Fire crews at work: Information Technology Challenges

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ABSTRACT
This paper reports from a study of operative fire crew work and information technology design. Introducing information technology in fire crew work has positive effects but also negative consequences on the work practice. The aim of this paper is to identify technology challenges that will be faced when introducing information technology for this setting. The following three challenges are identified and discussed; fluidity of tasks and contexts, serviceability of technology, and collaboration.

Categories and Subject Descriptors
K.4.3 [**Organizational Impacts**]: Computer Supported Cooperative work

General Terms
Design, Human Factors

Keywords
Technology challenges, ethnographical field study, fire crew

1. INTRODUCTION
Efforts in the field of Computer-supported cooperative work (CSCW) have resulted in numerous studies of professional workgroups with the common objective to understand system design requirements of cooperative work. Early influential studies focused on social groups in office settings revealing fundamental aspects on how work is socially accomplished and differing from formal organizational routines [13]. Other studies have revealed how people in office settings accomplish remote collaboration with colleagues that are geographically distributed [1]. Studies of time critical work in control rooms have resulted in an understanding of a need to be able to bring functionality from the control room into the field setting when the worker leaves the stationary setting [5]. In the border of CSCW and Human Computer Interaction (HCI), studies of service technicians in industrial settings and field service have focused on remote collaboration and specifically focusing on the issue of providing information technology that is able to operate when the hands of the user are occupied with manipulation of machine components [2, 8].

This paper reports from a study focusing on the work of fire crews and information technology design. Remote collaboration, moving between contexts and tasks, and physicality of information technology are all issues that will have implications on information technology design for this setting. The challenge in this setting is to provide artful integration between information technology, tasks, structure and actors.

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2. METHOD
In recent years, several books have published accounts of the "heroic" dimension of fire crew work [11, 12]. However, only limited research [14] has been published where focus is on the daily work of fire crews. In this project the widely adopted approach of ethnographical field studies [4, 6] has been used to gain a thoroughly understanding of the people and work practice of the fire crew. The field study has covered several fire and rescue services in different geographical regions in Sweden and consists of approximately 670 hours of participant observations. The majority of time, 550 hours, has been spent with a single fire crew. During this field study, the author has been participated in all activities of the fire crew on day and night shifts.

The author has intentionally taken a position on the fire crew side when exploring information technology support in this setting. The fire crew is the problem owner when exploring how information technology will have consequences, positive and negative, on their work. Participatory design (PD) techniques [7] such as future workshops, case-based prototyping and mini-seminars of alternative technology use have been used in this study to collect data to broaden the understanding of how information technology can be used in this setting. Further, the workshops have also aimed to provide higher awareness of the fire crew concerning how information technology in a direct way can improve their ability in emergency response. Perhaps most important, the workshops have aimed to reveal inconspicuous but critical aspects that are central for making information technology a natural support technology in fire crew work.

Based on this background the following research question will be elaborated: What are the challenges when introducing information technology in fire crew work?

3. FIRE CREW WORK SETTING
The fire and rescue services are as many other organisations under constant change to meet the demands from the society of increased effectiveness and limited resources. This change is also a reality for the fire crew. Lewitt's organisational change model [10] is used to structure the field study observations. Further, the model will be used to identify and analyse technology challenges of fire crew work. The model views an

organisation as a complex system with a set of fundamental and interrelated variables. Changes in one of the variables have implications on the other variables.

3.1 Tasks

The tasks of fire crew work can be divided into three broad functional types; preparedness, prevention and response. Preparedness consists of the fire crews tasks and responsibilities aiming to maintaining a high-level of preparedness for any plausible incident situation. Primary concern for the firemen regarding preparedness is on technology and procedure competences of using tools, heavy equipment and vehicles. Equally important as tool competence is to maintain knowledge about the local district regarding street names, contextual restrictions in specific areas and knowledge about risk objects (industries, hospitals, child-day centres, homes for older people, shopping malls, etceteras).

Accident prevention aiming to reduce the number of accidents using a proactive approach has in recent years gained increased focus. This has resulted in an increased number of visits by the fire crew to schools and workplaces, informing about fire safety, appropriate behavior in emergencies, and also arranging exercises.

Response is the historical and fundamental task for the fire crew. The command centre is responsible for the call out process of a fire crew to an incident. The alarm is sent via an intercom system to the fire station and consist only limited information. While being on enroute to the incident location contact is established with the command centre and additional information is communicated. On arrival to the incident location the fire crew starts to deploy appropriate equipment and the incident commander starts the work of getting a situational overview. In the early phase of the response work the fire crew follow a predetermined work pattern with intense communication with the fire crew foreman and the incident commander.

3.2 Contexts

The contexts where fire crew work is accomplished are more than a few, each having its own unique characteristics. This section presents briefly the contexts of the home base, enroute, and transitory locations.

The fire station is the home base of the fire crew and is sited centrally in local the district. As a home base, the fire station provides facilities for a range of activities. The garage, mechanic workshop and equipment storing room are targeting the needs to manage and maintain vehicles, tools and other equipment. Locker rooms, sauna, sleeping quarters, gym, TV-room, and the pub are areas for recreation, physical exercise and activities on non-scheduled work hours. The kitchen and dining room are locations for food and coffee breaks as well as general social activities. Classrooms, office of the fire crew commander and fire crew foreman are locations for formal learning activities and administrative work.

Enroute is the work context when the fire crew is moving between geographically locations such as driving from the fire station to an incident location. The enroute context consists physically of various vehicles. The primary vehicle is the rescue vehicle equipped with a wide range of tools and equipment for typical response operations such as; fire in buildings, traffic accidents, water rescue, and minor chemical accidents. Secondary vehicle is the ladder vehicle providing a mechanized ladder for evacuations of people from buildings and a platform for work on building roofs. These vehicles constitute the work context when the fire crew is driving to an incident as well as in preparedness activities such as exercises and orientation.

Transitory locations are all the geographical locations to which the fire crew arrives to perform emergency response, preparing as well as prevention activities. The fire crew is trained and equipped to be able to fulfill their activities regardless of contextual restrictions in geographical locations, let it be apartments, industries, office complexes, along highways, etceteras). The notion of transitory locations elucidate that this context is temporal in time, its restriction, and its location. Further, these locations and its conditions vary from one emergency to another. Meaning that the fire crew must be able to fulfill their mission regardless of the context but at the same time be aware of the context to deploy the appropriate tools and procedures.

3.3 Structure and Actors

The fire crew is part of a larger hierarchical structure with several actors constituting the emergency management system. In top of this structure is the Chief Fire Officer responsible for the overall emergency preparedness and planning of the region. Depending of the size of the fire and rescue service, the Chief Fire Officer have a command centre, under the command of the Chief of Staff, where command centre operators handle the operative decisions and dispatch of fire crews. Command centre operators are senior firemen recruited from the local fire crews. Every fire crew has an appointed fire crew commander and a fire crew foreman. The fire crew commander has the role of incident commander when the fire crew are dispatched to on an incident. The fire crew consist of six to eight firemen that are assigned to different roles determined by a rolling schedule for each shift. This hierarchical structure is also an illustration of the chain of command and normative communication structure, compulsory in emergency response operations.

3.4 Information technology

Information technology in the rescue services has mainly been an issue for the administrative- and command centre-functions and not a priority for fire crews. This has changed in the last few years with the introduction of desktop computers at the local fire stations. Today, all firemen have access to shared computers and individual network accounts and e-mail addresses on the communal fire and rescue services network. The fire crew has access to office programs, reporting systems and information repositories including Hazmat databases and digital maps.

The rescue vehicles are by no means an excluded area for information technology use. The information technology installed in the vehicles is currently primary aiming to provide support for the fire crew in case of alarms. Depending on the type of fire and rescue services, urban or rural, different approaches has been adopted when equipping rescue vehicles with information Urban fire and rescue services that can rely on a command centre and Mobile Command Vehicles have less information technology in the rescue vehicles contrasted to rural fire and rescue services. Rural fire and rescue services with limited command centre resources or Mobile Command

Vehicles have more information technology installed in the rescue vehicles. Information technology installed in the rescue vehicles range from traditional route planners without remote positioning, map-systems with remote positioning, to laptops with hazard material and property databases including advanced GIS and positioning functionality.

Mobile information technology on the accident location is still a relatively untried territory for Swedish fire and rescue services. Mobile phones and a selection of handheld radios are the only information technology currently used outside the rescue vehicles on the accident location. Initial experiments, conducted by the Swedish rescue service agency, have elaborated the benefit of handheld computing and wearable computing aiming to support command functions on large-scale incidents.

4. TECHNOLOGY CHALLENGES

There are numerous challenges when introducing and designing information technology for fire crews. In this section based on Lewitt's model, three important challenges of information technology will be presented and analysed in relation to the variables task and context, actors, and structure.

4.1 Fluidity of work

The technology challenge of fluidity of work targets challenges related to the relationship between the task and the technology variable of Lewitt's model. The work of fire crews are characterised by fluidity of task and context and is a consequence of the very nature of emergency response work. Many of the activities conducted during a workday cannot be known in advance or scheduled. The fluidity of tasks is driven primarily by sudden requests for emergency response. An alarm could at anytime interfere with the current ongoing and scheduled activity, leaving little choice but to respond. Further, situation specific circumstances of the location and creativity of the fire crew contributes to fluidity. Being in a specific location for one task creates the opportunity to improvise a different task.

An example of this is when the fire crew is responding to alarms triggered by automatic fire detecting systems. These types of alarms are very common, but only a fraction of them concerns a real emergency. In most cases the alarm has been triggered by mistake. Being in a situation where the fire crew has been dispatched to a false alarm, the incident commander sometimes take advantage of the situation and perform a short orientation on the facility and by that changing the task from emergency response to a preparation activity. The context is not changed only the task. The change of task is not scheduled in advance but the situation creates an opportunity for an ad-hoc activity.

The fluidity of contexts put focus on the transition from one context to another in one specific task. Fluidity of contexts is most visible in the task of response. The fire crew will in this task move from the stable and geographically fixed context of the home base via enroute in vehicles to the transitory location of the accident site.

The current technology support for the response task is dependent on technology designed for each specific context without any integration capability. For example, the use of the wall-sized map in the fire station garage does not have even the simplest integration with the route planners in the rescue vehicles. Further, the fire hydrant map lacks integration to the route planner. This means, for each activity, the different users must start over and lookup the address, without being able to benefit of previous activities.

The challenge is to move away from context or tasks specific solutions and try to strive for information technology that can handle the fluidity of contexts and tasks. Information technology focusing on one task in one context has the risk creating a situation where the fire crew not only have a large selection of physical rescue tools but also a wide selection of information technology, each having it's isolated purpose and use.

4.2 Serviceability

Serviceability is a fundamental technology challenge focusing on the relationship between the technology and the actor variable of Lewitt's model. Serviceability means the ability of the technology or system to provide distinct value and easy of use for its particular user. The importance of serviceability is evident in emergency response, where rapid intervention in crisis situations accepts limited time for system time-delays or time-consuming interaction. The following quotes from a future workshop illustrate this issue.

"IT must give me something that I need in the situation I currently face. If it fails to do so, I will only waste my time and I wont use it anymore" (fireman)

" We do not have time to click around and look for information. It must somehow be very simple to use, we are no IT-experts" (fireman)

" It [information technology] must be firemen-proof" (fireman)

As the quotes show, information technology must therefore deliver a distinct value for the user. Such value is related to the direct benefit of using information technology for the specific situation confronted by the user. If the system fails to fulfil these needs, it will not be used. The fire crew has an implicit mandate to approve or discharge which tools that will be used. These requirements could be interpreted as the firemen view the use of information technology similar to the current practice of physical tool use. This means that information technology must be designed not only to provide value but also to be perceived as being a tool for the fireman, being on their side [2].

The technology challenge of serviceability is to provide information technology that has distinct value to its intended actor and that supporting technology is perceived as a "firemen-proof".

4.3 Collaboration

The last technology challenge presented in this paper concerns the structure variable and the relationship to the technology variable of Lewitt's model. Providing information technology on a fire crew level will have implications of collaboration and transfer of responsibility between the actors in the emergency response structure. In emergency response operations, the fire crew and the incident commander are highly dependent on information from the command centre. The incident commander and the fire crew need access to relevant and valuable information that helps them to make sense of the emergency and potential restrictions on the accident location. Delivering such information is problematic, due to the variety of emergencies that could be faced. The following quotes illustrate this problem.

" they [command centre operators] must understand what we [fire crew] would like to know" (incident commander)

" sometimes one wonders what they really do at the command centre" (fireman)

In a number of rescue services in Sweden, laptop computers has been installed in the rescue vehicles to provide access to information repositories otherwise only available on the fire station or at the command centre. However, moving the office and command centre systems into field settings will introduce more problems than it will solve. The office systems and its content are not designed to be used in a vehicle during high speed driving or to be used on an accident location. Distributing information retrieval tasks to the fire crew that are closer to the phenomena of concern is at first thought a good idea. But the consequence will be added responsibility and isolation of the fire crew by disconnecting them from the command centre. The technology challenge of collaboration is to understand how the actors structurally separated could be supported by information technology that improves communication and collaborative activities. This means that there is a need to establish a balance between pushing information from the command centre and the fire crews own ability to request information. Studies of communication support for physical work in bicycle repairing [9] presents interesting directions for this design challenge.

5. DISCUSSION

In previous sections, technology challenges regarding; fluidity, serviceability and collaboration has been identified. The fluidity of tasks and contexts urges for design of IT that provide systems and artifacts that could be used in several tasks and context and in the transition between tasks and contexts. Serviceability calls for designs of systems and artifacts that are targeting to the needs of a specific use situation. These two challenges are potentially conflicting. This conflict could potentially be avoided by focusing on the collaboration between the fire crew and the command center operator.

The fundamental technology challenge is to establish a harmony between the fire crew and the command center and provide communication functionality that fuse these two actors regarding responsibility, while at the same time separating their individual tasks. The fire crew has a need to be better supported of timely information. The fire crew is the actor closest to the phenomena of attention, the emergency. This means that they are in the best position to value what information is needed. But they are not in the best position to actually retrieve such information, which would potentially lead to a range of specialized information technology. The actor in best position to do this is the command center operator. This distinction put focus on enhanced functionality for collaboration between the fire crew and command center operators. Information technology should be used to integrate the two actors, not to increase separation or disconnecting them.

Returning to the research question, the answer suggests that the primary challenges when introducing information technology in fire crew work are; information technology must support the fluidity of work, it must have a high-level of serviceability, and improve collaboration between the fire crew and the command center.

Contributions of this paper are evaluated by relating them to the three perspectives suggested by Greenbaum [3]. From a pragmatic perspective, this paper provides findings regarding fire crew work practice and challenges for information technology design. Further, findings for the theoretical perspective is also presented, highlighting the need for designers of information technology to actively participate in the real work setting to gain thoroughly understanding of the setting and the value of providing prototypes for hands-on experiences. The contribution of this paper also touches briefly on the political perspective targeting the need to design information technology that are firemen-proof and thereby improve quality of work life.

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