TRAINING FIRST RESPONDERS FOR PUBLIC SAFETY USING MODELING, SIMULATION, AND VISUALIZATION

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ABSTRACT

Training is extremely important to establish and tune an effective and efficient response system capable of handling new threats to public safety. The paper characterizes the unique conditions for training responders from multiple agencies within separate jurisdictions. Examples from four full-scale emergency response exercises cover weapons of mass-destruction, urban environments, and political violence. In each such live simulation exercise, computer tools based on modeling and visualization supported feedback and evaluation to promote effective cross-organizational learning.

1 INTRODUCTION

The way we look at public safety has changed in the light of recent world events. Asymmetric warfare is a reality that not only concerns military forces in war zones, but also has the potential to affect the everyday life of millions of people. Large-scale terrorism, potentially using weapons of mass destruction, may inflict casualties and create havoc in civilian communities. At the same time, transportation accidents, technological failures, and natural disasters continue to challenge public safety agencies. Responding to these challenges requires systematic approaches to crises management and preparedness. Interoperability and integration of services are fundamental to leverage the resources available across both civilian and military organizations in multiple jurisdictions.

Training is a cornerstone in future emergency preparedness and response. Training challenges include response to chemical, biological, radiological and nuclear events, military support to civil authorities, multi-agency cooperation, and integrated command and control.

In this paper, we analyze the specific problems involved in training first responders for large-scale operations in response to contemporary and future types of events. Our emphasis is on live simulation exercises. We examine how methods and tools developed around simulation, modeling, and visualization can facilitate this type of training. In particular, we consider how the taskforce training approach by Jenvald (1999) and methods for multimedia representation of tactical operations by Morin (2002) combine to address crucial training issues. A series of examples from previous exercises provides an illustration of difficulties and possibilities identified. Finally, we discuss some future directions for research and development.

2 TRAINING FIRST RESPONDERS

When people train in a live simulation, they take part in experience-based learning. However, participants in complex, dynamic situations are thrown into action with limited possibility to step back and reflect on actions as the situation unfolds (Winograd & Flores, 1986). After the action, on the

other hand, it is essential that they reflect on the exercise as a basis for sustaining strengths and remedying weaknesses. Kolb (1984) emphasized the combination of concrete here-and-now experience with the use of feedback to change practices and theories. Norman (1993) noted that reflection on performance makes it possible to better know what to change and what to keep. Effective processing requires accurate feedback on the actions taken, which is often a problem in dynamic and distributed environments, such as rescue operations, where the people may not see the effects of their actions and where the environment may change state spontaneously, without deliberate intervention.

Debriefing provides an opportunity to engage in structured reflection on an experience in order to modify behavior based on that experience (Lederman, 1992). In training, debriefing is commonly referred to as after-action review (Morrison & Meliza, 1999). An after-action review is a professional discussion of an exercise, which concentrates on performance standards. To provide effective feedback, methods and tools to present representations of operations have been developed and used to support after-action reviews in military settings as well as in emergency management and response (Jenvald, 1999). Morin and colleagues (Morin, Jenvald & Thorstensson, 2000) described how models of rescue operations built from multiple sources of data could support analysis and feedback. Applications of this method include training (Crissey, Morin & Jenvald, 2001) and real operations (Thorstensson, 2002). It has also been used to investigate communication in command and control (Thorstensson, Axelsson, Morin & Jenvald, 2001; Albinsson & Morin, 2002).

Morin and colleagues (Morin, Jenvald & Crissey, 2000) analyzed training needs and training opportunities for emergency response to mass-casualty incidents. They identified training audiences and classified training on the individual, team, command post, and taskforce level. In this framework, taskforce training corresponds to full-scale, live exercises with people and equipment in the field. This type of training enables all personnel to engage in a common exercise, where they can apply their skills in a realistic scenario. Such training can produce learning situations at the level of complexity that do not occur in individual training or team training. However, effective taskforce training requires that individuals and teams have attained proficiency in their roles.

Public safety agencies spend most of their time on watch or responding to calls. The time available for training is limited. Furthermore, the public safety community has primarily been organized to handle the everyday accidents that constitute the vast majority of emergencies. Also, the community is heterogeneous in the sense that it includes many different agencies at various levels of government. Effective training must incorporate public safety assets both vertically across levels of government and horizontally across multiple professions and specialties.

A primary challenge in training responders for public safety is to overcome organizational and jurisdictional barriers. Flin (1996) observed that there seemed to be limited cross-transfer between public safety organizations despite their having similar goals and employing similar means to achieve those goals. Training together and debriefing together may be one way to promote the interaction between agencies.

3 COMPUTER-SUPPORTED TASKFORCE TRAINING

Conducting a major exercise that includes an effective after-action review requires a systematic approach to training. Jenvald (1999) presented a method for computer-supported taskforce training, which incorporates steps to ensure that the course of events of the exercise is documented and accessible for after-action review and analysis. Figure 1 gives an overview of the method, which includes the following five steps:

- *Planning*. The planning step defines the goals of the exercise, identifies particular topics or themes that should be highlighted, and creates the exercise scenario accordingly. Evaluation criteria are established relative to the goals and an instrumentation plan is developed. This plan links the goals of the exercise to evaluation criteria by defining observable measures of performance and prescribing means of data collection.

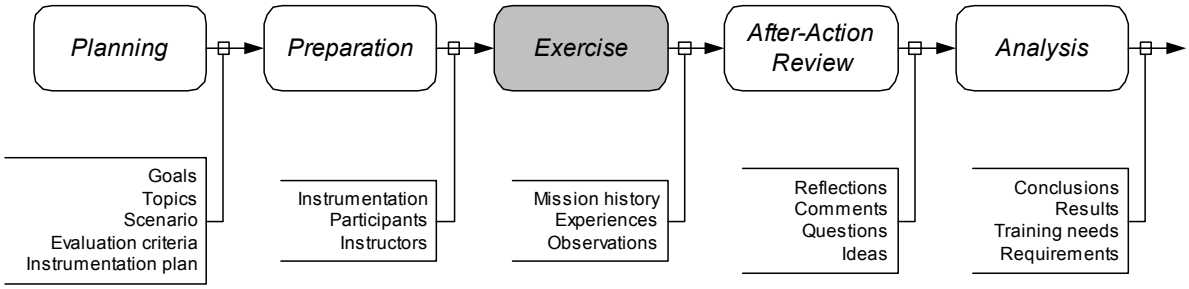

Figure 1: Overview of a method for computer-supported taskforce training.

- *Preparation*. Before the exercise, it is necessary to inform participants about the exercise. Instructors and observers need guidelines and instructions regarding what to pay attention to and how to report observations. Automatic instruments for data collection must be installed, configured, and started.
- *Exercise*. During the exercise, the participants act in their roles in the unfolding scenario. Data are captured by the instrumentation system to document the course of events. The result of data collection is a mission history, which is an event-based, time-ordered multimedia model of the mission.
- *After-action review*. Participants, observers, and trainers assemble to conduct an after-action review of the exercise. In a process of critical reflection, the participants explore the exercise using the mission history as a cognitive aid. Instructors and observers may pose questions or offer comments and guidance to facilitate debriefing.
- *Analysis*. Reflections, comments, and remaining questions may serve as starting points for a deeper analysis of the exercise. Evaluation results and observations may lead to new training needs and modified tactics, organization, and equipment.

Both the after-action review and the post-mission analysis are exploratory tasks. Observations during the exercise and findings from examining the mission history lead to new questions that can be explored. To support this mode of analysis, the MIND presentation tool includes an exploratory multimedia interface. This interface enables a user to browse the mission history and to replay sequences of the mission (Morin, 2002). Figure 2 shows a screenshot from MIND.

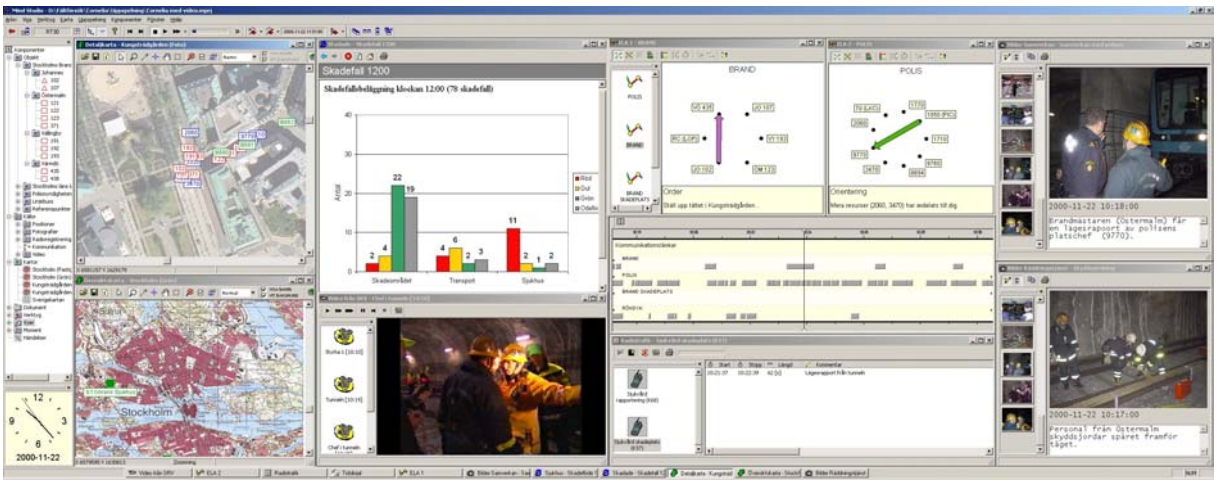

Figure 2: A screenshot from the MIND multimedia interface exploring the mission history of an underground exercise in Stockholm. MIND presents geographic information, casualty statistics, communication links, digital photographs, and video clips. All data are ordered in time. Browsing controls support temporal navigation as well as replay in natural and fast-forward modes.

4 APPLICATION EXAMPLES

We describe four examples of how computer-supported taskforce training applied to emergency management and response in scenarios involving complex, multi-agency settings. The examples come from exercises: *Alvesta*, *Orlando*, *Cornelia*, and *Daniela* (see also Figure 3).

The Alvesta exercise took place in 1997 in a project sponsored by the Swedish Rescue Services Agency (SRV). The goal of this project was to develop methods and tools for assessing emergency planning for incidents involving chemical warfare agents (Rejnus, Jenvald & Morin, 1998). The exercise involved emergency response to a simulated chemical attack on the town of Alvesta. Approximately 180 first responders from different agencies participated and 49 extras acted as casualties. Data collected included (1) position tracks from GPS locators on vehicles; (2) reports from chemical detection; (3) observations of units in clean and decontaminated areas; (4) observations of decontamination and first aid stations; (5) casualty flow and treatment; (6) digital photographs; and (7) tactical radio communication. MIND supported the exploration of the mission history at an after-action review for all 230 participants 90 minutes after the end of the exercise. The SRV exercise commander acted as a tour guide in a walkthrough of the exercise with frequent stops at critical situations. Key participants commented on situation assessment and decisions, using the mission history both to recall situations and to illustrate their line of thought. Two weeks later the model was used in a similar manner to support a detailed analysis of different functions as a basis for assessing the emergency planning. Finally, the mission history was included in a multimedia CD-ROM addressing chemical warfare hazards and used in a curriculum covering nuclear, biological, and chemical hazards at Umeå University, Sweden (Jenvald, Morin & Rejnus, 2000).

In May 2000, a joint Swedish–American team organized a field study in Orlando, Florida (Crissey, Morin, & Jenvald, 2001). The purpose was to apply the methods and tools used in Alvesta to a different country, organization, and culture. To this end, the team participated in an emergency-response exercise involving a chemical incident. In the operation, fire–rescue units from two counties and three police forces, drawn from a 25- by 25-kilometer area, responded to a simulated chlorine gas leak in a suburban location. There, they rescued and treated two victims and contained the leak. The operation took place in the morning and after a lunch-break the participants assembled for an after-action review. The Director of Training of the Orange County Fire Rescue Department facilitated a walkthrough of the operation supported by the mission history. The Orlando exercise in many respects was a replication of the Alvesta exercise. The same methods and tools were used. Models and views could be reused once the geodetic differences were settled. Reconstruction and exploration of a mission history supported an after-action review similar to that in Alvesta. We found nothing in the study that contradicted the assumption that our methods and tools could, indeed, be transferred to a different environment.

Figure 3: Snapshots from three exercises. The left picture shows Orange County fire fighters decontaminating a chlorine victim in the Orlando exercise. The middle picture shows a paramedic nurse and a fire officer in a subway tunnel in the Cornelia exercise. The Right picture shows police officers encountering violent demonstrators in the Daniela exercise. (Photographer: Johan Jenvald)

In November 2000, some 200 first responders and command staff from the local fire department, the county medical services, and county police joined forces with personnel from the urban transport authorities and train operators to practice emergency response to an underground train derailment in the Stockholm subway system. In a tunnel, 150 meters from the platform of a downtown subway station, sabotage caused a train to derail, hit the tunnel wall, and come to an abrupt stop. The impact left 86 people on the scene with various injuries. The train driver, who had sustained only slight injuries, used the train's radio to notify the traffic control center. Personnel in the traffic control center initiated emergency activities according to their standard procedures. First responders removed all victims from the train, stabilized them, and transported them to three trauma hospitals in Stockholm. Using similar data collection procedures as in Alvesta and Orlando, we reconstructed a mission history from the exercise. This mission history supported an after-action review three hours after the exercise ended. Furthermore, it was crucial in the analysis of coordination and collaboration among responders from different agencies. The starting point of the analysis was questions raised by participants and observers at the after-action review. However, several new issues were discovered in the course of analysis, which is typical in this type of explorative analysis. Multiple sources of data made it possible to corroborate findings and construct a chain of evidence to formulate hypotheses and support conclusions. The mission history was a crucial element in this analysis by presenting the basic facts of the tactical operation. MIND facilitated exploration by supporting access and navigation in the mission history. In particular, it helped analysts link communication data to contextual information and vice versa.

In December 2002, first responders from various agencies in Linköping, Sweden, trained together in a scenario that involved politically motivated violence. A covert political meeting turned into a blazing fire, when militant members of an opposing fraction appeared on the scene. This scenario was constructed to force commanders from various agencies to integrate command and control, while the focus of the incident shifted from law enforcement, to fire suppression and rescue, and to medical aid. During the exercise in the morning, observers and technical systems collected data. In the afternoon, participants and observers conducted an after-action review facilitated by the mission history. Later, the agencies involved used the mission history to analyze incident command, coordination, and communication. This use of computer-supported taskforce training supported the conclusion from the previous exercises: Exploration and context are crucial for reconstructing the events of a complex scenario to facilitate reflection and analysis.

5 DISCUSSION

Although complex and resource intensive, live simulation exercises are essential for developing and sustaining the preparedness and responsiveness of our first responders. They provide an opportunity for managers and responders to gain an insight into the processes involved in a major operation and their interactions. With appropriate performance measures, live simulation can be used to validate the incident response system (Rejnus et al., 1998). However, Jenvald (1999) cautioned us not to confuse training and system validation, because they have different ends and means.

Feedback is a critical component in experience-based learning. In a distributed environment, people have problems relating actions to outcomes. Computer-supported taskforce training operates under the assumption that providing a coherent view of the course of events is a crucial step toward overcoming this difficulty. Modeling and visualization are key techniques in constructing a mission history and exploring it in an after-action review as well as in subsequent analyses (Morin, 2002). A mission history is a tangible and visible representation of an operation that can be examined and disseminated. As such, it can convey lessons learned from operations to responders who did not participate.

The examples included in this paper indicate how the methods and tools of computer-supported taskforce training apply to training of first responders for public safety. Dealing with weapons of mass-destruction in urban environments is a nightmare scenario that must be seriously considered. Such events never entail just a fire–rescue mission or a law enforcement operation. Instead multiple agencies must join forces within their jurisdictions to handle the situation. The Cornelia example

demonstrates some of the difficulties involved in inter-agency coordination. It also gives ideas for future research on how explorative analysis can be conducted using process data and multiple levels of representations (see also Woods, 1993).

The need for training is perpetual. Acquiring new skills and new knowledge, sustaining proficiency, and practicing to achieve higher levels of competence must be inherent activities in any response organization. To this end, public safety agencies must analyze training needs and identify training opportunities to devise appropriate training programs (Morin et al., 2000). Taskforce training is one crucial element in a training approach for public safety and preparedness. In our field exercises, we have observed that the after-action review process is greatly facilitated by the use of a mission history. The trainees were able to relate their own performance to the activities of other teams and individuals. Usually, the trainees accepted the mission history presented as a fair and unbiased description of the course of events. As a result, the discussions at the after-action reviews tended to be very open-minded and focused on facts. We have found that this positive environment promotes rapid learning by facilitating the process of identifying strengths and shortcomings in individual, team and management procedures.

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