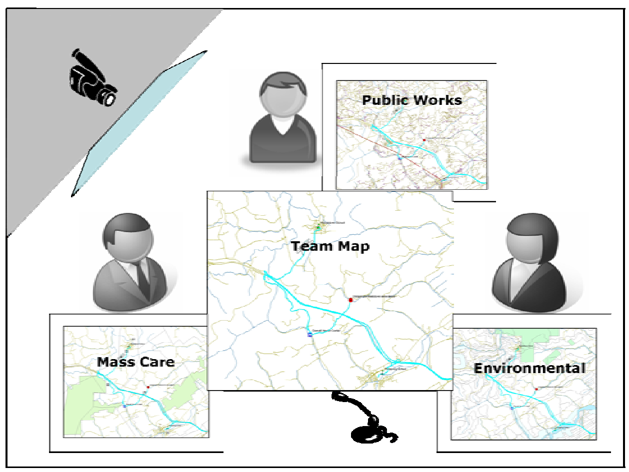

Figure 1. Experimental Set-up

STUDY PROCEDURE

Study Design

Our study with this experimental design and paper prototype examined the salience of role in a collaborative endeavor that involves information sharing (Stasser & Titus, 2003). We used a 2x3 factorial, where the two factors are pre-task briefing on the roles and repeated runs using analogous versions of the task scenario. All participants were briefed on the role they themselves played, but for half of the teams, participants were also briefed about the roles that other team members played. This manipulation was intended to raise the salience of roles, and increase members' awareness of what their partners were doing. The order of the versions of scenario was a Latin Square in which each version appeared 1st, 2nd or 3rd an equal number of times across teams.

Participants

The study was run with twelve teams. Thirty-six university students and employees were recruited from Penn State University and were assigned to 3-member teams, 6 in each of two pre-briefing conditions. In the condition with briefing, when the participants were given their own individual role description they also received role descriptions for their partners' roles with additional time to read them over. All except one were same-gender teams (6 male, 5 female, and 1 mixed-gender team of one female and two males). All participants were fluent English speakers, but 17 of the participants were non-native speakers. Twenty of the participants had undergraduate degrees; the remaining 16 had advanced degrees. Participants had uniformly low experience with the domain of emergency management planning. No aspect of prior experience varied significantly with the factor of pre-task role briefing.

The use of novice participants controls prior experience with respect to weighing cons information in the experimental design, and is consistent with our objective of investigating the feasibility of an experimental model of expert teams. The two versions of the pre-task briefing and the three repeated experimental runs investigate the expert roles manipulation. Work by Larson et al. (1996) suggests that experts (medical professionals in their study) perform similarly to non-experts in hidden profile tasks with respect to mentioning unshared information, though more senior experts were more likely to repeat unshared information as the task progressed. Stasser (2003) discusses Larson's work, and obtained similar results where repetition of unshared information was more likely.

Experiment Procedure

Participants signed an informed consent form and completed a background questionnaire online. Then they sat around the tabletop working area to start the task. The task performed consisted in solving three emergency planning problems. The entire work session was video-recorded.

Before starting the task, the participants received a short introduction and read the descriptions of their roles and shared task scenario (10 min). They briefly completed a role manipulation check verifying their understanding of task and roles (3 min). The participants then read the role-specific information sheet (their list of cons). For each con, they rated the severity (or importance) on a scale from 1 (minimal risk) to 5 (very severe risk) and then wrote their preferred solution based on their individual knowledge. At this point, the participants started the actual planning task, which lasted about 20 minutes. They were instructed to not show their role-specific information sheet or map to the other participants and they were asked to share information with the team on the shared map using their pens and post-its. When they reached a decision, they wrote down the final plan along with three alternatives in order of preference on a final plan sheet. At the end of the task, each of the participants moved to a separate computer workstation to complete a post-task questionnaire and a recall questionnaire. While the participants filled out the questionnaire, a new batch of task materials was made available on the tabletop area. These were used for the next run of the same task using the same procedure described above. This process was repeated two more times. All that remained with participants from run to run was the role description. Overall, the three runs of the planning task lasted about 2.5 hours.

FOCUS GROUP PROCEDURE

After the third and final task run, while the participants were still situated in the context of the planning task, teams participated in a 15-minute focus group activity to elicit design requirements for collaborative emergency planning software. The participants were given a few minutes to write individual feedback on (a) critical functions that should be supported (e.g., annotation, data sharing, awareness tools); (b) preferred ways of navigating both team and role-specific views; (c) preferred granularity and direction for transferring information between views. They were then asked to individually comment on a coordinated multiple views (CMV) user interface design for a geo-collaborative system (Convertino, et al., 2005) and then were given about 10-12 minutes to share and discuss briefly with their team their design ideas prompted by the user interface design in light of their prior experience on the task.

RESULTS

Our results focus on those observations, questionnaires and focus group responses which address our three objectives for this paper: the use of an experimental reference task to compliment field-based methods, the efficacy of paper prototyping methods for collaborative problem-solving, and the use of focus group exercises to elicit design requirements. Thus, we primarily report on observations about the process of sharing information during the planning runs and on the post-experiment focus group that was used to elicit requirements for the design of an interactive geo-collaborative system.

Use of Experimental Reference Task

The teams seemed quite engaged by this task; it was difficult for them, but not intractable. We consistently observed lively discussions about group decisions as well as the rationale for those decisions. Overall, teams recommended the optimal (hidden profile) plan for 13 of 36 problems. There was a learning/warm-up effect: Only 2 of 12 teams recommended the optimal alternative in the first problem they planned, however for the 2nd and 3rd problems planned, teams recommended the optimal alternative in 11 of 24 cases. The pre-task briefing appeared to have no significant influence on performance of the task.

Answers to post-session and recall questionnaire suggest that the amount of common ground increased significantly over the three runs. For example, the perceived "Gain of Shared Knowledge" on a scale from 1 to 7 grows significantly from an average rating of 5.69 (0.13) in the first run to 6.15 (0.11) in the third run. This addresses the requirement of validity: we are actually enabling and measuring a realistic process.

The design of the task (initial individual bias & hidden profile) reveals possible weaknesses in the decision process of a team solving a complex geo-collaborative problem. Even though the amount of shared knowledge increased, a large number of team members tended to remain anchored to their initial (biased) preferences as they proceed with the decision process. However, more experimental evidence is needed to confirm that the anchoring to early preferences is a systematic bias of the teams and not an effect of our manipulations of information in this task.

Given the complexity of the task and the effects of built-in bias, the response of the participant was far from reaching a ceiling effect: optimal solution picked in 36% of the runs and 46% if we consider 2nd &3rd run only. This is a useful feature for our reference task that can be used for testing collaborative tools and visualizations designed to reduce bias.

Paper Prototyping Efficacy

Our use of a collaborative paper prototype provided insight into group decision processes in collaborative emergency planning as well as requirements for the design of an interactive geo-collaborative system. We were particularly interested in studying *what* pieces of information team members chose to share (e.g. specific cons, shared or unshared information), *how* they chose to share it (e.g. direct annotation on the map, post-it notes), and *why* each method was used. The analysis focused on the shared maps that groups created in making their decision.

Post-its (dominant form in 7 teams) and directly annotating the shared map (dominant form in 5 teams) was primarily used for listing the cons as well as general information about the problem at hand. Many of the post-its had more than one con listed on it. In addition, participants added to each other's directly annotated con lists. One interesting finding was in Team 3 where one member felt like he could not participate as much as he liked. This was primarily because he was not a native English speaker as well as because another member of the group consistently spoke over him. Thus, this "left out" member began writing down cons on separate post-its and placing them on the shared map whenever the other two members were discussing a shelter or route.

Three teams used one post-it or an annotation at the bottom of the shared map to cover general information or rescuee information. For example, Team 11 had one post-it at the bottom of one shared map with the text *Rescue Vehicle. 1 hr. gas left. Problem going through water.* For team 3, the decision leader had written a list of the shelters at the bottom of each shared map to keep track of which shelter they eliminated and why.

All of the teams annotated the shared maps with graphical elements. This included tracing the routes and circling or highlighting important information (i.e. shelter, rescuees, road work sign). One member of Team 5 wrote 'fire' on the map and then created his own icon by drawing flames.

In watching the videos, it is clear that pointing and gesturing (deixis) was used for discussion to specify a shelter or possible route. Pointing was especially used while recapping options and decisions since there was no need to put down anymore post-its or annotate the map.

Focus Group Discussions

After the final run, we sought to leverage the participants' experience with the paper-map-based planning task in a focus group discussion of ideas for design features that would support planning in distributed collaboration. First, participants wrote individually their preferences for three key design decisions, and then they listed functions they thought would be useful for a collaborative system. Finally, feedback and discussion from the entire group was elicited using a screen-shot mock-up for a geo-collaborative system (Convertino, et al., 2005).

When asked about their preference between *independent* vs. *yoked* map navigation: 22 out of 36 preferred independent navigation (team members should always be able to work on any part of the shared map, but also be aware of what others are doing elsewhere in the map). The 13 of 36 who chose yoked navigation (it would be easier to see what other team members are looking at). Some suggested that one team member would have control of this yoked view for the whole team. 3 participants felt the software should support switching between the two modes.

When asked about their preferences on *granularity* and *directionality* for transferring information between multiple map views, there was no clear favorite. For granularity, 17 out of 36 preferred an interaction design based on selection of map regions; 14 of 36 preferred interaction based on selection of map objects (annotations, roads, power lines, etc). For directionality, 20 out of 36 participants thought that information only needed to be transferred from individual maps to the shared map; 14 participants felt transfer needed to be bi-directional; 2 thought transfer only needed to be from shared to individual maps.

The answers from the focus group sessions were transcribed and coded separating ideas generated individually from ideas generated in group. Design suggestions about *Annotation* and *Map Sharing* were particularly common; for instance more than half of the individuals and at least two thirds of the groups suggested an ability to annotate maps with text, and to be able to transfer information across maps. Participants offered a number of ideas related to *Awareness,* both with respect to information and role information. We can see the impact of the mock-up and group discussion on the ideas about *how* to promote awareness (e.g., mousing-over a map to reveal associated information) that are more common in the group-generated requirements data.

Annotation	**Ind**	**Grp**	***Map Sharing***	**Ind**	**Grp**
notes or text	20	7	share and transfer data across maps	21	9
shared list of pros/cons	1	1	access others' maps	1	4
drawing and marking	1	2	multi-layer map views	2	3
icons for fire, power, tree etc.	3	3	synchronized view	3	2
delete objects from shared map	0	2	synchronized action with master control	2	3
movable markers/notes	1	0	pointing	1	1
Awareness			radar view	0	1
highlighter	3	3	conflict solving (vote, rating, etc.)	5	1
color coding by roles/experts	0	3	***Map Features (Misc.)***		
color coding by severity of risk	3	2	distance calculating function	1	2
mouseover to display map object info	0	4	meteorological info	1	2
alerts of current events/updates	1	3	history of emergency operations	2	2
current overview of the map	0	1	map rotation		1
Ease of use			search function for roads, shelters, etc.	1	1
better quality maps		1	store information about permanent risk factors		1
legend	2	4	***Voice Communication***		
shared map could be bigger than individual map		1	voice/IM contact with ground	1	3
shared map and individual map side by side		1	voice/IM comm between roles	3	3
zoom bar should be more clear		2	***Other Misc.***		
clearly labelled individual and shared maps		1	touch pad with a stylus	1	1
one tool bar for both maps is better than two		1	software training		1
intuitive tool buttons		1			
reduce number of buttons on user interface					
label map objects more clearly		2			
less and clear info in shared map		1			

Table 2. Requirements generated individually (left column, N=36, these ideas were prompted by categories) and via group discussion (right column, N=12, these were prompted by the prototype user interface)
Gr = Group Count, In = Individual Count

It was interesting to note that groups with strong leaders discussed a need for synchronized view with master control. Others were satisfied with just synchronized views. Some type of rating/voting capability was also considered to support group decision-making. Some also felt that it would be helpful to see the others' maps. Pointing was another feature that would help them show relevant points on the map. There were many requests for enhancing the quality of the map and adding more functions such as history of emergency operations and a search facility for finding roads. *Voice communication* was considered not only for communication between experts but also with rescue vehicles and shelters. Requests for making an *easy to use* interface was key in saving time for emergency planning. This included clearly defined labels and zoom bars, intuitive as well as less number of tool buttons.

DISCUSSION AND CONCLUSIONS

Our research goals in this paper were (1) to develop an experimental paper prototyping method for a complex collaborative problem-solving activity, map-based emergency management planning, and (2) to elicit focus group guidance for the design of an interactive geo-collaborative system to support this work activity.

Reproducing and measuring the coordination process as part of a *realistic* group work serves both CSCW design and research. We developed a plausible reference task (Whittaker, Terveen, & Nardi, 2000) for collaborative planning in general, and for geo-collaborative emergency planning in particular. Creating an authentic reference task, one that is both engaging and tractable for users and felicitous to important characteristics of the application domain, is a good investment for design. Our task helped us to identify requirements to guide our software development work, but we plan to use it again to evaluate and refine the software prototype we have developed (http://cscl.ist.psu.edu/public/projects/ONRproject/index.html).

We developed an experimental reference task useful for research—that is, a relatively controlled task in which specific parameters can be varied, with other properties held constant, and their consequences measured. For example, using our task, we can vary the role definitions of team members (the three roles we used could be articulated differently, collapsed, refactored, etc.), the salience of roles to the participants (which we did vary here, but which had only a small effect), the complexity of the geo-spatial planning task (varying number of cons, number of solutions, number of collaborators, and designation of a team leader), and so forth. Such manipulations make possible the investigation of a range of specific issues in group performance. The experimental design of the present study allows us to investigate the effects of a role salience manipulation on information sharing and development of common ground over time in teams. In this short report, we did not have space to discuss these issues in detail.

For problem domain of emergency planning, the "hidden profile" seems to be an effective paradigm. Stasser and Titus (2003) and others have already demonstrated that hidden profile alternatives are relatively difficult for groups to successfully identify. Our study demonstrates how the application of the hidden profile concept to emergency planning information can create a non-trivial but achievable challenge for group coordination and performance. Integrating methods from research on group decision-making (e.g., Stasser & Titus, 2003) with measures from research on computer-mediated communication and work (e.g., McCarthy & Monk, 1994) can lead to novel solutions to study process and design technology. Research by Dennis (1996) suggests that decision support systems can improve the sharing of initially unshared information over strictly verbal hidden profile type work.

This reference task and experimental design led us to identify a set of system requirements for collaborative geospatial emergency planning, and specifically planning tasks in which collaborators play distinct roles associated with distinct map-based data. Our set of requirements was drawn from both our observations of the paper-based collaborative work and focus group activities carried out immediately after situating participants in an experimental model of the paper-based work. The convergence between these two sources of requirements helps us to prioritize some requirements over others.

For instance, we collected many requirements related to the way in which information might be visualized or annotated on a shared map. From the qualitative analysis we were able to see that teams used a mixture of annotation and post-it notes, and that the post-it notes were used primarily for text information, while annotation was used for both text and graphical content. The focus groups expanded on these observations by providing more specific suggestions as to icons that might be provided and the importance in general of being able to add text to a map. These findings help us to see that we should *not* make a simple distinction between graphical content like fire symbols and textual content like a note about a shelter's status. Instead we should support text input as part of an annotation process, but also provide a small set of common graphical elements to easily complement text.

Our investigation, and the specific task scenario we investigated in the experiment, addressed planning for a "natural" emergency: heavy rains with consequent flooding, power outages, road failures, medical emergencies, and evacuation. Obviously, these are real and important emergencies in Centre County and elsewhere. However, we believe that the task we are developing and investigating is more general, and that the paper prototyping methods we have used to specify and refine our reference task can be applied to any geospatial emergency planning context.

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