A real-time role-playing exercise as a methodology to support command and control research

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ABSTRACT

In this paper, methodological issues in research and training of complex command and control structures in emergency management are addressed. In particular, a methodological approach combining real-time role-playing exercise, after action review and observations is presented. An explorative study – ALFA-05 – utilizing this approach is described. A brief overview of methodological aspects of preparation and execution is given. Further, experience gained and methodological lessons learned are also discussed. Finally, real-time role-playing exercise in combination with other methods is suggested as a feasible method for researchers and exercise managers to tackle present and future command and control in complex settings, where interaction and communication are in focus. In addition, areas for further development of the real-time role-playing exercises as a research method are suggested.

Keywords

Role-playing exercise, after action review, command and control, complexity, collaboration, emergency response.

INTRODUCTION

Present emergency management (EM) is multi-disciplinary in its nature and contains a number of different cooperating actors. In this sense, EM becomes so complex that coordination is subject to increasing complexity, especially during emergency response (Shen and Shaw, 2004). Consequently, command and control (C^2) also becomes complex and dynamic to meet the demands of the EM itself (Jungert, Derefeldt, Hallberg, Hallberg, Hunstad and Thurén, 2004; Jansen, Jones and Sovereign, 2002). Management of internal resources but also resources of other EM actors, multiple goals of these actors as well as diverse multiple operational procedures constitute extra challenges for C^2 in EM (Shen and Shaw, 2004). Commanding staffs also become more interdependent forming a type of interconnected C^2 networks. Different time scales in various C^2 staffs are thus an important characteristic. Commonly used hierarchical and quasi-hierarchical C^2 structures are often no longer static (Brehmer, 1991). Particularly in emergency response, the cooperating EM actors may shift their C^2 structures (Smith and Dowell, 2003; Perry, 2003). This, as an adaptation to the situation requirements, could be supported, for example, via an incident command system (Hannestad, 2005) but is often emerging on ad-hoc basis.

The possibility to gain knowledge from such C^2 work and re-using this knowledge in research and training is essential. One of the problems is a lack of methods allowing researchers to study such C^2 work, in terms of information seeking, data exchange, common operational picture (COP) and communication, in repeatable and realistic settings. At the same time the exercise managers face issues of emulating these complex situations in training scenarios. From this perspective, to document and analyse C^2 in real-life context is still a challenge. The traditional research methods used in the C^2 research and training do not allow the researchers to fully exploit the issues of information seeking, data exchange, COP and communication in C^2 work, particular during improvisation or adaptation work. In the case of microworlds (scaled worlds) it is the issue of real-time management, realism, complexity and overfitting (adjustment to the specific features of a simulation/scenario) in the simulations (Granlund, 1997a). Realism is also a problem in exercises and interviews, where participants often act and describe their actions in accordance with operational procedures. Another example is ethnographical studies that may put observers at risk, are time consuming and require many observers (Landgren, 2004). At the same time, by combining advantages and good experience from the traditional methods and alternative approaches from other

fields together with advanced information and communication technologies (ICT), the possibilities to study C^2 work may further advance.

The goal of the research, presented in this paper, is to assess one methodological approach – real-time role-playing exercise combined with after action review and observations – for study of C^2 structures in complex settings with regard to information seeking, data exchange, COP and communication.

COMPUTER-ASSISTED ROLE-PLAYING EXERCISE

A role-playing exercise (RPE) builds on a role-playing game philosophy to large extent. In a role-playing game, participants and game-master assume roles of various characters, as well as their duties and tasks. In addition, the game-master is responsible for creating conditions for the role-playing game in the form of a scenario the participants should experience. The goal of the role-playing game is to constitute a collaborative challenge where the participants try to solve a problem or overcome various obstacles, described by the scenario. The role-playing game executes via dialog between the game-master and participants, where the game-master describes surroundings, sense impressions and roles of different persons in the world where the game takes place. The participants describe their reactions to the conditions they obtained from the game-master. The game-master describes the consequences of their actions. This procedure repeats during the entire game. The difference between the RPE and the role-playing games is that the participants in the RPE do not play presumed roles but act in their professional roles. The scenario is also different. In the RPE the scenario is strictly steered by realism and real-life settings. The game-master is often replaced by a RPE staff, a team of researchers and exercise managers with expertise in various areas.

RPEs, also known in this context as tactical decision games, have been used for training purposes, for example, in Sweden by the Swedish Rescue Service Agency and the Swedish Emergency Management Agency. However, RPEs have also become a research method. For example, Barreteau (2003) discuss methodological issues of RPE and RPG in research on interaction, communication and negotiation. In the context of the EM, the RPEs & role-playing games have been used in scenario planning (Turoff, Chumer, Yao, Konopka, and Van den Walle, 2005) and evaluation of a decision support system prototype (Ikeda, Beroggi and Wallace, 1998). Compared to these previous applications of RPEs & role-playing games, in this research a synchronous real-time RPE is used as a research tool to study existing C^2 structures, their functions and modalities in real-life settings. By combining a real-time RPE with after action review and observations it makes it possible to study the actual interaction between commanding staffs as well as individual commanders beyond the organizational and technological dimension of the C^2. Advanced realistic scenarios can be developed without putting participants and RPE staff at risk, something that would be very difficult in reality.

By providing an advanced computer-assisted visualization of an event, in this case RPE, researchers, emergency managers and participants can examine the course of events of an emergency operation. It is of great value to establish an overall view of the RPE to provide a common frame of reference and to facilitate subsequent analysis and evaluation of complex situations. This support can help researchers and professionals both to grasp the big picture (Morin, Jenvald, and Thorstensson, 2000a) and to explore the interaction between critical factors in great detail. Visual models of minutely documented missions in the RPE make it possible to analyze similar scenarios to systematically identify cause-effect relationships that influence the outcome of emergency operations (Rejnus, Jenvald and Morin, 1998; Jenvald, 1999; Morin, 2002). However, the usefulness of the visualization is determined by the models devised to represent the scenario, the means of data acquisition employed and the data collected from the actual RPE. Such methods and tools have been successfully used in various exercises ranging from emergency response to mass-casualty incidents (Morin, Jenvald and Crissey, 2000b; Ingrassia, Geddo, Lombardi, Calligaro, Prato, Tengattini, Morin, Jenvald and Della Corte, 2005) to training of critical incidents management in the power production industry (Morin, Jansson and Jenvald, 2005). They are also highly relevant in the context of research applications, such as the discussed real-time RPE.

ALFA-05 DESIGN

The ALFA-05 study is a real-time RPE utilizing computer-assisted planning, execution and evaluation. The following list presents the main design steps for the ALFA-05 study:

- *Definition of methods and research focus* imposes restrictions on what factors to prioritize in order to make data collection and visualization viable with respect to the technical, financial, and personnel resource available.
- *Scenario modelling* is the process of defining the objects and events that make up the model of the scenario. This

process is iterative and involves both domain experts and modelling experts.

- *Scenario structure analysis* aims at identifying critical phases in the RPE, which are likely to require careful coordination (Morin et al., 2000b).
- Data collection is carried out during the study, in particular the RPE, and serves to register and store the events that represent the activities of the participants. The types and amounts of data collected are governed by the selected methods, research focus as well as the requirements of the scenario model.
- *Visualization* is the means of making events, circumstances, and relationships visible to the participants during debrief after the RPE as well as to the researchers carrying out analysis. The visualization tools retrieve collected data and format them according to the objectives of the visualization and the needs of the researchers and target audience.
- *Documentation* is the final step of organizing and packaging models, data, and procedures in a form that is comprehensible to a research and professional audience and easy to access and distribute (Jenvald, Morin and Kincaid, 2001).

In this paper, we focus in particular on definition of methods and research focus, scenario modelling and structure analysis, and data collection. The visualisation and documentation steps are still ongoing at this moment.

Definition of methods and focus of attention

The goal of the ALFA-05 study was to assess a real-time RPE as a method for C^2 research. Further, the study focused on the following areas of C^2 work: (a) information seeking at different command posts, (b) data exchange between these command posts, and (c) selection of data sources by particular commanders.

Due to the relative high complexity of the real-time RPE, two additional methods, often used in the context of RPG and RPE (Daré and Barreteau, 2003) – observation and after action review – were utilized for the purposes of methodological triangulation (Denzin, 1978).

After action review

After action review (AAR) is a professional discussion of an event (e.g. accident, training exercise), which focuses on performance standards (Rankin, Gentner and Crissey, 1995). AAR is in particular important, when units from different organizations form a task force and work together (Gentner, Cameron and Crissey, 1997). By using AAR important factors pertaining to the interaction between the units and organizations can be documented. The goal of the AAR is to give participants feedback on mission and task performance and to support the reflection phase of the learning process (Scott, 1983; Downs, Johnson and Fallesen, 1987).

In the context of the ALFA-05, the AAR was designed to start one hour after the RPE and continued for two hours. First, the participants were given a short debrief of the RPE and the incidents as they were planned and actually occurred. In the following reflection phase, the participants were motivated to recapitulate their actions to clarify for the researchers and themselves what happened and why it happened. Led by a facilitator, six topics were debated in a moderated discussion, i.e., participants wrote down notes related to the topics (all), read their notes aloud (selected key participants) and further discussed the topics (all). The topics were prepared by the AAR facilitator, observers and RPE staff members, and concerned the areas of real-time RPE as a method, information seeking, COP, and communication.

Observation

The observations were designed as open semi-structured observations, where observers act as complete observers (Burgess, 1984), i.e., not participating or interacting with the participants during the RPE. The observations were made directly as well as indirectly (via video surveillance and communication monitoring system). The observers were also allowed to move freely during the RPE and AAR. Four different observers were in place as a part of investigator triangulation (Denzin, 1978). Following areas were particularly addressed during the observations: information seeking, data exchange, COP, communication, and methodological issues. The observer for methodological issues also carried out observations also during the planning and evaluation of the ALFA-05, attending meetings, studying documents, etc.

Scenario modelling and structure analysis

In order to reach sufficient complexity of the C^2 structures and at the same time reach a high level of realism, the scenario type and size were designed to involve EM actors from two neighbouring counties in a joint emergency operation. This operation was a response to an incident located at the border area of the two counties. To achieve a realistic scenario and to simulate a plausible situation a single, self contained event – a middle-size forest fire in summertime in Sweden – was selected as the main incident. The scenario was planned as a *real-time scenario*, where scenario time is equal to real-time. Additionally, the scenario was proposed as continuous with start time 00:00 to stop time 02:00, corresponding to 2 hours in reality.

In the scenario, a forest fire develops at the border area of two municipalities, located in two different counties. Further, there are a number of additional incidents, which are launched during the RPE. These incidents are carefully selected in order to control the tempo of the RPE as well as to establish certain context with regard to experiment objectives. The additional incidents are: (1) traffic disturbances on surrounding roads, (2) threat from the fire to a neighbouring zoo with several thousands of visitors, (3) search and rescue of a group with small children on a picnic, (4) life threatening allergic reaction of one of the responding fire-fighters, (5) traffic accident on the nearby highway and (6) pressure from media requiring incident information. The scenario takes place on Saturday, July 2, 2005, starting at 10:30 and continuing for two hours. Based on the scenario size, location, time and incidents, relevant EM actors were selected. This was followed by mapping of their C^2 structures, resources, etc. From the collected data, incident commanders and dispatch officers were chosen as the most relevant command posts to focus on in the RPE. EM personnel from these organizations were invited, and at the end, the following commanders took part as participants in the RPE: county 112/911 emergency operator (2x), municipal fire & rescue on-site incident commander (2x), municipal fire & rescue dispatch officer (1x), county police on-site incident commander (1x) and county police dispatch officer (1x). The other command posts (e.g. county medical team leader, county emergency officer) were also invited from the concerned EM actors and were allocated as a part of the RPE staff. The overview of the EM actors in the RPE and the involved command posts are shown in the Figure 1.

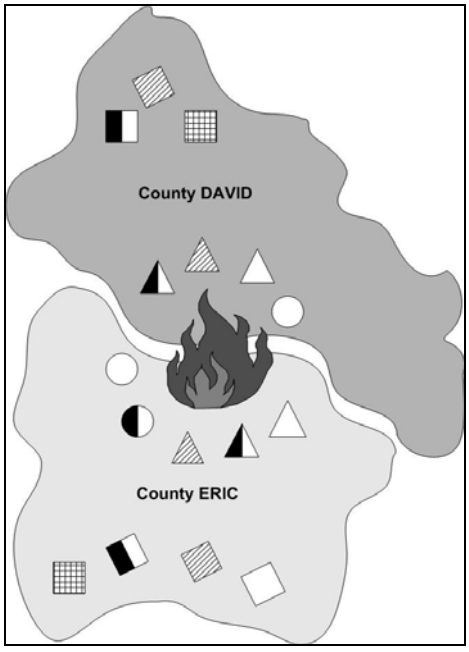

Figure 1. Command posts involved in the RPE and their distribution between participants (◇

Legend: ○ *fire & rescue on-site incident commander (OIC);* ◐ *police OIC;* △ *fire & rescue incident response units (IRU);* ◭ *police IRU;* ◬ *medical IRU;* ▱ *112/911 call-center;* ◇ *fire & rescue dispatch;* ◣ / ◧ *police dispatch;* ▥ *other (municipal crisis committee & county emergency officer, etc.)*

Data collection

Communication during the RPE represents the main data source. The participants were allowed to communicate between each other and with the RPE staff only through text messages. For this purpose a network comprising twenty computers and one server was set up. A research environment for collaborative team work called C3Fire (Granlund, 2002) was used to support the computer-mediated communication (see Figure 2). All communication was stored in log-files.

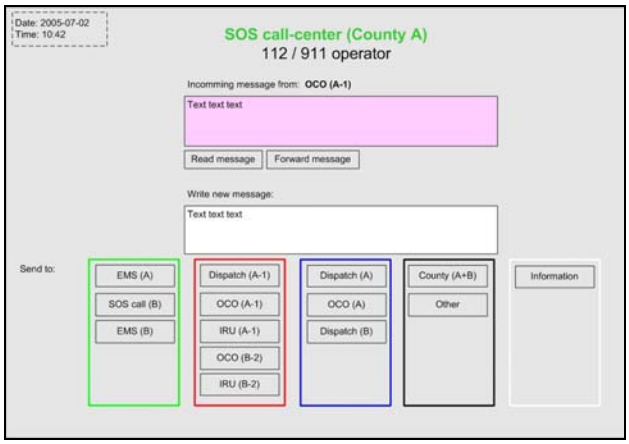

Figure 2. C3Fire communication environment – 112/911 call-center operator user interface

With regard to the intensity of the RPE, the RPE the participants' workplaces and the RPE staff were monitored via nine video cameras connected into a video surveillance system. The video cameras recorded all the activities during the RPE. Video recording was also used during the AAR.

All the material used in the study was archived. This includes notes participants, RPE staff, observers and AAR facilitator made as well as paper maps used during the RPE.

ALFA-05 EXECUTION

The study took place at the Linköping University in Linköping on December 1, 2005. The day started with briefing and RPE introduction to the participants, observers and RPE staff. It was followed by a short introduction to the RPE area.

The RPE took place in a closed room, which was divided into two sections. The first section comprised RPE staff (see Figure 3). Conceptually a complete C^2 room was established. The nine members of the staff had information about all recourses (e.g., officers on duty, all vehicles in the region, including pictures of units, call signs, equipment, size of a water tanks, etc.) available. Their task was to launch incidents, play incident response units and other command posts, data sources, and to answer questions from the participants. For this reason, the Internet, phones, various maps, and resource sheets were available for the RPE staff.

Figure 3. During the RPE execution – RPE staff's situation map together with video- and communication surveillance (Photo: Björn Johansson)

In the second section eight participants' working places were organized. Each workplace was customized to the concerned command post, including relevant map material, list of available resources and a short brief of the situation at the RPE start (see Figure 4). The ambition was to provide the participants with as realistic data as possible. For example, the police dispatch officer was provided with a list of available resources – police patrol vehicles, including pictures and call signs – in the RPE, which were corresponding to police resources of that day in reality (July 2, 2005).

Figure 4. Participant's working place – paper map, overview of available resources, notes and computer-based communication tool C3Fire (Photo: Björn Johansson)

The RPE started at 10:30 when multiple emergency calls (messages) were sent to the 112/911 call-centers by the RPE staff. From this moment the participants carried out actions to handle the incidents in the scenario. The RPE continued for two hours until it was stopped by the RPE staff. After a one hour break the AAR was carried out during two hours.

METHODOLOGICAL LESSONS LEARNED

Scenario and RPE settings

The workload and tempo of the scenario was experienced as realistic by the participants. The observers also reported signs of high workload of several of the participants. The level of realism is also supported by the fact that problems occurring during real emergency response operations also occurred during this RPE. For example, the concerned fire & rescue on-site incident commander was called to the incident site later than the other EM actors. This commander faced the problem of insufficient command hand-over and missing information from previous response phases, like in situations often occurring during middle-size and large fires.

It is also important to explain to the participants that they may become involved in the scenario at later stages, or on a very limited scale, as happened in one case in this RPE. Due to the nature of the RPE, this problem was efficiently handled by adding an extra incident to the scenario by the RPE staff. It is important to be aware that participants' involvement in the RPE is strongly dependent on how the incidents are managed by the other participants. The RPE is self-going since sufficient complexity is at place as an effect of the interaction. Thus, due to the nature of the RPEs, exploring reality, the researchers should not strive for full control as it is hardly possible and may influence the level of realism in the RPE.

Communication settings

The participants were only allowed to communicate via text messages. The research team was aware of this limitation. Nevertheless, due to the fact that the RPE was executed for the first time as well as the limited technical resources it was decided to still use only text communication. This resulted in some negative comments from the participants. First, the 112/911 emergency operators found it limiting when only text communication with a certain narrow number of persons was possible. This caused problems since they are making their judgements about the events partially on the volume of received emergency calls. A solution to this problem is a combination of voice communication and a high number of callers in future RPEs together with tools already in use during live exercises, such as CITE® and MIND (Jenvald and Morin, 2004). Second, all the participants missed the opportunity to listen in ongoing radio traffic between responding units. In reality, this is commonly used by the participants as one of the data sources to create an operational picture. In this RPE, to simulate such communication would have been too demanding from organizational as well as technical perspective due to the high number of incident response units involved. However, this problem can be resolved by using real-life radio communication as, for example, in the Swedish Army's training RPEs (Granlund, 1997b). Besides the discussed limitations text communication was not found as a significant problem, where communication one-to-one normally occurs. Moreover, the delay caused by the actual writing of the messages allowed the RPE staff to easier manage the incidents and tempo in the RPE. From this perspective, the text communication is an advantage.

Co-localized actions

Another issue, which the research team was aware of, was a co-localized action. This situation occurred when fire & rescue and police on-site incident commanders met at the incident site. Instead of having face-to-face dialogue, they were forced to communicate only through text messages. This was again caused by the organizational settings in which the RPE took place, i.e., number of available rooms. This can be handled in future RPEs by using more rooms and modes of communication.

Workspace settings

In the RPE a simplified working places were built with the use of paper maps. It turned out to be restricting for the participants used to work with advanced computer-based decision support systems (DSS) with digital maps. The participants found it difficult to work without this support. They felt that they could not perform at the level of speed and quality they normally do. By replicating the participants' DSS this problem can also be eliminated.

Social context settings

A topic related to the workspace settings is the social context of a workplace, in this case dispatch rooms and emergency call-centers. Response to an emergency event is commonly teamwork between several operators and dispatchers. This influenced the number and selections of tasks the participants did in the RPE. In reality the participants would share the workload with their colleagues. This is, of course, a relatively serious methodological

issue since such social context is difficult to establish in the context of RPE. On the other hand, this factor is very much dependent on the objectives of particular RPEs. In this case, the attention was given to particular commanders concerning how they conduct information search and exchange. It was concluded by the research team, that AAR together with eventual interviews with the participants sufficiently documented this factor. Nevertheless, particular attention has to be given to this issue in design of future RPEs.

SUMMARY

This paper contributes to the discussion on relevant research methods to study C^2. The discussed ALFA-05 – an explorative study combining real-time RPE, AAR and observations – produced data, providing the research team with different descriptions of C^2 work compared to traditional methods. The most essential contribution of using real-time RPE together with thorough data collection is its possibilities to identify and document differences between the planned and intended C^2 processes, and the real C^2 work. Further, the opportunities to create complexity, design own scenarios, involve professional users, and repeat the RPE are the advantages of real-time RPEs as a research method. An additional benefit of the RPE is the co-location of the participants in one area enabling a joint AAR immediately after the RPE. At the same time, a number of issues were identified during the ALFA-05. The documented methodological lessons learned have to be addressed in future RPEs. As discussed in the proceeding text, most of these issues can be resolved by various means. These means, however, often require further resources. In this sense, real-time RPEs represent a demanding method, requiring extensive technological, organizational and human resources.

On the other hand, real-time RPEs can be used to create situations, which would be very dangerous or difficult to establish in reality. From this perspective, real-time RPE combined with other methods can be considered as a feasible method for researchers and exercise managers to tackle present and future C^2 in complex settings, where interaction and communication are in focus. Still, it is essential to gain more experience and to further map advantages and disadvantages of real-time RPEs in C^2 research. The real-time RPE in the presented form is suitable for scenarios no longer than eight hours. Longer scenarios bring in methodological questions (management of realism and complexity) as well as practical problems (RPE staff rotation, fragmented debriefing, participant availability). These longer scenarios are also more demanding with regard to advanced technical support.

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REFERENCES

1. Barreteau, O. (2003) The joint use of role-playing games and models regarding negotiation processes: characterization of associations, *J. Artificial Societies and Social Simulation*, 6, 2.
2. Brehmer, B. (1991) Organization for decision making in complex systems, in Rasmussen, J., Brehmer, B., and Leplat, J. (eds.), *Distributed Decision Making: Cognitive Models for Cooperative Work*, John Wiley & Sons.
3. Burgess, R.G. (1984) In the Field: An Introduction to Field Research, Routlege.
4. Daré, W. and Barreteau, O. (2003) A role-playing game in irrigated system negotiation: between play and reality, *J. Artificial Societies and Social Simulation*, 6, 3.
5. Denzin, N.K. (1978) Sociological methods, McGraw-Hill, New York.
6. Downs, C.W., Johnson, K.M. and Fallesen, J.J. (1987) Analysis of feedback in after action reviews, (ARI Technical Report 745), U. S. Army Research Institute for Behavioural and Social Sciences, (AD A188 336), Alexandria, VA, USA.
7. Gentner, F.C., Cameron, J.A. and Crissey, M.J. (1997) Essential Training Needs and Resources for Simulation Observer/ Controllers, *Proceedings of the 19th Interservice/Industry Training Systems and Education*

Conference, Orlando, FL, USA.

8. Granlund, R. (2002) Monitoring Distributed Teamwork Training, Linköping Studies in Science and Technology, Dissertation No. 746, ISBN 91-7373-312-1, Linköpings universitet, Linköping, Sweden.
9. Granlund, R. (1997a) C^3Fire – A Microworld Supporting Emergency Management Training, Linköping Studies in Science and Technology, Thesis No. 598, ISBN 91-7871-890-2, Linköpings universitet, Linköping, Sweden
10. Granlund, R. (1997b) Micro-world Systems for Emergency Management Training, in Waern, Y (eds.), *Co-operative process Management: Cognition and Information Technology*, Taylor & Francis.
11. Hannestad, S.E. (2005) Incident Command System: A Developing National Standard of Incident Management in the U.S., *Proceedings of the 2nd ISCRAM conference*, Brussels, Belgium.
12. Ikeda, Y., Beroggi, G.E.G. and Wallace, W.A. (1998) Supporting multi-group emergency management with multimedia, *Safety Science*, 30, 1, 223-234.
13. Ingrassia, P.L., Geddo, A., Lombardi, F., Calligaro, S., Prato, F., Tengattini, M., Morin, M., Jenvald, J. and Della Corte, F. (2005) Objective evaluation in a disaster drill: accuracy of triage operations, *Proceedings of the 3rd Mediterranean Emergency Medicine Congress,* Nice, France.
14. Jansen, E., Jones, C.R. and Sovereign, M.G. (2002) The Command and Control – Emerging Effects Framework: An Overview, *Proceedings of the 7th ICCRTS Command and Control Research and Technology Symposium*, Monterey, CA, USA.
15. Jenvald, J. (1999) Methods and Tools in Computer-Supported Taskforce Training, Linköping Studies in Science and Technology, Dissertation No. 598, ISBN 91-7219-547-9, Linköpings universitet, Linköping, Sweden.
16. Jenvald, J. and Morin, M. (2004) Simulation-supported live training for emergency response in hazardous environments, *Simulation & Gaming*, 35, 3, 363–377.
17. Jenvald, J., Morin, M. and Kincaid, P. (2001) A Framework for Web-Based Dissemination of Models and Lessons Learned from Emergency-Response Operations. *Int. J. Emergency Management, 1*(1), 82-94.
18. Jungert, E., E., Derefeldt, G., Hallberg, J., Hallberg, N., Hunstad, A., Thurén, R. (2004) Architecture-based Model for Preventive and Operative Crisis Management, *Proceedings of the NATO SCI-158 Symposium on Systems, Concepts and Integration Methods and Technologies for Defense against Terrorism*, London, UK.
19. Landgren, J. (2004) Fire Crew Enroute Sensemaking in Emergency Response, *Proceedings of the 1st ISCRAM conference*, Brussels, Belgium.
20. Morin, M. (2002) Multimedia Representations of Distributed Tactical Operations, Linköping Studies in Science and Technology, Dissertation No. 771, ISBN 91-7373-421-7, Linköpings universitet, Linköping, Sweden.
21. Morin, M., Jansson, L. D. and Jenvald, J. (2005) Training and Evaluation of Crisis Information Management, in Fritzson, P(ed.), *Proceedings of the Modeling and Simulation for Public Safety Conference (SIMSafe2005)*, Linköping, Sweden.
22. Morin, M., Jenvald, J., and Thorstensson, M. (2000a) Computer-Supported Visualization of Rescue Operations, *Safety Science*, 35, 1–3, 3–27.
23. Morin, M., Jenvald, J. and Crissey, M.J. (2000b) Training Needs and Training Opportunities for Emergency Response to Mass-Casualty Incidents, *Proceedings of the 11th International Training and Education Conference (ITEC'2000)*, Hague, Netherlands.
24. Perry, R.W. (2003) Incident Management Systems in Disaster Management, *Disaster Management and Prevention*, 12, 5, 405-421.
25. Rankin, W.J., Gentner, F.C., and Crissey, M.J. (1995) After Action Review and Debriefing Methods: Technique and Technology, *Proceedings of The 17th Interservice/ Industry Training Systems and Education Conference*, Albuquerque, New Mexico, USA.
26. Rejnus, L., Jenvald, J. and Morin, M. (1998) Assessment of Emergency Planning Based on Analysis of Empirical Data, *Proceedings of the 6th International Symposium on Protection against Chemical and Biological Warfare Agents (CBWPS)*, Stockholm, Sweden.
27. Scott, T.D. (1983) Tactical engagement simulation after action review guidebook, (ARI Research Product 83-13), U. S. Army Research Institute for Behavioural and Social Sciences, (AD A143 014), Alexandria, VA, USA.

28. Shen, S.Y. and Shaw, M.J. (2004) Managing Coordination in Emergency Response Systems with Information Technologies, *Proceedings of the 10th Americas Conference on Information Systems*, New York, NY, USA.
29. Smith, W. and Dowell, J. (2003) A Case Study of Co-ordinative Decision-making in Disaster Management, *Ergonomics*, 43, 8, 1153-1166.
30. Turoff, M., Chumer, M., Yao, X., Konopka, J. and Van den Walle, B. (2005) Crisis Planning via Scenario Development Gaming, *Proceedings of the 2nd ISCRAM conference*, Brussels, Belgium.