Computer-Supported Visualisation of an Inter-Agency Exercise in the Stockholm Underground

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Abstract

Inter-agency operations in response to emergencies necessitate close collaboration at different command levels in a taskforce. Personnel from different organizations must work together to solve upcoming problems in the field, despite belonging to different command and communication structures. The overall performance of the taskforce depends on this cooperation between individuals, and their ability to communicate across borders. We report on a subterranean exercise in the centre of the Swedish capital Stockholm where multiple agencies responded to a train derailment in the Stockholm underground. To reconstruct the activities of the rescue force above and under ground we used the MIND visualisation system. We describe how the exercise was planned, prepared, executed and evaluated with support from the MIND system. An important question is how to define the objectives of each participating organisation and how to translate those into requirements on data collection and visualisation procedures for supporting analysis and evaluation.

Introduction

Emergency management and response in inter-agency taskforce operations stretches the resources available to their limits. In such stressful situations the careful coordination of resources from multiple agencies becomes a high-priority task. The overall goal of command-and-control training in taskforce operations is to learn how to master these complex processes. This goal is hard to reach without the presence of all aspects of complexity (Morin et al., 2000b) and therefore requires training in large scale inter-agency exercises.

Training together in inter-agency operation scenarios enables all personnel throughout each organisation to cooperate with their counterparts and necessitates cross boarder communication for solving common problems despite different organisational cultures and structures. The upcoming friction in the taskforce and the mutual understanding from participating individuals can not be trained in simulated environments or in focused small unit exercises. However, large scale inter-agency emergency exercises are complex and demanding to organise and difficult to survey and analyse for reaching maximum training output. In Stockholm we have found a model for organising exercises that meets the needs of training together. A number of joint exercises including the Stockholm Fire Department, the Stockholm County medical resources and the Stockholm County Police are organised every year. Each exercise in the series is adapted to certain training objective to ensure that every organisation can focus on specific training goals on an annual basis. To increase the level of realism in the training situation, some exercises are held at training sites for smoke diving to meet the needs of the fire brigade and some exercises are held in the city to target police requirements in handling traffic and curious civilians. The need for realistic training for medical-aid teams is handled by having a number of well trained, and highly motivated extras serving as casualties with relevant injuries for the overall scenario. Each exercise is organised by a small group with one representative from each organisation.

Striving for enhanced possibilities for learning from large-scale exercises the Swedish Defence Research Agency has developed methods and techniques for computer-supported visualisation of exercises and operations which have been implemented in the MIND system (Morin et al., 1998; Thorstensson et al., 1999a; Jenvald, 1999). In this paper we describe one exercises in Stockholm County that was conducted using the computer support provided by this system.

The rest of this paper is outlined as follows. In the next section we describe the circumstances for the specific exercise. We then proceed with one section explaining the methods and tools implemented in the MIND system. We then present how the exercise was planned, prepared and executed and evaluated and we conclude by giving some results and describe necessary future work.

The Cornelia exercise

Every year in Stockholm County we organise one exercise that is large and includes multiple organisations and agencies. This specific exercise, named Cornelia, was extended to include organisations throughout the chain of medical attendance, from

the incident area to the receiving acute hospitals, and also rear echelon staffs for fire-rescue resources, medical resources and police resources. The purpose was to train all participating components in a mass-casualty incident in Stockholm County. The Cornelia exercise included the following organisations:

- The Stockholm Fire Department
- The Stockholm Police Department
- The Stockholm County Council
- Three different emergency hospitals: Stockholm Söder hospital, Sankt Göran hospital and Danderyd Hospital.
- Two different ambulance operators: AISAB and Falck.
- The Stockholm subway infrastructure owner: SL Infrateknik AB.
- The Stockholm subway operator: CONNEX AB.

In total approximately 200 trainees participated. However, there were three factors affecting the realism in this exercise: (1) the allocated time was 2 hours, (2) no blue lights or sirens could be used, (3) limited resources from Stockholm Fire Department and the ambulance operators were available.

Additionally, this exercise was to be followed up by the Swedish Defence Research Establishment (FOI) using the MIND system which has been used in previous emergency response exercises, (Jenvald et al., 1998; Rejnus et al,. 1998; Crissey et al,. 2001).

Methods and tools

The methods used for the exercise addressed the problem of how to transform the operational objectives of a task force into goals for the visualization and evaluation of the operation, and how those goals directed the modelling of the operation. The end result was a *mission history* (Morin et al., 1998; Morin et al., 2000), an executable, discrete-event model of the rescue operation. A mission history is made up of hierarchical object models, representing the units participating, and a sequence of events representing state transitions that take place in those objects. Each event is marked with the time when it occurred during the operation.

Construction and visualization of a mission history rely on the existence of methods and tools to collect data from a rescue operation, to compile and appropriately organize these data and to present them using succinct and comprehensible displays and views, such as digital maps and diagrams. These tasks are performed by an *instrumentation system,* MIND, (Morin et al., 1998; Thorstensson et al., 1999a; Jenvald, 1999). MIND is an integrated data gathering and After Action Review presentation system that includes displays for tactical maps, annotated photographs from the exercise, recorded tactical radio communications and compiled statistics about unit performance.

The following list presents the main steps for the mission history construction and visualization method (Morin et al. 2000a).

1. *Scenario structure analysis* aims at identifying critical phases in the operation, which are likely to require careful coordination (Morin et al. 2000b).

2. *Definition of the focus of attention* imposes restrictions on what factors to prioritise in order to make data collection and visualization viable with respect to the technical, financial, and personnel resource available.
3. *Scenario modelling* is the process of defining the objects and events that make up the model of the scenario (Jenvald et al., 2000a). This process is iterative and involves both subject matter experts and modelling experts
4. *Data collection* is carried out during the exercise and serves to register and store the events that represent the activities in the task force. The types and amounts of data collected are governed entirely by requirements of the scenario model.
5. *Visualization* is the means of making events, circumstances, and relationships visible to the participants and trainers after the exercise. The visualization tools retrieve data collected and format them according to the objectives of the visualization and the needs of the target audience.
6. *Documentation* is the final step of organizing and packaging models, data, and procedures in a form that is comprehensible to a professional audience and easy to access and distribute (Jenvald et al., 2000b).

Exercise planning

Focusing emergency operations in problematic environments the scenario was set up as a train derailment in the subway in the Stockholm city. The train carried 80 passengers and thus several training goals could be met. Each participating organization had early clarified their training objectives in a broad perspective:

- Training of organising forces in large scale operations.
- Train forward command and control regarding acquiring information, information transfer, decision making process and orders.
- Train rear echelon staffs and their cooperation with forward commanders.
- Train inter agency cooperation throughout the organisations.

Also, some specific training issues were:

- Rescue operations in tunnels where communication always becomes a problem. Also the long approach to the incident scene several hundred meters in a tunnel system causes a logistic problem that must be dealt with in cooperation between agencies.
- The city problems for the police handling dense city traffic regulation and many curious civilians.
- The command and control problem with an operation that is impossible to overview.
- Mass casualty situation with heavy workload on medical resources.

The details of the casualty panorama can be seen in table 1.

Table 1: The casualty panorama.

Casualty	Position			Sum
	Train	Tunnel	Platform	
Dead (mannequins)	5	0	0	5 (mannequins)
Severely injured	10	0	0	10
Lightly injured	21	30	20	71
Sum	35	30	20	86

It is important to point out that this was a training exercise where several positions were held by personnel under training, and that one main purpose for the CORNELIA exercise was to provide good training and a good support for feedback and evaluation.

Data collection for giving an overview of the operation required use of multiple different data sources which necessitates a firm grip of the organisation for data collection and we structured a data collection plan (DCP) for the Cornelia exercise. The specific DCP was a 38-page document, comprising a short overview of the exercise purpose, scenario, execution and was emphasising observer instructions and technical data collection. The registration methods we used are listed in table 2.

Table 2: Data collection registration methods.

Data collection method	**Abbreviation**	**Significance**
Observation	Obs	Observers manual recording of activities. All observer reports specifies time (hour and minutes) and place.
Recording of communication	Com	Automatic digital recording of radio and telephone communication. All communication is time stamped.
Registration of positions	Gps	Automatic registration of geographic positions using satellite navigation equipment (GPS)
Photography	Photo	Documentation of activities and situations using digital camera. All photographs must be manually recorded and time stamped.
Video recording	Video	Video recording of activities and situations.
Casualty cards	Casualties	All extras serving as casualty markers are equipped with casualty cards on which they make notes during the exercise (Thorstensson et al., 1999b). They note the time for specific events in the medical attendance. The casualty card also has a filed for noting the police registration id number, thus enabling cross references to the information registered by the police.
Printing and collecting log files	Police registration	The content of the police catastrophe register is printed in 15 minutes interval. This will facilitate the study of information flow to the register and enable a comparison with the actual situation recorded with the casualty cards.
Collection of situation reports and briefings sent by fax	Fax	Rear echelon command posts uses fax machines to some extent to send and retrieve situation reports. Copies of these will contribute to the exploration of the information situation in the rear echelon command posts and the field units.
Registration of tableaux for recourses and activities	Tableaux	Rear echelon command posts often use tableaux for presenting situations and prognoses regarding important resources and key activities. By regular documentation, using photographs or by other means document these tableaux, it will be possible to create a picture of the information situation and activities in the command post.

Exercise execution

The evolving scenario was a train derailment in the Stockholm subway, caused by sabotage and including 86 casualties. In a tunnel, 150 meters from the platform of a central subway station, the train hit an item placed on the tracks, which caused a

derailment and made the train hit the tunnel wall and come to an abrupt stop. A person in the tunnel was run over and the passengers tumbled in the three carriages. Some passengers left the train set and reached for the ground, a number of passengers did rove about in the tunnel and some remained in the train (the detailed distribution of casualties can be seen in table 1). The engine-driver, only slightly injured, called for help on his radio to the CONNEX communication centre, who then alarmed the rescue forces.

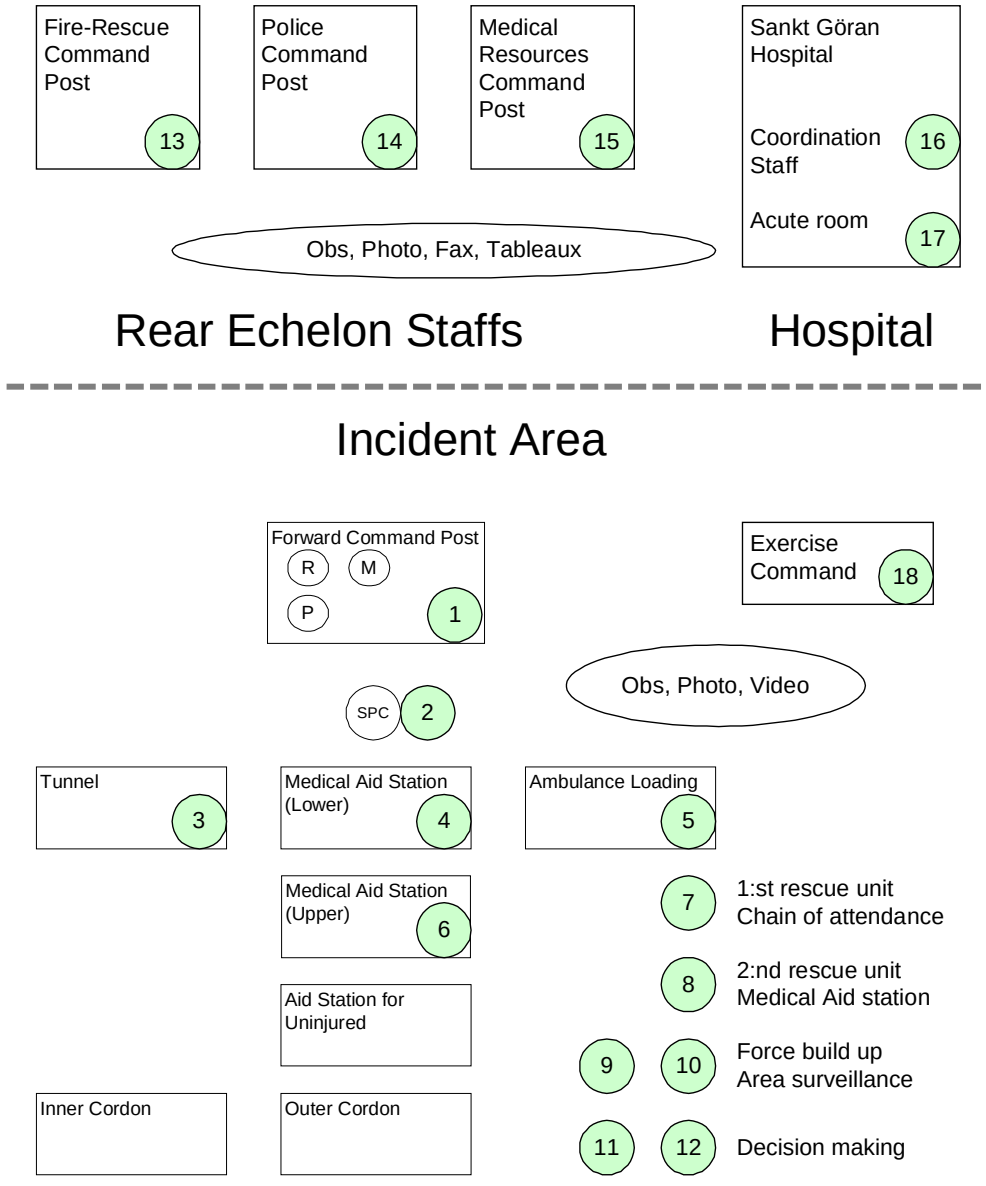

Figure 1. Distribution of observers during the exercise. Each numbered circle is an observer connected to the specified function (boxes) or tasks as described. The ellipses describes the data collection methods used in each area.

The technical registration we used for data collection was GPS on key vehicles in the taskforce, Digital time-stamped radio recording (Axelsson, 1997) of six radio channels using own equipment and four additional communication channels from external sources. We also used 18 observers at 15 different locations, distributed as

described in figure 1, for data collection. Each observer was given specific tasks and used a set of data collection methods as described in table 2. Eight observers were expert observers and the rest were novices in this type of work. A short briefing the night before the exercise was the only occasion we had to train all observers and present the detailed DCP.

Exercise evaluation

Directly after the exercise we conducted a preliminary data compilation and prepared for the after-action-review (AAR), which is a structured professional discussion which focuses on performance standards of the training exercise (Rankin et al., 1995). The data set from the exercise was very dense so we planned to show a small subset of data consisting of a short animation of force build up in the area, some samples of recorded radio traffic and photographs showing snapshots from different locations in the incident scene. Three hours after the exercise all exercise participants took part in an AAR and we used the MIND system (se figure 2) to replay the course of events.

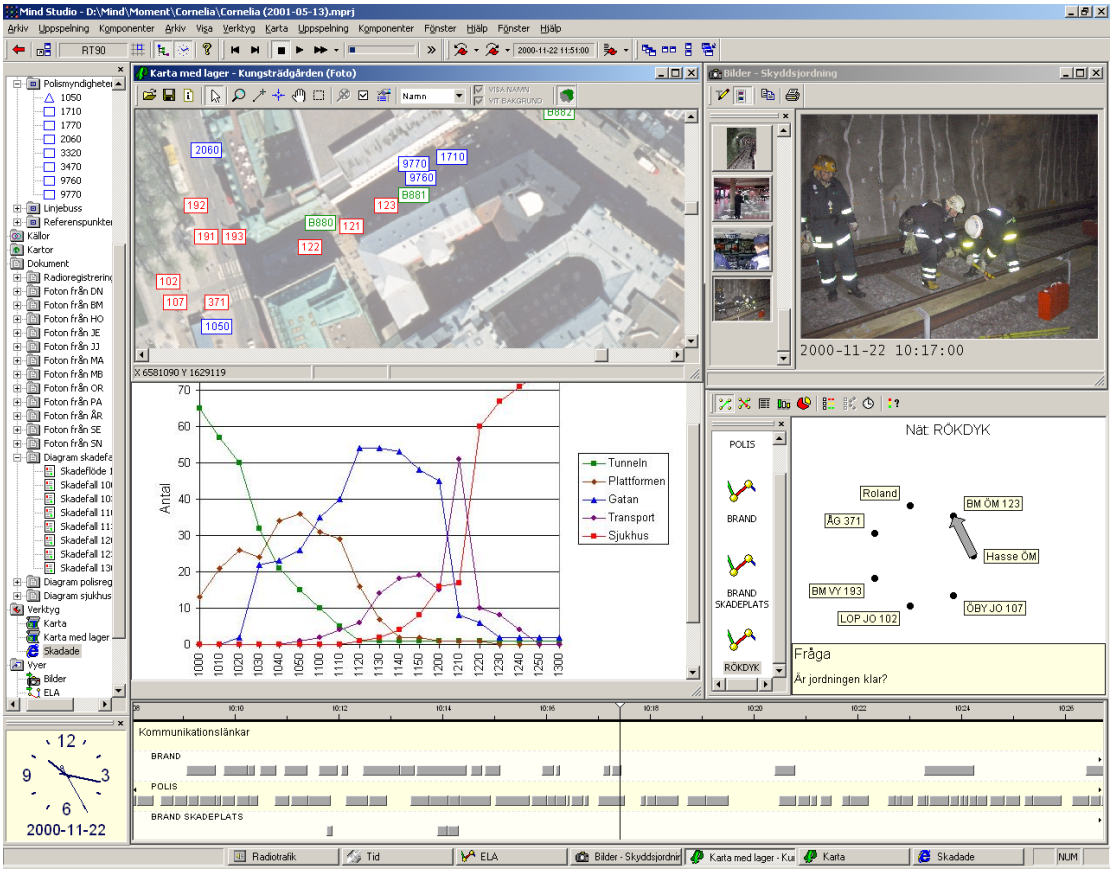

Figure 2: A screen dump from the MIND system used for the AAR and the post mission analysis. This picture contain compiled information used at the post mission analysis 2 moths after the exercise.

Two moths after the exercise we had compiled more data and together with commanders from different positions in the exercise and made a post mission analysis where we used the MIND system for repeated replay with certain focus and analysed specific parts of the operation.

Results

The Cornelia exercise provided a unique opportunity for all participants to train together in a complicated environment and prepare for a plausible emergency. Multiple response team had the opportunity to cooperate with personnel from other organisations they are likely to meet in a real incident, learn from situations, decisions and each other. We believe that this form of training, jointly in large scale inter-agency exercises, is the most fruitful way of reaching the goals of interoperability and mutual understanding across organisational boarders.

Reviewing and evaluating training was enhanced by using the MIND system. Replaying the mission history directly after the exercise, performing an AAR with all participants, gave an opportunity to increase understanding of each others situations in such a complicated operation. However, we need to improve methods and techniques for data compilation of large amount data to improve value added at an AAR directly after the exercise. Nevertheless, we believe that great value is added by using a computerises instrumentation system in this type of training.

To a large extent we used observers to collect data. For some data observers is the only possible solution, but there is a strong need to reduce the number of observers, due to cost and time for data compilation, without loosing quality data. This implicates the need of new techniques and methods for data collection. However, when we choose to use observers for specific tasks it is necessary ensure that they are properly trained and equipped. We see a need to improve observer training and technical observer support tools.

Future work

Performing data collection from multiple sources in large scale exercises needs to be improved. Automated techniques for data collection and improved methods for data compilation of large data sets from different sources must be developed to shorten time from exercise to an adapted AAR with a substantial information content. We also need to do research in how to navigate in large data sets to find interesting sequences and situations to learn from. This will probably address system architecture questions as well as method questions.

Connection between live training and simulation based command post training also needs further research. We believe that a recorded mission history, like the one from Cornelia, can be used in simulations and gaming for command post staff training, but how this should be done to gain real effect is not at all clear.

Conclusions

Large scale inter-agency emergency response exercises is necessary for being prepared for future plausible emergencies. Training exercises can be enhanced using computer supported methods and tools for documentation, analyses and

communication. Operational activities can be visualised to increase mutual inter agency understanding of specific operational procedures and information flows and communication can be analysed for identification of possible needs of procedural improvement.

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Biography

Mirko Thorstensson holds a MSc in Mechanical Engineering from Linköping University and is currently a PhD candidate at Linköping University. Mr Thorstensson is a member of the MIND research group at the Swedish Defence Research Agency, where he is responsible for structured reports for manual observations. His research interests include knowledge acquisition, structured reports, simulation and registration systems. Mr Thorstensson is a Lieutenant in the Swedish Army (res.).

Anders Björneberg is a Superintendent in the Stockholm County Police and has great experience from several years of field operational commanding of police operations. He is the responsible police officer for inter agency cooperation and planning of exercises in Stockholm County and he has a professional interest of methods and tools supporting evaluation and analyses of police operations. Mr Björneberg was responsible for the police participation in the CORNELIA exercise.

Bo Tingland is a Station Officer with the Stockholm Fire Department and has served several years commanding fire-rescue operations. He is active in developing fire-rescue operations at sea and has a professional interest in computer supported evaluation, training and analyses of emergency operations. Mr Tingland is responsible for Stockholm Fire Department participation, planning and cooperation in inter agency exercises and he was second in command for the CORNELIA exercise.

Marga Tirmén Carelius is Training Manager at DEMC, Disaster and Emergency Medical Center, Stockholm Söder hospital. She is a trained nurse and responsible for the training of medical teams by order of Stockholm County Council. She has several years of experience in training medical teams for work in the field in taskforce operations. Mrs Tirmén Carelius is responsible for DEMC participation and planning of inter agency exercises, for doctors and nurses under training, and took the initiative for this exercise.