Empowering the Responders to Learn From Real Incidents: A Swedish Research Initiative

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Abstract

Emergency incidents are by nature complex and demanding. Responders often have to work under time pressure and sometimes even under life-threatening conditions. The quality of the activities that the responders carry out during the incident often has a decisive effect for the total outcome of the operation. To be able to learn and improve from past experience it is necessary to be able to reflect on the rescue performance in relation to the specific incident. However, it is difficult for the responders to recapitulate the course of events and to be fully impartial about their own performance during the operation.

Based on the successful results from the training domain we are now ready to start investigating what methods and tools used in computer-supported full-scale emergency training are applicable for monitoring real emergency incidents. Our approach is to form a team of decision makers, scientists and responders capable of addressing these issues. In this paper we describe the first steps in a research initiative that will provide the responders with means of detailed registration of rescue activities. Together with flexible visualisation tools we strive for improved feedback and evaluation after each rescue mission.

Introduction

Rescue operations are often complex and demanding tasks. First responders have to collaborate in the field to save lives and property. Command, control and communications must be performed efficiently to manage available resources both to solve the task at hand, and to keep a certain level of readiness for response to possible new incidents.

To acquire and sustain the ability to perform various rescue operations the rescue agencies need to devise appropriate plans (Jenvald et al., 1998), develop standard operating procedures, and design common training programs (Morin et al., 2000b). All these tasks require a fundamental understanding of the processes involved in a rescue operation and their interaction (Flanagan, 1954, Raths, 1987; Salas et al., 1992; Fredholm, 1996). Means to this end include the careful analysis of real disasters and after-action examination and evaluation of rescue exercises (Rejnus et al., 1998). To be able to learn and improve from past experience the responders need to be able to reflect on the rescue performance in relation to the specific incident. However, it is difficult for the commanders, leaders and fire fighters to recapitulate the course of events and to be fully impartial about their own performance during the operation.

The most important goal for the research initiative presented in this paper is to increase the possibility for the responders in the rescue community to systematically learn from real operations as well as from different exercises. We want to provide the rescue forces with the methods and tools appropriate for conducting constructive after-action reviews with their personnel after each training opportunity or real incident. Our approach is to form a team of decision makers, scientists and responders capable of addressing these issues. The goal is to devise a set of methods and tools that the responders can use themselves to help them document and learn from real operations. We will work bottom up by supporting the responders with methods and tools for automated registration of their operational activities. The recorded data will be used together with a computerised model that represents both the rescue organisation and its various activities. After each rescue operation it is possible to review the model and make detailed studies of various phases of the operation. It is mandatory that the applied methods and tools do not interfere with the responders' ordinary rescue activities.

To achieve this goal we work towards three sub-goals. The first sub-goal is to provide the appropriate means of automated registration of real operational activities, so that the feedback to the responders is based on unbiased data whenever possible. To be successful, this work must be carried out in close cooperation between the scientists, the practitioners and the domain experts in the project.

The second sub-goal is to investigate and develop methods and tools for compiling, representing and visualising various rescue activities (Morin et al., 2000a). This goal is necessary if we want to be able to replay and distribute the lessons learned in a way that makes is possible both for participants in the actual operation and for external viewers in the rescue community to learn from what really happened.

The third sub-goal is to explore the training activities at the Rescue Colleges and suggest how a combination of the lessons learned from real incidents and the methodological and technical findings from the research community can improve the training at the rescue colleges.

In the following we present a number of critical requirements for our research initiative. We also briefly describe the training at the rescue colleges together with the first steps of our approach when it comes to monitoring the rescue forces during real operations. Finally we discuss preliminary methodological and technical means of achieving the goals of the research initiative.

Preparing the Responders

The goal of the establishment of resources for emergency management and response in our society is to prevent incidents, and in the cases when they nevertheless occur, minimize their negative consequences. To maintain a particular level of preparedness and to adapt to the increasing requirements of safety in our society, the rescue forces have to continuously develop their organisation and procedures. The standard operating procedures have to be regularly assessed to assure the quality of service.

There is a number of activities that promote high-quality preparedness of our rescue forces. One activity is the basic training that fire fighters and rescue personnel conduct. This training is supervised by the Rescue Services Agency and delivered as centralised courses at the Rescue Colleges. However, to continuously develop the rescue force, the training has to continue at the local fire department after the end of the individual training too. Another important activity is when the local rescue departments arrange local training events both for individual and team training. Finally, leaders and commanders attend both centralised courses and perform individual studies. These and other activities for organisational development can benefit from a systematical approach with three major phases:

1. *Documentation*. The first phase is the ability to observe and document the current situation. This may seem simple, but often methodological support and an external view provided by researchers can help the organisation to describe its own activities in an unbiased way.
2. *Analysis*. The second phase includes analysis of the documented description of the organisation and the activities. Now it is possible to relate and compare the goals and mission statement for the organisation with the analysis results.
3. *Communication*. The third phase includes the changes and improvements of both the organisation and the various operational activities. During this phase it is of utmost importance to communicate not only the changes needed, but also the analysis results, in order to improve the understanding for the need of changes and the required participation from the members of the organisation.

The corresponding description of our approach and its application to training and monitoring of real rescue operations is (1) the recording of the rescue performance as *documentation*, (2) the compilation and *analysis* of recorded data for the analysis

phase, and (3) the visualisation of the rescue activities as a means of *communicating* the lessons learned with regard to the prerequisites for the response.

Roles and Requirements

One of the motivations for our research initiative is to increase the usability of different research results by involving the practitioners in the definition of relevant research questions. There is also an increased awareness of the need to improve the knowledge transfer from scientists and domain experts to and among practitioners in the field.

The different roles for the authorities participating in the research initiative can briefly be described as:

- The Rescue Services Agency (SRV) is responsible for the national competence in the rescue area. SRV supervises the formal training programs that are carried out at the Rescue Colleges. The agency has the national lead role for documenting, maintaining and developing knowledge regarding rescue operations. SRV also initiates research programs in the rescue area and is head of our joint research initiative.
- Linköping Fire Department represents the first responders and the real users. The department formulate the operational requirements and supports the research project with operational expert competence. Linköping Fire Department hosts the field trials.
- The Defence Research Agency (FOI) has the scientific competence that is essential for the research project. The agency brings methodological and technical competence together with international contacts in the research community. The agency has long-term experience from development of methods and tools to support analysis of organisations and operational activities in the military and civilian defence.
- The Swedish Armed Forces have long-term experience in the training area and brings knowledge from individual, team and taskforce training. The Armed Forces also brings the lessons learned from the use of modelling and simulation to improve and develop different operational activities.

Unfortunately, most research and development projects are conducted within individual professions. We argue that our research initiative benefits from a mix of professions and competences. The multi-disciplinary approach requires and enables mutual understanding of the problems that members of different professions meet during organisational and operational development and indeed affect the joint team.

This kind of research also requires the capacity of system development within the research group, so that prototype systems can be used to demonstrate methodological and technical improvements in an iterative development process. It is also vital that the participating first responders get the time required to participate actively in the project and that their opinions in operational matters affect the direction of the research efforts.

Finally, this approach strives to evaluate new methods and tools in their real environment with real operators and users. This is of course more complicated than theoretical studies or laboratory experiments, but eventually it is more rewarding when the work is successful.

Monitoring and Visualisation of Rescue Operations

In order to reconstruct the activities from a rescue operation, we have to decide how to collect data. Much data can be acquired through automatic procedures, either from existing systems or from data-collection devices attached to the units in the operation. In addition, participants and observers can provide important information about specific events. In training operations specially assigned and trained observers can provide valuable feedback to the trainees afterwards (Gentner et al., 1997). In general, we can choose from various data sources. Even if it is not possible to record the activities during a real rescue operation to the same extent as during an exercise, the automated data collection sources can provide a frame of reference that can be very useful when supporting the commanders, leaders and responders to conduct an efficient debriefing (Rankin et al., 1995).

The ability to communicate the lessons learned to the rescue personnel during the after-action review can be greatly facilitated by different ways of visualisation. The actual views used to visualise the rescue operation or exercise depends on the focus of the debriefing. During our research and field trials in the area of computer-supported taskforce training we have used the following visualisation views (Morin et al., 1998; Jenvald, 1999; Morin et al., 2000b; Crissey et al., 2001):

- *Map views* show the position of rescue units, the location of points of interest, and the dispersion of chemical substances.
- *Photograph views* show digital photographs together with their time stamps and text annotations provided by the photographer.
- *Casualty views* show detailed information about the location, type of injury and status of each casualty throughout the chain of medical attention.
- *Communication views* show text-annotated radio and telephone transmissions from the tactical communications networks and support the audio replay of the communication.
- *Report views* show observation reports from observers.

If we collect information systematically and document the lessons learned from both full-scale emergency exercises and real rescue operations it is possible to create interactive descriptions (replays) of various emergency situations. These interactive descriptions can be used in constructing multimedia courseware: (1) to enable prospective training participants to study similar operations in advance in order to come well prepared to the training exercise; (2) to extend the learning experience by allowing the trainees to continue their analysis and discussion of a training event or rescue operation after its conclusion; and (3) to promote the dissemination of lessons learned throughout the rescue community by facilitating easy access to detailed documentation of the rescue operation. (Jenvald, et al., 2000a)

Emerging web-based technologies enable information sharing within and among rescue agencies and organizations. This development can facilitate education, training and development through effective distribution of documentation, models and lessons learned from training exercises and rescue operations (Jenvald et al., 2000b).

Application to Training

Documentation, analysis and communication are important factors of the training activities at the Rescue Colleges. However, the present methods and tools available mainly support the training as it happens, and lack support for systematical exercise documentation and distribution of lessons learned. One important goal is to decrease the trainer workload, so that the competence of the trainer can be used more efficiently. To do this we want to automate routine tasks and leave the advanced and complex tasks to the expert instructor.

The activities at the Swedish Rescue Colleges include education and training of rescue personnel at different organisational levels. The training of leaders and commanders can be divided into four major groups:

- Basic tactical training, where a physical miniature model is used to represent the incident and the rescue forces together with various available resources. The students gather around a large table that holds the miniature model and the teacher leads the unfolding of the scenario by talking and asking the students questions that arise during the simulated incident. Figure 1 shows a picture from a training session at Sandö Rescue College.
- Leader training, which takes place around the miniature model or on site at the location for a real object or facility. The rescue force is then organised in groups where only the group leaders and commanders are present during the exercise, and where the group leaders represent fully equipped teams.
- Full-scale emergency training, which takes place about twice a year at each college. During these exercises the trained forces are fully manned and consist of members from different classes at the college. These exercises often include paramedics, medical emergency personnel and personnel from the police forces.
- Command post training, where the commander and the staff are trained without real subordinate units. The different rescue units are represented by a number of trainers. The training can include one or more staffs in the same scenario.

The instructors at the Rescue Colleges use video and voice recording to document their various training sessions. One problem is to navigate in the large quantities of recorded information and to select the sequences that best illustrate important or even decisive events from the training scenario during the after-action review. We are now investigating if it is possible to use a combination of digital, time stamped and text annotated voice recordings (Axelsson, 1997), originally developed for full-scale emergency response exercises, together with computer-based structured observer reports (Thorstensson, 1997) to reduce the trainer and observer workload. We strive for improved methods and tools (Thorstensson et al., 2000) that support the training commander in both compiling, selecting and visualising the recorded information from

the training event, so that efficient feedback can be given to the trainees during the after-action review.

Figure 1: The trainer uses a miniature model of buildings and rescue forces during a basic tactical training session. The model is used to illustrate alternative approaches for a simulated rescue operation. (Photographer: Conny Qwarforth)

Improved feedback from the documented rescue operations to the rescue personnel is an important part of our research effort. We also want to investigate if we can feed forward the lessons learned to other fire departments, to the Rescue Services Agency and to the Rescue Colleges using modern information technology (Jenvald et al., 2000b).

Discussion

Our research initiative is based on close cooperation between scientists and responders. We want to approach the research problems bottom-up, and we will do it by instrumenting rescue units at Linköping Fire Department. Our goal is to systematically record a set of measurable parameters from the instrumentation system and to collect additional information and data from various systems that are presently in use. Initially, we will instrument a few rescue vehicles and evaluate the usefulness of different data sources.

We have also planned and conducted an education program for personnel from the fire department, the police force and the ambulance units, to make the responders aware of the purpose and the goal of our research project. It is very important that the responders get the opportunity to ask questions about the data collection and the monitoring of different rescue activities. Moreover, we have to explain how the

recorded information can be used by the responders to improve their future responses to critical incidents. The feedback from the rescue personnel is crucial for further research in the project.

The visualisation of the recorded information is important, because it is the responders' interface to abstract data collected from operations. Also, this area requires iterative refinement in close cooperation with the domain experts and the real users. Our approach is to start with the methods and tools successfully used in computer-supported taskforce training and to tailor these according to the lessons learned from the field trials together with Linköping Fire Department. Finally we want to evaluate our findings together with both the personnel at Linköping Fire Department and the Rescue Colleges during some of their courses.

Another important way of improving the College training is to calibrate the command post training scenarios with data recorded during real rescue operations. This will increase the level of realism when it comes to different time constraints and the use and availability of different resources.

Conclusions

Our challenging approach is a research project that covers a broad spectrum of competences and includes the requirements from the real users. We have faced a great need for new knowledge in this research area and the interest from the rescue community for our results is great. The lessons learned from the cooperation between the members of our team so far is that we learn a lot continuously from each other by working together towards a common goal. The team members also have different personal networks that are useful when we want to try new ideas or when we want to communicate important results or findings.

Documentation, analysis and communication are important factors of organisational development. These factors are also essential to sustain and improve quality. In this paper we have described the importance of analysis and distribution of the lessons learned from both exercises and real rescue operations.

We think that we have initiated a project with great potential in which we will bring theory to practice via close cooperation between decision makers, scientists, system developers and practitioners.

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Biography

Dr. Johan Jenvald (Lieutenant Colonel) is Head of the Modelling and Simulation Section at the Swedish Armed Forces Headquarters. He is also a member of the MIND research group at the Defence Research Agency. His research responsibilities include modelling and simulation, and he is especially interested in methods and tools for computer-supported training. Dr. Jenvald holds an MSc in Computer Science and Technology and a PhD in Computer Science from Linköping University.

Bo Johansson is project manager at the C4I group at the Swedish Rescue Services Agency. He is a retired Fire Chief and is responsible for the coordination of training issues for the Rescue Colleges within the research project. Mr. Johansson has a professional interest in the command and control area, especially methods and tools to increase the ability for different authorities to work together during large-scale critical incidents.

Anders Nygren is Deputy Fire Chief at Linköping Fire Department. Mr Nygren is responsible for the operational rescue activities at Linköping Fire Department. He is a fire engineer and has great experience from several years of commanding rescue forces. Mr Nygren is liaison officer with the Linköping Police Department and with the medical emergency units at the Linköping University Hospital where he also holds a position as fire-rescue instructor.

Dr. Sören Palmgren is Director of Research at the Defence Research Agency. He has been with the Agency for almost 30 years and is presently a member of a Division for System Analysis and Computer Security at the Department of Command and Control. Dr. Palmgren holds a PhD in theoretical plasma physics from the University of Umeå.