# Designing Context-Aware HCI for Collaborative Emergency Management

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**ABSTRACT**
When a disaster strikes the management and coordination of available resources becomes a crucial and challenging task. Hereby, availability of information and effective communication is of utmost importance. Efficient support for first responders and decision makers, coordinating the assignments, is necessary to save time and lives, as many victims might not survive long without appropriate assistance. Context-aware computing and adequate HCI can be key factors, supporting first responders as well as decision makers in their difficult tasks. This position paper discusses preliminary thoughts on basic questions relevant to the design of HCI for emergency management. A short overview of the challenges of HCI in emergency scenarios is given. Some implications of these challenges, the need for context-aware user interfaces as well as the careful design of interaction methods and devices are discussed briefly.

**Author Keywords**
Disaster Management, Incident Management, Emergency Management, HCI, Context-Awareness

**ACM Classification Keywords**
H5.2 [Information interfaces and presentation]: User Interfaces.

**INTRODUCTION**
The larger the impact of a disaster, the more different organizations (public but also private) are involved in all phases of disaster management: the preparation, the incident, and the debriefing phase. In our work we focus on the incident phase that can further be divided into five sub phases: orientation, decision, defense, recovery, and demobilization. Especially the first phases are critical, because they are chaotic by nature and influence the course of the following more structured phases to a very high degree. This results in an extreme time pressure at the beginning of the incident to limit the effects of the disaster and to assist injured victims [4].

Throughout the five sub phases, the provision and kind of information available is different: During the orientation phase information is sparse and not reliable; the main challenge is to get a broad overview of the situation and to extract the relevant information as fast as possible. During the decision phase more information is available but usually still incomplete and no common picture exists among involved parties. Therefore, a common relevant operational picture (CROP) has to be developed and communicated. Finally, the defense phase usually is characterized by a vast amount of information. Challenges hereby are structuring and condensing this information, and to distribute just the information to the partners that is relevant to them.

Using information and communication technology (ICT), especially advanced concepts of context-aware computing and HCI, can contribute to deal with these challenges and can help to improve the gathering, the processing, and the distribution of information. While the use of ICT is often recognized by individual organizations [16], the use of ICT across different organizations still involves many difficulties. We think that the full potential of ICT for emergency management can only be developed if these difficulties are solved. An important issue in this regard is the creation of simple but powerful human computer interfaces (HCI).

In the following, we will discuss the special challenges for designing HCI in the context of incident management. A case for context-aware user interfaces will be made and the design of the interaction methods and the selection of interaction devices will be discussed briefly. Finally, a brief introduction to the SoKNOS project, in which the authors currently are engaged in, is given.

**CHALLENGES OF HCI FOR INCIDENT MANAGEMENT**
There is a number of issues which have to be taken into account when designing human computer interfaces for incident management. The following challenges have been identified from literature research and in discussions with firefighters, people being in charge for incident management and operators of critical infrastructures.

1. Reduction of complexity
   Disaster management demands efficient decision making in extremely complex situations. Often, the exact size of the incident, the effects and the resources at hand are not completely known. Depending on the size there is a large number of organizations involved and a strong time pressure. To address this, there are well-designed methods in place in order to reduce this complexity (strict command structures, guidelines, procedures, etc). Although it is possible to have more information at hand using ad-

vanced ICT (like sensor networks [13]), it is important that user interfaces do not counter the reduction of complexity. Information has to be presented in a compact form and a common relevant operational picture has to be shared among all involved parties. The ease of use and simplicity of user interfaces is of utmost importance in order not to increase the complexity. Decision makers and field workers are working under stress and time pressure and have to interact with information systems in an almost casual way [3].

2. Priority of the primary task
   Interaction with information systems should not distract from the primary task, i.e. interaction devices have to be chosen according to the primary task [5]. For example, a firefighter usually needs hands-free interaction capabilities, while voice output may be distracting in a command center environment, because there is a need for communication between the persons working there. Therefore, it is absolutely necessary to understand the primary tasks in detail. Modeling approaches can contribute to this understanding in a systematic way and facilitate the choice of interaction devices and the design of suitable interaction strategies [11].

3. Heterogeneity of the involved actors
   There is a huge heterogeneity of involved actors: ranging from professional firefighters to voluntary helpers, from people working in the field up to crisis management groups at all political levels. They all have different backgrounds. While some have to deal with similar situations almost every day (although on a much smaller scale), others are highly unfamiliar with these situations. In order to deal with this challenge, user interfaces have to support the whole spectrum from novices up to very experienced, well-trained users.

4. Heterogeneity of ICT
   The involved organizations have different technological systems. Besides the huge challenge this poses for interoperability and ad-hoc integration from a technological point of view [14], this also implies a big challenge for HCI. It is not clear in advance how the information systems are structured, which kind of information is available, and what the exact environments are, in which they are used. Therefore, flexible and adaptive user interfaces are needed.

5. Security and Privacy
   Information security and data privacy are important issues to be considered [15]. Beyond guaranteeing protection for data exchanged in underlying networks, decision making has to be traceable. I.e. involved actors have to authenticate themselves (if possible in an unobtrusive way) and non-repudiation has to be guaranteed for some sort of audit [6]. Privacy also is an issue, as some organizations (like the police) and first responders may have to access sensitive information that is not to be disclosed to other participants [7].

## CONTEXT-AWARENESS

Context information can have a substantial impact on emergency response by contributing to an accurate view on the situation (as illustrated by Jiang et al. [10] for the case of firefighting). Thus, methods of context-aware computing may help shortening the orientation phase. It may improve emergency management in the command post as well as for mobile units. In both cases, context information needs to be adequately presented to involved emergency workers [17]. This can be on-site, by, e.g., using wearable computing, PDAs, smart phones [12], or further specialized devices. And in the command post, possibly using an interactive wall display, PCs, notebooks but also small personal devices like mobile phones. Emergency workers, typically the first responders in the field, can furthermore collect context information using their mobile devices; for example to mark places of victims with less urgent injuries, which allows to reach those who most urgently need assistance first.

Context-aware user interfaces can contribute to meet the challenges described above. By context-aware user-interfaces, we mean user interfaces that are able to adapt to the user, the platform at hand, and the environment (for example as in [2]). When *adapting to the user*, we can, e.g., distinguish between experienced and novel users. While experienced users can deal with a huge amount of information which is displayed simultaneously and in a compact form, for inexperienced users this information may have to be provided sequentially and with additional explanations. An adaption concept could address this challenge by reducing the cognitive load according to the user's experience and current tasks. This also helps to deal with the heterogeneity of organizations by providing the right information at the right level of abstraction. The distinction between different users is also important for security reasons, e.g. to meet privacy constraints of certain sensitive information.

By *adapting to the platform* at hand, we mean that the same interface may have to be rendered on very different devices. For example in one case on a desktop computer while in another case on wall-sized high-resolution displays. Besides different display geometrics, a desktop PC offers other kinds of interaction possibilities as a wall-sized display. This aspect accounts for the heterogeneity in ICT.

*Adapting to the environment* means taking available environment information (e.g., via sensors) into account. For example, in a noisy environment voice interaction is not possible. Also location information can be used to ensure the priority of the primary task. Depending on the location and the user, the current task could be inferred: a first responder who is still in the car may need some information to prepare for the incident. On the other hand, a first responder in the field may need some information on the exact location of victims relative to his current position.

## INTERACTION DESIGN

The HCI design has to match the tasks of ICT in incident management. In our opinion the following tasks are among the most important ones:

- Creating a common relevant operational picture (CROP) by providing information about the current situation and the availability of resources, by processing and filtering incoming information and by contributing to the assessment of the current state. The goal hereby is an optimal provision with information, to prepare decisions and to minimize the cognitive load of the users, while respecting data protection considerations as well.

- Provide advanced modeling, simulation, planning and analysis tools to improve the basis for decisions.

- Provide advanced communication capabilities to supply all involved parties with relevant information and improve command and control.

For the design of the human computer interaction, there is a clear distinction between those who work directly in the field and those who work in command posts and crisis management teams. For field workers wearable solutions are important. Field workers are *physically acting*, they need to communicate using ICT and need information regarding their direct surrounding (e.g., about nearby victims to be rescued, immanent threats and orientation). For this environment we expect a focus on audio and maybe tactile interaction with a possible extension with some visual feedback (e.g., maps or warnings on PDAs, important visual information in helmets).

In command posts and crisis management teams a different approach is necessary, as the staff focuses on *planning and organizing*. They need to collaborate and direct interaction [1] is necessary. Therefore, in these circumstances, multi-user interfaces are necessary. Visual information has the most important role in these environments. For example, large screens can be used to visualize the situation to the whole team. People can interact with these visualization to explain the situation and discuss solutions. Interaction should make use of usual interaction patterns for these working environments, e.g. rather using pens or pointers instead of keyboards or mice. HCI must be designed not to disturb the necessary direct interaction between the people but to support this interaction.

In the command post both is important: to provide a general overview of the situation and to provide all details of a situation if necessary. Zoomable UIs could be applied in this environment [8, 9]. They allow for an efficient navigation in large information sets by providing techniques like semantic zooming. Information is presented as an information landscape and the user can pan this information map. If he needs more information about a certain object, he can zoom in and more detailed information about the object is displayed.

The recently introduced surface computing platforms offer interesting possibilities especially for control center environments. Also, the use of large, high-resolution displays gets more and more common. However, while they offer multitouch and the option of several people working simultaneously, the identification and authentication seems to be an open problem. The use of such large, high-resolution displays in emergency situations is one of the topics of the recently started research project *SoKNOS*, described below, in which the authors are involved. It is planned to present first results at the workshop.

## THE SOKNOS PROJECT

The SoKNOS project aims at developing and testing concepts that are necessary to support governmental, private and non-profit organizations involved in public security topics. Especially in cases of major events, SoKNOS aims at supporting foresighted and quick actions, as well as increasing the reliability of such actions. The approach of SoKNOS is to look at a variety of related topics. Taken into account are situation models and context information, user and interaction models, management of cooperations, management of organizations, security, predictive analytics and simulation, adequate and adaptive user interfaces and interaction, service engineering, service migration, SoA[1] governance, service self organization, semantic technologies and network structures.

SoKNOS is hereby following a user centered design approach: it currently is gathering requirements from its application partners, in order to identify areas viable for improvement. Requirements are iterated between researchers, industry and application partners again. Finally, the collected requirements are used to refine the scenario (starting with a major flood) into use cases. Contributions from application partners, research and industry are then used to build a detailed vision of the SoKNOS system. The system will be based on a service oriented architecture; furthermore, building a control post using large, high-resolution displays to visualize geographic-based information, is planned.

## CONCLUSION AND FUTURE WORK

We illustrated some of the key challenges for HCI in emergency management. We argued that context-aware computing is a way to meet distinct requirements for HCI in this field. While wearable computing seems applicable in the field, emergency management in the command post probably needs techniques to maintain a common operational picture. It further should provide an effective overview of the situation with the option to have access to all details without losing the orientation. In the future, we plan to investigate the challenges more systematically in the scenario given by the SoKNOS project described above. We plan to build prototypic control posts where we want to apply the techniques we have discussed in this paper to investigate their potential together with end-users.

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