Co-Designing a Virtual Training Tool for Emergency Management

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ABSTRACT

Responders and decision makers can be trained through simulation tools where participants learn how to deal with an ongoing crisis and make decisions through a realistic, simulated environment using a game or gamification approach. Training through a simulated, virtual crisis tool would be a more affordable way of conducting a drill, as a supplement to field drills. In this paper, we describe the requirements' elicitation process for co-design of a virtual training tool for emergency management. The cooperative design process included researchers and end-users together to generate potential solutions for a defined problem. The elicitation process involved brainstorming, interviews and a workshop together with representatives from emergency stakeholders. A systematic qualitative data analysis was conducted. The paper reports our analysis results which serve as a basis for further development of an emergency management virtual training tool using an extreme weather scenario.

Keywords
Emergency management, co-design, training tool planning, extreme weather.

INTRODUCTION

One of the most challenging parts of responding to a crisis is to understand precisely when each actor should start taking action at each stage of the crisis development, without ignoring the standard procedure of crisis response. Sometimes, improvisation is needed in the initial phase of a crisis due to unknown threats ahead, before the first responders can follow pre-defined plans. Field drills are an essential part of crisis responder training and contribute to comprehending timely actions needed in a crisis. However, field drills are time-consuming in terms of preparation, resource-intensive in terms of recruitment and coordination of all the players and logistics, and also financially expensive. In addition, the opportunity to train inexperienced staff to become more experienced decision makers in different roles is very limited. An alternative way to train responders and decision makers is through simulation tools where responders learn how to deal with a crisis and make decisions through a realistic, simulated environment using a game or gamification approach. Training through a simulated, virtual crisis tool will be a more affordable way of conducting a drill, as a complement to real field drills.

Serious games (SG) have been used in different organizational contexts as a means for training. Several studies have initiated and proposed to use serious games for emergency management as an approach for conducting training (Di Loreto, et al., 2012, Di Loreto, et al., 2013). The application areas for SG are wide, including military training, organizational education, medical care emergency services, politics, business, and many other sectors of society. There is also a slight disagreement on the definition and coverage of SG (Boyle, et al., 2016, Djaouti, et al., 2011), with different game-like experience terms in use: *Game, Serious Games, Simulation, Gamification* and *Game Inspired Design* (Marczewski, 2015). Most authors refer to SG as games intended for non-entertainment purposes (Metello, et al., 2008), such as education (Linehan, et al., 2009). Promoting learning and education, participation, and behavioral improvement are the core of the SG (Seaborn and Fels, 2015).

The advantages of a gaming approach are numerous. It is a less costly alternative for training activities that can complement field training or as an alternative to the table-top exercise, and allow intended trainees (e.g. emergency management personnel and decision makers) to train more often than they would otherwise be able to do

in field-based exercises. Adequate training games can replicate conditions in various scenarios, allow organizations to record logs, and store the actions for later review, debriefing or repetition. Moreover, games are a less risky environment to train new personnel rather than exposing them to risk (Radianti, et al., 2017).

Even though SG is gaining popularity as an alternative for crisis management training, Di Loreto, et al. (2012) indicate that there are several missing elements in SG for crisis management: 1) connection with an actual territory (i.e., the game takes place in an abstract environment); 2) possibility to play with roles; 3) emphasis on the importance of the debriefing phase, and 4) support for coaching during the playing sessions. The KriseSIM project reported in this article aims at developing an emergency and disaster Virtual Training Tool (VTT) prototype that address several of these elements. Important questions addressed in this project are: how to gather the requirements and design of the VTT from the end-user perspective and tailor this into a VTT tool? What kind of user interface requirements will be useful and understandable for the end-users? How can such a tool be made relevant for various emergency stakeholders?

The paper describes the co-design process (Martinez, et al., 2016) carried out for the development of a virtual training tool linked to the Norwegian crisis management context. Co-design refers to a cooperative design process where researchers and end-users together generate potential solutions for a defined problem. This method has already been used in the emergency management domain (Cinderby and Forrester, 2016, Hughes, 2014, Munkvold, 2016, Petersen, et al., 2015), as an iterative approach with participants representing various stakeholders whose degree of participation varied depending on user needs and stage of the design process.

The paper is organized in six sections. The next section presents relevant literature on co-design and the approach employed in this work. The third section describes the methodology of the elicitation processes. The fourth section elaborates the results of the co-design, followed by a discussion of the findings, including challenges and opportunities. The final section concludes the paper, also presenting implications for future work.

CO-DESIGN METHODOLOGY

Relevant Literature

Co-design refers to a cooperative process between stakeholders involved in an enterprise. The undertaking is usually developed on a particular domain or field, such as information and communication technology, health or marketing, with a specific purpose: to cooperatively design a solution related to a specific pre-described problem or case involving target users of such a solution (Sanders and Stappers, 2008). Co-design was initially invented in the Nordic countries (Bødker, 1996), with the purpose of allowing the employees to take part in the decision and control of their production means. Co-design has been used in information and communication technology to transform end-users into active contributors of a technology solution design for and with them (Martinez, et al., 2016). In this way, it is the end-users who describe their needs with their own voice. Co-design gathers representatives of end-user groups in the same place at the same time, facilitating a common understanding and prioritization of needs that will be later translated into functional and non-functional requirements and look and feel of the desired system solution.

Co-design has been used in different ways and areas, such as building community participation in community strategy (Leicestershire, 2017), governance (Hill, et al., 2007) and developing regions (Ramachandran, et al., 2007). However, a common underlying principle is that the method requires the recruitment, consent and interaction of the representatives of the user groups for whom a solution is intended. The word solution means that there is a problem or scenario to which co-design participants are usually confronted, immersed or described. The problem or scenario may or may not be familiar to participants. The key is that the co-design sessions may stimulate the imagination, cooperation and dialogue between participants to find a solution for the problem (Martinez, et al., 2016). The participants are then responsible to explain and present what they mean by their suggestions and propositions, and why these may be important for them and others.

There is evidence in the literature about the use of co-design and analogous methods, such as co-creation (Prahalad and Ramaswamy, 2004), user-centred design (Vredrenburg, et. al, 2002) or participatory design (Hughes, 2014) used to co-design technology solutions involving end-users. Examples of studies that involve end-users for disaster and crisis management can be seen in the literature. For instance, community participation in the form of a collaborative action-research method by the Tasmania fire service to transform community education (Middleton and Leahy, 2017), governance to solve policy issues on tension between the government agencies and local companies (Hill et al 2007), and investigation of technological solutions in the domains of communication, microfinance and education in developing regions such as India and Uganda (Ramachandran et al 2007). While participatory or user centric designs have been adopted for the crisis management domain, reports on the involvement of stakeholders in actual co-design of technological tools for disaster management is still limited (Akama and Light, 2012, Lundberg, et al., 2012, Petersen, et al., 2015). Several factors may explain why. In the first instance, the recruitment of end-user representatives from emergency organizations requires resources and

time available to free them from their work, which may be challenging due to their required permanent availability to assist if an emergency occurs. In the second instance, the unpredictability of certain disasters and crisis may hinder the appropriate selection of user-group representatives.

Basically, there is low tolerance for errors in this kind of technology support, so include all stakeholders' needs is one of the reasons for implementing co-design process. Further, co-design of emergency management requires users who are familiar with coordination and communication tools, limiting then the range of stakeholder representatives potentially selectable for the process.

Our Approach

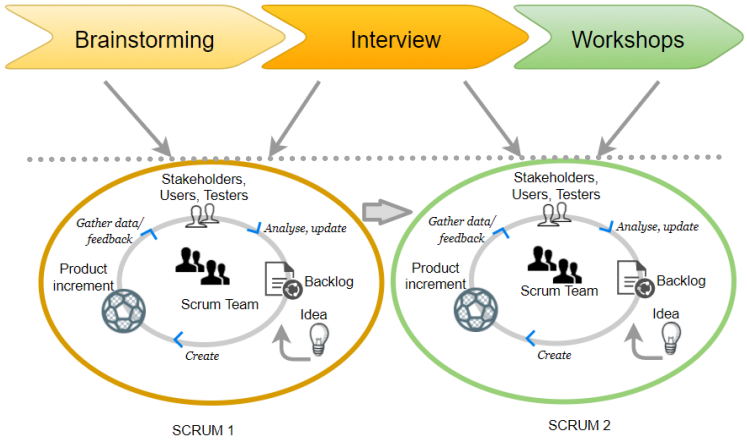

Figure 1. Two-levels of Co-design Processes

In this project, the co-design processes were iterative and occurred at two levels, as seen in Figure 1: First, at *the general level* where the research team interacted with the stakeholders to discuss general requirements. The co-design process was conducted as a combination of brainstorming, interview and workshops. The focus group discussion (FGD) was used in all these subsequent processes at the general level. FGD involves the use of in-depth group interviews focusing on a given topic, in which participants are selected with the recommended number of participants between six to eight (Rabiee, 2007). This technique is unique due to its ability to generate data based on the synergy of the group interaction, to discuss differences between participants and to tackle abstract and conceptual subjects (Ritchie, et al., 2013).

Second, at *the technical level* of developing the VTT, which entailed another iterative co-design process adopting the Scrum method (Cervone, 2011). The participants of the Scrum were grouped into different roles: *product owner* (who maintains the product backlog, prioritizes product requirements, defines features of the product), *Scrum Master* (a leader of team members responsible for running daily Scrum meetings) and *Scrum Team* (the developers). The workload was split into several *sprint cycles*, always starting with an agreement on the tasks to do. Each cycle was split further into main tasks and subtasks. At this technical level, we have conducted two Scrum processes where each scrum was divided into seven and six stages respectively.

The brainstorming results were sent to the Scrum Team in the first Scrum stage, which focused on prototyping and developing a proof-of-concept product. During the development cycles in Scrum 1, we also included the iterative co-design processes of testing, discussion and collecting feedback from the stakeholders. In the workshop, we conducted a more detailed information gathering to allow us to adjust the VTT prototype into the next level, i.e. a usable, realistic training tool. All results obtained from the second workshop were fed to the second Scrum stage**.** In this paper, however, we mostly report on the result and analysis of the co-creation process *at the general level*, and not at the technical/ Scrum processes.

ELICITATION PROCESS

Brainstorming

The participants in the brainstorming were representatives from the following emergency stakeholders: fire brigade, police, municipality, hospital, and Red Cross. In addition, four researchers from the university participated, and two persons in addition taking notes and photos (eleven in total). This session consisted of two themes: 1) General discussions on the proposed project and comments from the stakeholders related to their current emergency management practices, and 2) Brainstorming using the mind mapping technique. In theme 1, we mostly discussed the general issues, especially making all participants familiar with the project ideas and building a shared understanding of the local emergency management practices and current training situation. In theme 2, we went deeper into the main concepts of the VTT features. The brainstorming process was a way to collect spontaneous ideas from the experts/stakeholders on a specific problem. Our goal was to elicit some keywords that were considered essential as elements for developing VTT as a SG. This elements are taken from design framework proposed by Van Daalen, et al. (2014). As the term serious game was also new to the participants, we started with predefined SG elements to be explored further.

To elicit information from the stakeholders, we designed the brainstorming session as an interactive mind mapping session. Mind mapping is considered a highly effective way of getting information out of our brain and can quickly map out our ideas (Davies, 2011). The predefined serious-game elements mind map was displayed on the wall. Using sticky notes, each stakeholder was asked to suggest important scenarios and detailed elements needed to be taken into account to build a game that can help to train in decision-making processes. The workshop focused the following main issues:

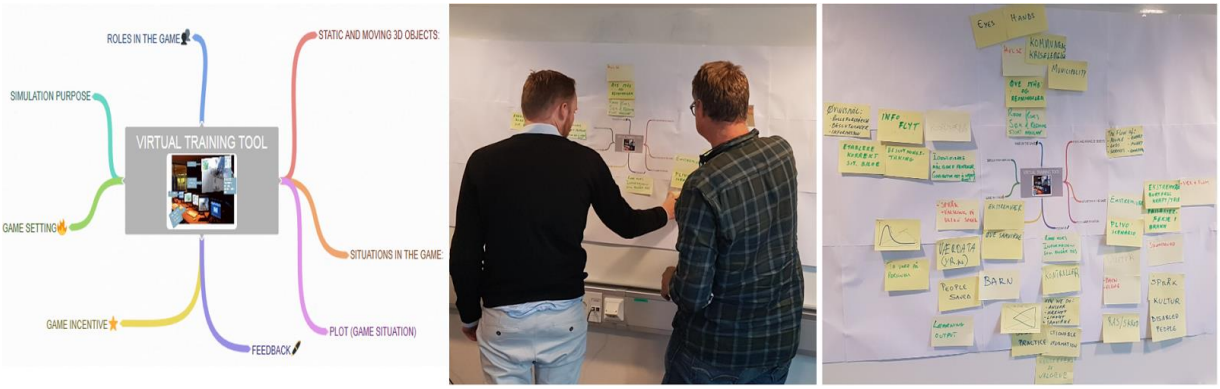

Figure 2 Mind-Mapping Sketch (left), Brainstorming Process (middle) and the results. See Table 1 for detailed information from this activity

The mind mapping process is illustrated in Figure 2. The participants were asked to provide as many ideas as possible within 3 minutes for each branch in the mind mapping sketch in Figure 2 (left). This process took approximately 30 minutes, and then each of them explained their ideas briefly. All elements in the mind-mapping sketch and the results in Figure 2 are summarized in Table 1 (Brainstorming Results Section).

Workshop

The workshop involved eight participants representing the fire services, the county governor's office, the Red Cross, and the university. All participants from emergency stakeholders had extensive experience with emergency management practice. The workshop lasted four hours and focused on the following main issues:

1. Participants' overall expectations from the project.
2. Discussion on what scenario(s) that would be most useful to include in a virtual crisis game.
3. Information requirements for the VTT user interface (UI), as perceived from the different stakeholders.
4. Based on 4), sketching a UI considered useful for the purpose of the emergency management training.
5. Discussion on target user groups and possible role of a facilitator for the VTT.

Figure 3 Figures presented in the Workshop to trigger ideas and elicitation process

The workshop was videotaped, and the audio was fully transcribed. As a basis for issues 2-5, an initial prototype of the VTT was presented. Figure 3 is the illustration of a user interface sketch to trigger discussions and facilitate elicitation in issue 4. The workshop provided detailed suggestions in terms of information requirements from the different stakeholders and also important considerations for how to make the tool relevant for different user groups. The key results of the workshop are presented in the following Results section.

We also conducted interviews as part of the planning work. The role of interviews in this co-design process was a supplement or an alternative, such as when we found doubtful issues on the project process, new questions along the way, or whether the expected key stakeholders would be hindered from coming to the planned workshop. In fact, we interviewed police personnel on the training requirement and other issues that are critical in the decision-making process. The interviews were audiotaped and fully transcribed.

Data Analysis

The data analysis was done by examining, categorizing and recombining the evidence to achieve our research goals, as suggested by Yin (2013). This includes managing the information, making sense of the content, and discarding irrelevant information (Rabiee, 2007). To minimize the potential bias, Rabiee (2007) also pointed out the importance of conducting analysis in systematic, sequential, verifiable and continuous ways. This means that systematic analysis requires a protocol that follows a predetermined and verifiable set of sequential steps in advance of the group discussion. While continuous means that the analysis can be started during the focus group discussion, which can be done by asking more questions if vague issues are detected. This activity continues after the discussion through the transcription process and deeper text analysis.

Our raw data consisted of key concepts written in sticky notes and transcribed text. For data treatment, written information in the sticky notes were grouped into similar themes, while the transcribed text was annotated by highlighting the relevant ideas for the project goals in short phrases. Subsequently, we developed a thematic framework by looking closer at the main ideas and concepts arising from the text, and began to develop categories. Afterwards, indexing was done by shifting the data, sorting out quotes and making comparisons among different themes and point of views of the different participants.

RESULTS

Brainstorming Results

As a basis for the brainstorming, we adapted the SG design framework proposed by Van Daalen, et al. (2014). We listed all ideas collected during the brainstorming process, as seen in Table 1. The goal was to identify main features that would be good to incorporate into the VTT tool development, and an interesting scenario that would be relevant for all parties. The results in Table 1 show very broad ideas. However, the most critical features as a basis for working further are the ideas listed under the "the situation in the game" and "the game setting". From the word frequencies under these two themes, "extreme weather" and the use of weather data were the most frequently mentioned. In addition, there were some ideas that could be associated with the extreme weather scenario, such as flood, loss of power and telecommunication infrastructure, and landslide. The stakeholders also indicated a preference for a large scale scenario where each emergency unit could take part and make decisions in the game.

Table 1 Results from the Brainstorming Session

Elements	Ideas
Static and moving objects	The flow of people, goods, money, information, services and energy
Situation in the game	Extreme weather, passengers trapped in a ship fire, flood, loss of power and telecommunications infrastructure, Plivo (*Pågående livstruende vold*—a Norwegian term referring to a situation with life threatening violence), dilemma, landslide/ avalanche
Roles in the game	Municipal crisis management, health, staff and rescue management, Red Cross's search and rescue, crowd of people, children and old people needing help, gestures (eyes, hand, brain)
Feedback	Information that concerns Red Cross, controller, how the crisis management actors conduct: responsibility, closeness, equality and cooperation (In Norwegian: *ansvar, nærhet, likhet, samvirke*); actionable information, consequences of a choice, best practice feedback in the game on an unknown situation, multilingual alerts
Game purpose	Cooperation training, understanding of information flow, understanding of the role, decision making, establishing appropriate situation description, coordination, taking care of personnel
Game setting	Extreme weather, the use of weather data
Game incentive	Identify measurable factors (what does it mean to be good?), people saved, learning output

Based on this analysis, selecting extreme weather as the scenario could apparently cover most of the ideas generated in this brainstorming, as this could also include cascading effects such as a fire in the electricity power grid due to fallen trees and dilemmatic situations such as several events appearing simultaneously and requiring priorities to be made. The rest of the elements mentioned in Table 1 served as feature ideas that could be inserted gradually during the VTT development. One of the challenges from the results was defining "the role in the game". Each actor mostly suggested a role that was in line with their own role in real life, resulting in broad variations with respect to the roles in the game. We brought these brainstorming results into a proof-of-concept tool development process, i.e. the first, and tried to start with developing an extreme weather scenario. We selected the extreme weather named 'Synne', that occurred in Eigersund, Norway in 2015, as a reference case to ensure the realism of the VTT development. While we do not discuss the development process in this paper, we could mention that the product of the first Scrum process was shown in the next workshop (see Figure 1) as an inspiration for getting the right information required for the project.

Workshop and Interview Results

On Technology and Crisis Management Issues

In this section we provide the background information taken from the discussions in the brainstorming and workshop that we would use for developing the SG. In the workshop, there were several problems identified as current crisis management issues, one of these being the lack of communication between the municipality and the police. Communication from the municipalities is defined in the emergency plans, but does not work well the other way. On technology, the need for better map support was raised. The municipality has a crisis communication technology today, but this does not include any common platform for electronic maps, as the map module from the technology provider is still considered too expensive. While there exist other map sources such as used by the regional power company for showing power outages, and the road authority map showing real-time information on closed or damaged roads, none of these maps are interconnected.

Another technology discussed was drones, which have been used for some purposes. However, the local responders currently only hire external services for drones when needed, or use them for testing purposes. The energy company that is a critical stakeholder often deploys drones for inspecting power lines. In a search and rescue operation, the responders may deploy a helicopter with an infrared camera that is very effective at finding people. This could also be done by deploying a drone. In the local Red Cross, the use of drones for emergencies so far only results from individual initiatives, and there is yet no national initiative. The stakeholders considered this as a characteristic for emergency preparedness in general, that often is fragmented and lack of coordination.

On Defining the Training Context

In line with the issue of communication challenges raised earlier, the stakeholders argued for the importance of realistic training in terms of using the actual communication solutions in use. They considered it useful to offer training in collecting the required information for establishing a situational picture in the municipality context. Further, they also pointed to the large differences between collecting information on a sudden onset event, e.g. a terrorist attack, and extreme weather forecasted five days ahead. The game should have different levels depending on whether the responders are in an operations central or the municipality, and who should be contacted. The game should have a system for 'picking' resources, as the participants often struggle with getting the right resource. In short, from the municipality perspective training in communication was repeatedly mentioned as necessary to be included in the VTT. While from the police perspective, training in decision making based on the flow of information was considered critical for effective emergency management.

In the current practice, emergency management actors learn from the evaluation reports produced after different events. However, there are two different practices for making an evaluation in the focused region, consisting of two counties. One county would run a series of exercises, and then the municipalities involved in each exercise would write the evaluation report with all learning points, self-assessment, and send this back to the county governor's office. This would then be used for quality assurance and ensuring that the emergency actors grasped the exercise goals. In the other county, the county governor's emergency management team themselves would write the evaluation reports, presenting to the municipalities what needs to be improved. In our VTT training design, these top-down and bottom-up approaches will be incorporated: on one hand, the players can derive the learning points by themselves for generating discussions with other players. On the other hand, the players can communicate the results and disagreements with more professional tutor. In other words, the planned VTT will accommodate possibilities for both self-learning and guided-learning.

On the Virtual Training Tool Design

As an introduction to the discussion on the VTT design, the facilitator explained the use of the event-based design for the VTT and how understanding the timeline of a crisis was important. In fact, the different stakeholders operate with different timelines in terms of their perceived role and when each stakeholder should start taking action. The left sketch of Figure 4 shows how the resources from the rescue efforts (police, firemen and health services) peak quickly in the acute phase of the crisis (thick line), while the municipality resources will peak after the acute phase (thin line), when other units are demobilized. The middle figure illustrates the *Information* vs. *Opportunity* where in the emergencies, the opportunity space for making decisions will shrink when the information level increases. The left triangle portrays the opportunity of decision making while the right triangle is the information level that starts accumulated over time. Figure 4 (right) matches the timeline suggested by the municipality, but is less steep in the beginning, as the preparation stage comes into the picture.

When such an emergency timeline is transferred into the VTT, the stakeholders agreed on the importance of presenting a correct timeline in the game, showing the actual delays between calling for resources and getting this in place, especially from the perspective of the fire services. However, if we think of the municipal crisis management, it needs to be considered how advanced this timeline should be, as it could also include affected

areas such as water and sewage, home nursing, etc. With an extensive design, the crisis management stakeholders could play with their entire organization. But the stakeholders also expressed a need to limit the scope of the graphical visualization in the VTT, as the information was perceived to be the core. As an example, if it is reported that water is rising and the municipality forgets to close the road so that some cars are trapped, then it is perhaps not necessary to show this in the game but just present it as vital information.

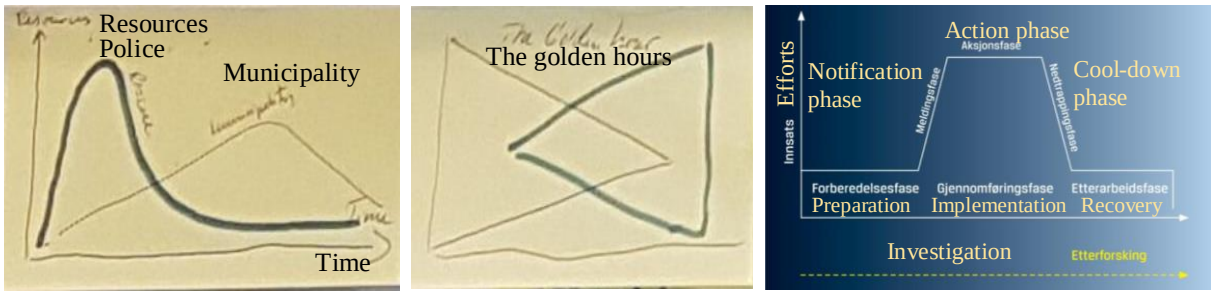

Figure 4 Crisis escalation over time and response as suggested by the municipality. *Left*: Resources dedicated for rescue (thick line) and municipality resources (thin line) as the crisis is evolving. *Middle*: The chart depicts how the opportunity space will shrink when the information level increases. *Right*: Crisis timeline as suggested by the police.

The firefighter argued for the importance of the first responders sharing information early to the municipality, the mayor and the councilman, and that this should be included as part of the game: "share the information you know, don't wait till you get all the pieces". The representative from the county governor's office mentioned that social media is currently not being used in emergencies, and that the county governor's office does not have a need for "every person's information" as they are only responsible for coordinating the information from the different relevant organizations. But he also pointed out that other stakeholders such as the municipality, the police and the fire department will have more need of such information. In short, with respect to the use of social media there were still differing opinions on the need of adopting it into their working procedures. Based on this opinion, we will treat the social media as an optional or a part of "nice to have" requirement in the VTT design, as for the training purpose, it is always good to have a possibility to make use of the new thing.

User Interface Suggestions

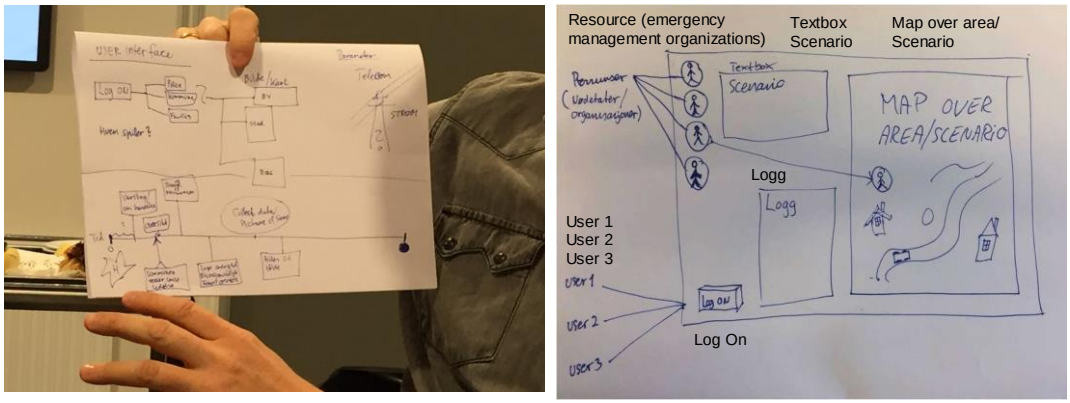

Figure 5 User interface elicitation. *Left*: a stakeholder presenting his idea. *Right*: example of a user interface idea

We conducted one round of exercise on the possible user interface that would be useful or in line with current practice for the different participants. As a starting point, we provided an illustration to trigger ideas, as shown earlier in Figure 3 in the Methodology section. Each stakeholder drew elements they considered would be necessary to appear in the VTT. Figure 5 presents results of the user interface elicitation.

The local Red Cross suggested an overview where one could get a good situation picture, but this should not be too complex. For example, for all kinds of vehicles (police cars, fire trucks, rescue boats, snow vehicles etc.), the number of vehicles and the crew for each of these should be listed. One also should know how many people have engaged in a rescue operation, and make sure that everyone returns safely. In the case of a volunteer organization, someone can join for two hours while others can join for two days. In bad weather, they have to know who is out there. In short, the Red Cross should be able to keep track of personnel including their volunteered time and material resources, which can be incorporated into the VTT design.

From the perspective of the fire services, the main collaborator in an extreme weather scenario will be the civil

defense, and the 110 Alarm Central (monitoring several municipalities) would be a branch that could provide resources for the fire services. Thus, the user interface would need an overview map with the ability to zoom in on actual buildings with flooded basement areas, so that one will know the affected area and the water level. Responders may have a dilemma in a flooding situation whether they should prioritize between evacuation from a parking basement or a nursing home with older people. If a fire is involved in the situation, data on weather and time is very relevant, as the firefighters aim to be ahead of the fire instead of running after it. In line with the responders' challenges in the field, the following elements were suggested to be included in the user interface: 1) *Weather data*: forecasts, wind directions and intensity, and its changes; 2) *Own Resources*: available resources and the number of deployed teams; 3) *Log of tasks*: completed tasks, new tasks, what is urgent and what can wait. A situation picture was considered essential. In practice, the fire services also need to balance between securing life and health of the victims and their own response personnel.

From the municipality perspective, their emergency management team would be put in operation when the they consider it is necessary. They create an overview, situation picture and focus areas to solve the event. The municipality will collect data such as images of the site from the media, for a better common situation picture. Moreover, there are some key parameters such as the kind of emergency situation, whether or not telecommunications and power are still available, etc. Thus, based on the log-on, the user interface will be adapted to who is playing the game: the police, fire fighter, heath service, municipality or volunteers. The map is vital for knowing the relevant area to manage. We also need a screen that can show the resources, emergency services and login button on who are the users. If it is the municipality who logs in, one gets a situation and can choose equipment, call resources, decide who will use it, which would be the same for the other responders. The decisions made can be updated continuously. There should also be an area in the interface that can show the new tasks and events continuously scrolling across the screen in relation to what has happened and being reported.

As we also considered the possibility to combine the VTT tool with some information flow into the game, we conducted a brainstorming to know what information would be important. The following data sources and technologies were mentioned in the workshop: GPS tracking of resources, interlinked-controlled swarms of drones to take comprehensive images, social media monitoring tools with a map interface, 3D video from smart glasses, weather information, and analyzed big data. In addition, satellite data such as from Copernicus, map with position, an overview of the resources and other data related to storm and flood threats are important. Lastly, on the choice of scenario the participants considered that extreme weather would provide possibilities for many different events that occur concurrently or as cascading effects. In fact, for local responders, there is currently limited competence in handling this scenario.

On Diverse Aspects of Training

There were some aspects discussed such as how the VTT should operate: whether the tool would be self-explanatory, or whether one should be able to stop during the game play for evaluation of decisions made, and then start again. For the latter design, the training would require a facilitator. The participants also discussed who should be the target users. One of the suggestions was that the tool should cover the full interplay between the different crisis organizations, to enable learning about the work methods of other parties. This because today, emergency responders work in a rather isolated way, sitting in their own "glass-bowl". In other words, a role-play type VTT was proposed where someone from each response unit can play, change role (login as another organization), and do joint evaluation afterwards. In this way, each actor can learn about the perspective of other emergency responders.

Finally, the suggested role of the VTT is to provide a kind of "theoretical exercise" that can support field exercises, and is thus not intended as a substitute for field exercises. For example, the VTT could be used before a full-scale exercise to ensure that the exercise focuses on the right things. And it could also be used after a full-scale exercise, for training in particular areas where a need was identified.

DISCUSSION

Challenges

In the elicitation process, we identified that each emergency responder organization has different challenges and goals in a crisis. The main challenge is how to accommodate different perspectives and needs from various actors and express them into manageable and doable tasks within the project timeline and available resources. Thus, careful design is needed to enable the research team to include as many needs as possible, and do the prioritization on "must have", "good to have" and "may have" features.

For the methodological part, the time allocation between the different activities were the main challenges. A couple of themes planned in several sub-sessions were discussed already before the intended sessions. Thus, we used shorter time to cover all planned themes. In contrast, the user interface elicitation proved challenging and

took longer time than planned as the stakeholders needed concrete example to be able to contribute ideas. Thus, we skipped an additional planned co-design activity, i.e. to provide color-coded labels on pre-prepared alternative user interfaces for indicating the importance of various elements. However, in general we achieved most of our goals, but we learned that flexibility and having backup plans are key for a successful co-design workshop.

Opportunities

Over the last 20 years, we have seen a development in game engines and what they are capable to do. As they have matured, they have broadened their scope from games for entertainment to include serious games, and training and e-learning applications. It is this development in game engines that have made it possible to develop a VTT, with limited resources, that includes realistic 3D surroundings, easy to use interfaces and multi-player possibilities as an alternative design to answer the competing goals issues of different stakeholders as described in the Challenges section. The new modern game engines have the tools available to create a virtual world that can potentially contain all the elements of what takes place in a real-world scenario.

The idea with serious games is to take the enthusiasm and fun factor from entertainment games and combine it with a purpose of learning a certain skill or master a certain situation. The use of different e-learning tools and techniques is expected to have a tremendous growth in the years to come (EU, 2014) and e-learning is expected tol grow to cover 30% of all educational provision before 2024. Through observation at our university we have seen that the use of multimedia and e-learning can both motivate and enhance the learning experience for our students. We believe that we with our VTT have accomplished a first version of a game that can actually ease the training and understanding of how to work with a crisis for different stakeholders. However, we should emphasize that the VTT is intended to complement real field drills, by training cognitive, analytical and critical skills. Field drills still represent a higher degree of realism for training contextual decision-making and coordination in time critical situations.

Lessons Learned

- *On the project goal*: the stakeholders thought it would be useful if the project could produce a tool that enables learning on the different emergency response organizations' working methods.
- *On the involvement of experts from different domains:* while the stakeholders represented have different roles in emergency management, their perceived need for improving communication between actors and coordination of resources enabled a common focus for the game. Thus, emphasis was given on interaction across the domains, rather than requirements specific for each domain.
- *On the requirements collection*: we managed to collect both high-level and detailed requirements that can be transformed into VTT tool features. We also have an overview of necessary and less important features, e.g., not all elements should be visualized into 2D or 3D objects, as text information is sometimes adequate.
- *On the elicitation method*: There were slight discrepancies between the plan and implementation as mentioned in the "Challenges" sub-section. However, we mitigated these issues by improvising during the workshop to ensure all points were discussed. The audio-video recording was very useful for extracting the most relevant information from the workshop.

CONCLUSION

The discussions with regional emergency management stakeholders in our project have revealed different perspectives and considerations regarding aspects that still need improvement in current emergency management practice. Training in decision making and communication are two elements that were emphasized, and information required in the VTT user interface and future use of the VTT has been identified. The results provide a strong basis for future research on the further development of Virtual training tools for emergency management. In particular, we identify five potentially fruitful avenues of development: (1) how to tailor necessary components into the tool; (2) information available in the VTT for the different players; (3) training guidelines with or without a professional mentor (4) usability testing; and (5) possibility to handle multiple roles as suggested in the brainstorming, with a multiplayer game as a potential future direction.

ACKNOWLEDGMENTS

The KriseSIM project is supported by Aust-Agder Utviklings og Kompetansefond and Sparebanken Sør, Norway. We thank the emergency management stakeholders in Agder, Norway, for their contributions in our workshops.

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