# Supporting Palpability in Emergency Response

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## 1. Abstract

This paper investigates how to design ICT support for emergency response. We conceptualize the incident site with people, vehicles, buildings etc. as boundary objects over which complex and imperfect work of coordination is done – and discuss how a 3D representation of these entities may be used as a way of bridging between the physical entities and the body of digital information about the site and the different entities, accumulating as the incident unfolds.

## 2. Introduction

To get an impression of the characteristics of an emergency response situation it is important to remember four central issues that characterize incidents: 1) they are (most often) life threatening, 2) time critical, 3) happens in unknown settings, and 4) there is lack of resources. This gives an idea of the level of stress and confusion that easily may arise in en emergency situation – and of the conditions for the design and use of technology support.

As a part of the PalCom project [8] we develop ICT support using Participatory Design [1, 3, 5]. We experiment with prototypes that can support all those involved in response work in major incidents: police, firefighters, ambulance personnel and medical staff. We develop support both for those who are working at the emergency site and those who are carrying out work away from the site (e.g. in the alarm centers, at the hospitals who are receiving the injured people and the vehicles going to and from the incident site). The structures, processes and problems in emergency response are described in more detail in [4].

As described in [4] each of the involved emergency responders takes responsibility for – and carries out each their part of – the response work, depending on the incident and its characteristics and the person's role, training and skills. Often a certain person has a predefined role in a specific emergency response situation, depending on a set of known – and exercised – rules, e.g. the first doctor, arriving at the incident site becomes the medical coordinator, and the first ambulance driver who arrives becomes the ambulance manager. It is also decided on beforehand who is in charge from the police and fire brigade. Those of the responders, who are working 'on the floor', i.e. those who are in direct contact with the incident and the victims, are assigned to specific tasks most often when they arrive. It becomes more and more common that these principles, describing who is going to do what and how things are structured and organized, are described in what is called an *Incident Command System, see e.g. http://training.fema.gov/EMIWeb/IS/is100.asp*.

Today most of the information used during the execution of a rescue operation is acquired by interacting in the setting, e.g. with (other) rescue workers and injured people at the incident site. Information from the incident site to hospitals, remote command centers, rescue vehicles etc. are communicated via incident site radios and cell phones. In addition some text-based ICT systems are used to communicate between some of the remote command centers and hospitals and these centers and hospitals and the rescue vehicles. Paper documentation is formally required, especially regarding the medical work, but is seldom produced on site. However, during ambulance transport an ambulance patient record is partially filled out and when the emergency response is over more paper documentation is produced, especially by the doctors. Thus the setting itself is the primary source of information and for this reason we, in line with [4], conceptualize the incident site with people, vehicles, buildings etc. as boundary objects over which complex and imperfect work of coordination is done. We term this the "physical information space".

## 3. A Scenario

As a background for our discussion of how to design for palpability we sketch an incident situation and some of the issues involved:

In a level crossing a train at high speed has crashed into a truck, causing the train to leave the rails. Moreover the truck has exploded and that has caused a fire also in one of the railway carriages, resulting in many heavily injured people. The incident has happened in the country side in a sparsely populated area around 40 km from the nearest hospital with emergency response capacity. As the involved responders are carrying out their work they need different types of information to do so.

A) One of the medical teams, carrying out first aid treatment of some of the injured people from the train incident has realized that they have almost run out of pain killer. So, they have asked for a rather huge amount of pain killer and should receive it soon with one of the returning ambulances. They now want to know when they will receive the medicine.

B) The ambulance manager wants to know where the available ambulances are.

C) The police manager and the fire brigade manager in charge both need to know where 'their' different groups of responders are.

D) The police manager needs to have more police at the train accident. Since he knows that the most obvious road is blocked, he wants to give the three specific wanted crews information about which route they should use, to get there.

E) The fire brigade manager recognize that a certain tool is needed by a specific firefighter crew, and he wants to find the tool, which he believes is in a certain fire engine, and have it brought to the crew.

F) The incident is huge, and the police and fire brigade managers in the On Site Command Post needs support regarding specific tasks, e.g. to handle the press and the contact to relatives, but also to support with specific information about available resources. At the nearest police station a Remote Command Station is established, to support the On Site Command Post. It is important that there two groups can communicate.

G) At the triage[1]/waiting area the medical coordinator wants to see how many injured people there are of each triage category, and he would also like to know the conditions of the injured people, who are trapped in the train carriages. He needs the information to find out if he has to call an extra medical crew to the emergency site.

H) At the main hospital in the area, the doctor in the remote acute medical coordination centre working as hospital coordinator is going to plan and coordinate the medical emergency response at the hospitals. S/he has to coordinate with the involved hospitals based on information on which types of injuries each hospital can treat – and what the capacity is.

I) In addition the hospital coordinator needs to how many injured people of which type and triage category there are and when they leave the incident site

J) The receiving hospitals need to know how many injured people of which type and triage category they are to receive and the estimated time of arrival.

K) When the injured people arrive the trauma team at the receiving hospital need information about the condition of the patient.

L) And the hospital needs to be able to follow each patient as they are moved around the hospital from the receiving trauma room to e.g. scanning, operational theater and intensive care.

## 4. Design Principles and vision

A main characteristic of emergency response is that acting in the physical world, e.g. treating the injured people to save lives, is what matters – ICT support is secondary and should improve the actions in the physical world. However experiences from real major incidents, e.g. [9, 10, 11, 12] show that use of ICT systems have been

[1] During triage victims are categorized by a doctor according to the severity of their injuries and treated according to these categories: 1) Needs treatment immediately, 2) Needs treatment as soon as possible, 3) Treatment can wait, 4) Deceased/beyond treatment.

sparse or difficult due to e.g. malfunction, lack of interoperability and integration, and lack of usability and usefulness in the context of the incident. In [4, 6] it is argued that when developing ICT support:

- focus should be on issues that are immediately relevant to the saving of lives
- systems and devices has to be effective and efficient – in reality this means that they should preferably be understood, known and practiced by the users on beforehand, and
- they should be technological stable and trustworthy.

In our current work on ICT support we use these principles as a starting point for investigating how to enhance what we in the introduction termed physical information space with palpable, digital information space.

A first observation is that most of the response workers on site are interacting with physical entities directly: other response workers, injured people, medical equipment, vehicles etc. The digital information space will contain information about these entities and to avoid adding an extra 'information access method', we have formulated the following principle:

*Physical entities, people, vehicles etc., should act as "access points" also for the digital information.*

Secondly, we noted during our field work that virtually no information is entered on site, due to time critical work and lack of resources. At the same time we noted that a lot of the information formally required for documentation, is available through inspection of the physical entities, primarily the injured people, e.g. when looking at the injured person it is immediately visible if a neck collar has been mounted or intravenous infusion is given. This led us to formulate the following principle:

*When providing digital information focus should initially be on information that is not immediately available through inspection of the physical world.*

Finally, it is a characteristic of many major incidents and all disasters that some equipment and systems as well as parts of the infrastructure malfunctions or break down. In these situations the rescuers could benefit from ability to improvise and use alternatives [7]. To illustrate: One of the firefighter managers involved in the 9/11 response once said in an interview: "I have looked and examined the whole response to the trade centre. I whish we would have seen while we heard what everyone saw on TV. We didn't get any messages that the top 15 floors were glowing red or the building looked like it was going to collapse".

This led us to formulate the third principle for design of ICT support:

*Allow for – and support – use of not preplanned technologies.*

### The vision

Two issues play a pivotal role in supporting the many different emergency responders (and/or groups of responders) in getting information and creating and maintaining overview on the levels they need:

a) information about *where* people (injured and/or responders) and things are
b) information about the *conditions* (broadly speaking) of people (injured and/or responders) and items

This – together with the above listed principles – has led to the following design vision:

*The ICT-support for emergency response should align the physical and the digital information space.*

## 5. The prototypes

As a first step towards realizing the vision we have decided to work with 3D maps of incident areas, and to locate the entities of interest in this map, cf. Figure 1. This is the first step in the alignment. The second step is to provide access to digital information about an entity both via the physical entity itself and via its representation in the 3D map.

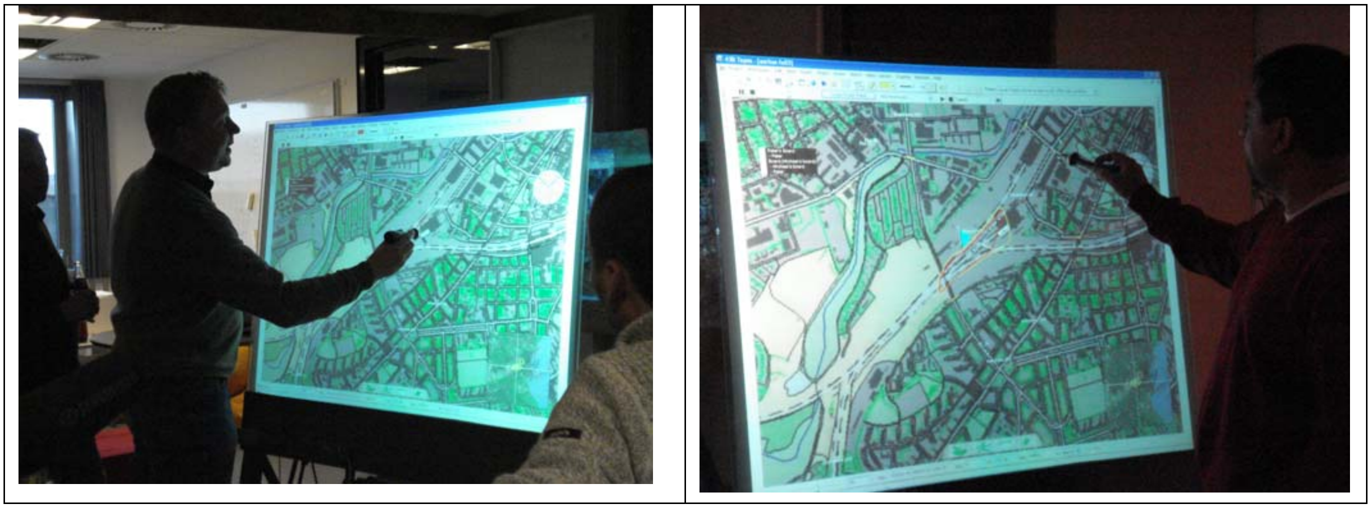

**Figure 1 Shared views on maps**

Until now we have worked with representations of the following entities:

1. Emergency responders
2. People who are involved in the incident (and who may be injured or not)
3. Emergency vehicles (e.g. ambulances, police cars or fire engines)
4. ID devices, e.g. RFID tags and readers
5. Location devices, e.g. GPS
6. Bio-monitors
7. Cameras (video or still picture)
8. Radios
9. Base-stations (computers with communication capabilities)
10. Displays

The first three types of entities are those of primary interest. The rest are used to provide and handle information about the entities of primary interest. Thus the ID devices are used to provide unique IDs for the primary entities. The biomonitors provide information from one or more biosensors etc.

When combining physical entities (e.g. an injured person, an RFID reader, a GPS and a biomonitor,), these will be represented as an assembly in the digital world (and e.g. shown on a display running the map prototype). This assembly provides information regarding the assembly (e.g. "Patient X is at position A and his biomonitor signals are …").

We have chosen to represent not only the entities of primary interest and the information available about them, but also the devices involved in providing and handling that information. There are two reasons for this – and they are both related to the issue of palpability:

First of all, if one wants to inspect one of the devices, e.g. a biomonitor, it is important that this device itself is also part of the digital information space. Secondly, when these devices are part of the digital information space we may also support interacting with them through this space. To illustrate: if a motor controlled video camera is represented in the digital information space we may use that representation to turn and zoom the camera – and to inspect its status incase of malfunction.

It is also possible to draw on the 3D map – to show a digital representation of e.g. where the inner and outer barriers are, where the triage area is and which roads ambulances or fire engines have to use as access roads to the incident sites. These sketches are also available on every display running the map prototype and can be used by any responder who needs the information.

The prototype takes an already developed software product, *Topos* [2], as a starting point. Topos is 3D dynamic visualization software that can be used for modeling and representation of different objects. Moreover it is developed to support collaboration across distances through shared views on different screens.

## 6. Designing for palpability

The principles and prototypes presented above work together to provide palpability in use. First of all the alignment of the physical and the digital information space support the user in transferring 'material strategies' to the digital space. To illustrate: information about an entity may be acquired through physical interaction with that entity, e.g. examining person with a broken leg. In addition digital information may be accessed through the physical entity, e.g. by RFID scanning. And finally digital information may be accessed through the representation of the entity in the 3D map.

Secondly, the alignment supports transfer from the digital to the physical by exploiting the 'well-knowness' of maps. To illustrate: creating - and communicating - digital entities in the 3D map, such as inner and outer barrier, simplifies the work of transferring these barriers to the physical world tremendously compared to a verbal description communicated over a radio.

Thirdly, the digital representations of the different devices supports inspectability, that is, the digital representation of e.g. a camera can be used to inspect that device: if it is working as expected, if failures have occurred, the type of failure etc.

Finally, the digital representation may support users in dealing with complexity in the physical world, especially when things scale up, i.e. when an incident is major, with many injured persons, spread over a large area and involving a huge amount of rescuers and vehicles and other equipment. In this case moving around in the 3D map may be used as a way of focusing attention on the entities nearest to one self.

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