11TH ICCRTS

COALITION COMMAND AND CONTROL IN THE NETWORKED ERA

Information Support in Collaborative Command and Control Work – Empirical Research Using a Role-Playing Exercise Approach

C2 Experimentation, C2 Concepts and Organization, Social Domain Issues

Jiri Trnka[1], Björn Johansson[1], Rego Granlund[2]

Point of Contact: Jiri Trnka, jirtr@ida.liu.se

[1]Linköping University
Dept. Computer & Information Science
SE-581 83, Linköping, Sweden
+46-13-28 10 00
jirtr@ida.liu.se, bjojo@ida.liu.se

[2]Rationella Datortjänster HB
Muggebo Fridensborg
SE-590 41, Rimforsa, Sweden
+46-494-20 56 6
Rego.Granlund@c3fire.org

Information Support in Collaborative Command and Control Work – Empirical Research Using a Role-Playing Exercise Approach

Jiri Trnka[1], Björn Johansson[1], Rego Granlund[2]

[1]Dept. Computer and Information Science
Linköping University
SE-581 83, Linköping, Sweden

[2]Rationella Datortjänster HB
Muggebo Fridensborg SE-590 41,
Rimforsa, Sweden

Point of contact: Jiri Trnka, jirtr@ida.liu.se, tel: +46-13-28 10 10, fax: +46-13-14 22 31

Keywords: Information seeking, communication, command and control, role-playing exercise.

This research aims at improving knowledge on design of computer-supported command and control systems. In particular, aspects of communication and information seeking are investigated. The method of role-playing exercises is presented and some empirical data from a study using that method is presented. A role-playing exercise is a real-time approach where participants act in their professional roles to manage various situations in a collaborative matter. In this case, a forest-fire together with additional incidents was used in order to study collaborative command and control work between commanding officers from different organizations, such as police, fire & rescue and emergency call-centers. Commanders' local knowledge and experience from similar events are factors influencing information seeking. Other types of information are seen as additional, and further information seeking depends on the dynamics of the events and the workload. The essential contribution of the role-playing exercise approach lays in its possibilities to document and identify differences between planned and intended command and control processes and real command and control work.

Information Support in Collaborative Command and Control Work – Empirical Research Using a Role-Playing Exercise Approach

Jiri Trnka[1], Björn Johansson[1], Rego Granlund[2]

[1]Dept. Computer and Information Science
Linköping University
SE-581 83, Linköping, Sweden

[2]Rationella Datortjänster HB
Muggebo Fridensborg SE-590 41,
Rimforsa, Sweden

Point of contact: Jiri Trnka, jirtr@ida.liu.se, tel: +46-13-28 10 10, fax: +46-13-14 22 31

Keywords: Information seeking, communication, command and control, role-playing exercise.

1 Introduction

Emergency management (EM) is a system, which the human society created as a reaction to harmful events, such as accidents, emergencies and disasters. The principal goal of the EM system is to produce countermeasures to such events (Waugh, 2000; Carter, 1991). Moreover, present EM is so complex that the coordination is also subject to increasing complexity. This is particularly the case of emergency response, i.e., a period immediately after a harmful event occurs, when countermeasures are put in place intensively and dynamically.

In order to improve the coordination in the EM system, a command and control (C^2) system is commonly introduced. This C^2 system is also complex and dynamic to meet the demands of the EM itself (Jungert et al., 2004; Jansen et al., 2002). Management of internal resources but also resources of other EM organizations, multiple goals of these organizations as well as diverse multiple operational procedures constitute extra challenges specific for C^2 work in EM (Shen and Shaw, 2004).

An essential element of collaborative C^2 work is communication and information seeking. If commanders and commanding teams from different organizations are to function as a system that strives towards a goal originating from a decision, this goal, or intention, has to be shared within the C^2 system. When many commanders and commanding teams are involved in an effort to control a dynamic situation, multiple, conflicting goals are bound to emerge, eventually leading to a need for negotiation about which goals to select and pursue. These two elements – communication and information seeking – are therefore of uttermost importance for successful joint operations. Researchers focusing on organizations working in high-risk areas, such as military affairs, acknowledge the importance of having good social, organizational and technological conditions to support communication and information exchange between the involved teams (Johansson, 2005) in order to tackle disturbances on performance and to uphold high reliability (Rochlin, 2000, 1999; Rochlin & Demchak, 1991).

The possibility to gain knowledge from such C^2 work and re-using this knowledge in research and development is essential. One of the problems is a lack of methods allowing researchers to study such C^2 work, in terms of information seeking and communication, in repeatable and realistic settings. From this perspective, to document and analyse C^2 in EM in real-life context is still a challenge. The research described in this paper employs a real-time approach to investigate the issues of communication and information seeking in collaborative C^2 work. Results from a real-time role-playing exercise are presented.

2 A role-playing exercise approach

A role-playing exercise approach, as described in this paper, refers to methods where the participants in a study face a task conducted in actual time where the development of the task can be described as dynamic (Brehmer, 1987). The interest thus primarily lay in understanding how participants act under uncertainty and time pressure when only having access to limited resources. The example provided below – role-playing exercise – is far from the only ones that utilize a real-time approach (see for example Gestrelius, 1998). Rather, it is the purpose of the usage of the method that is of interest. The concept of role-playing exercises has its theoretical foundation in role-playing games and has been developed so that it can be used in a systematic way to perform research on team decision making and communication.

2.1 Role-playing games

A role-playing game is in principle interactive multi-person setting, where participants (humans) try to solve a problem or overcome various obstacles in a collaborative manner. In this type of games, participants assume roles of various characters as well as their duties and tasks according to a scenario. In military, the use of various games has resulted into entire concept known as war-games or also tactical decision games (Jaiswal, 1997; Crichton et al., 2000; Green, 2000). The military domain is also one of the most common application areas for role-playing games, in particular operational games (Rubel, 2001; Thomas, 1984; Shubik, 1972). Role-playing games have also become more common in training in the area of crisis and emergency management (for example Crichton & Flin, 2001; Kaji et al., 2005). Various forms of role-playing games have been used in research too, for example, decision-making and behaviour research (Klein & Cooper, 1982; Cooper, 1979; Lewis & Barlow, 2005; Cooper et al., 1980).

2.2 Role-playing exercise

A role-playing exercise (RPE) is an operational game, building on the tactical decision game concept to a large extent. An important distinction between traditional exercises/role-playing games and RPE:s is the systematic use of different research methods to collect various types of data in the RPE, such as recoding of all participants' actions and communication. In this sense the RPE represents a research concept utilizing different research methods, for example, after action review, observation, and interview(s). The objectives are also different. The RPE has analytical research on how activities are accomplished as the main objective. In contrast to the RPE, the tactical decision games mainly focus on training to support participants in understanding of what should be done. Another distinction is in the scenario, number and type of participants, etc. In the RPE the participants do not play presumed roles but act in their professional roles, various commanding posts. The scenario is strictly steered by realism and real-life settings. In other words, the RPE is a synchronous game with (clock) speed corresponding to the time in reality. Such RPE 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. Due to its complexity and dynamics, the RPE is controlled by several umpires (game masters), called RPE staff (Fig. 1). The RPE staff is a team of researchers and exercise managers, which are supported with various computer-assisted tools, such as visualisation tools, geographical information systems, simulations, surveillance equipment, etc.

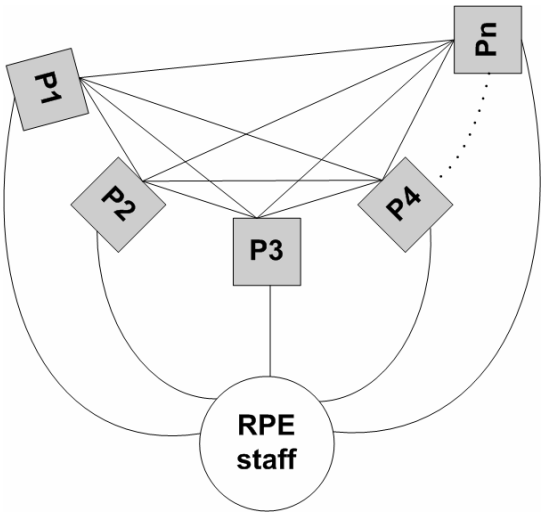


Fig. 1: A schematic example how a RPE is organized: n participants, which interact with each other and with the RPE staff

3 The ALFA-05 role-playing exercise

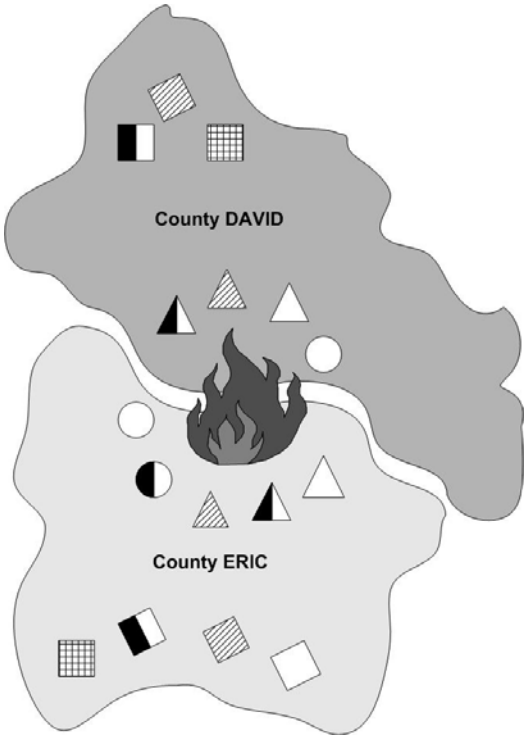
The ALFA-05 role-playing exercise focused on the operational level of C^2 during emergency response to a forest fire. The focus was on three areas of C^2 work: (a) information seeking at different command posts, (b) communication between these command posts, and (c) selection of data sources by particular commanders.

3.1 Organization

In order to reach sufficient complexity of the C^2 structures and at the same time reach a high level of realism, the RPE was designed to involve EM organizations from two neighbouring counties in a joint emergency operation. Seven commanding posts – different incident commanders and dispatch officers – were selected as the most relevant command posts to focus on in the RPE. 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 emergency medical team leader, county emergency management officer) also participated in the RPE however as a part of the RPE staff. The overview of the EM organizations and command posts involved in the RPE are shown in the Fig. 2.

3.2 Scenario

To simulate a realistic and plausible situation the scenario was built on a single, self contained event. This single self contained event was a middle-size forest fire located at the border area of two municipalities, located in two different counties in summertime in Sweden. Further, there were a number of additional incidents in the scenario. These incidents were carefully selected in order to control the tempo of the RPE as well as to establish certain context with regard to the objectives. The additional incidents were: (1) traffic disturbances on surrounding roads, (2) threat from the fire to a neighboring 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 took virtually place on Saturday, July 2, 2005, starting at 10:30 and continuing for approximately two hours. The scenario was planned as a continuous real-time scenario, where scenario time was equal to real-time.



Legend: [a] Command posts & EM organizations involved in the RPE as participants:
○ = fire & rescue on-site incident commander (OIC);
◐ = police OIC; △ fire & rescue incident response units (IRU);
= 112/911 call-center;
= fire & rescue dispatch;
= police dispatch;

[b] Command posts & EM organizations involved in the RPE as RPE staff:
◭ = police IRU;
= medical IRU;
◧ = police dispatch;
= other (municipal crisis committee & county emergency officer, etc.)

Fig. 2: Command posts from different EM organizations involved in the RPE as participants and RPE staff

3.3 Data collection

Communication during the RPE represented the main data source. The participants were allowed to communicate with each other and with the RPE staff only through text messages. All the communication was designed as one-to-one. The only exception was communication to the incident response units, which was one-to-many. For the communication purposes a network comprising twenty computers and one server was set up. A communication module from the C3Fire environment (Granlund, 2002) was used to support the computer-mediated communication (Fig. 3). All communication was stored in log-files.

Further, 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.

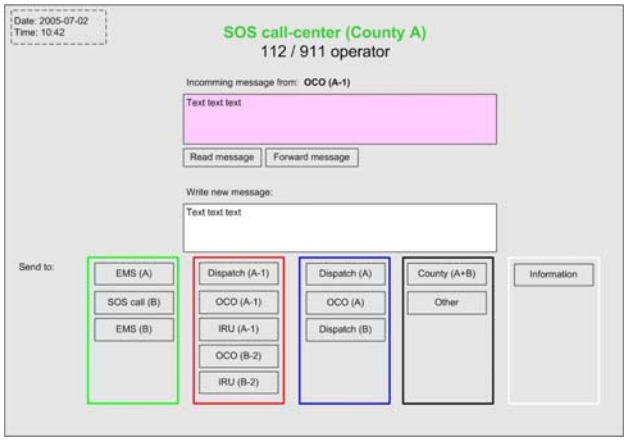


Fig. 3: C3Fire communication environment – 112/911 call-center operator user interface

Due to the high complexity of the real-time RPE, two additional data collection methods, often used in the context of role-playing games and RPE (Daré and Barreteau, 2003), observation and after action review were utilized.

The after action review (AAR) (see for example Rankin et al., 1995, Scott, 1983) 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 (an experienced researcher in the area of focus group and after action review technique), 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, shared understanding and communication. Video recording was also used during the AAR.

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, shared understanding, communication, and methodological issues. The observer for methodological issues also carried out observations during the planning and evaluation of the RPE, attending meetings, studying documents, etc.

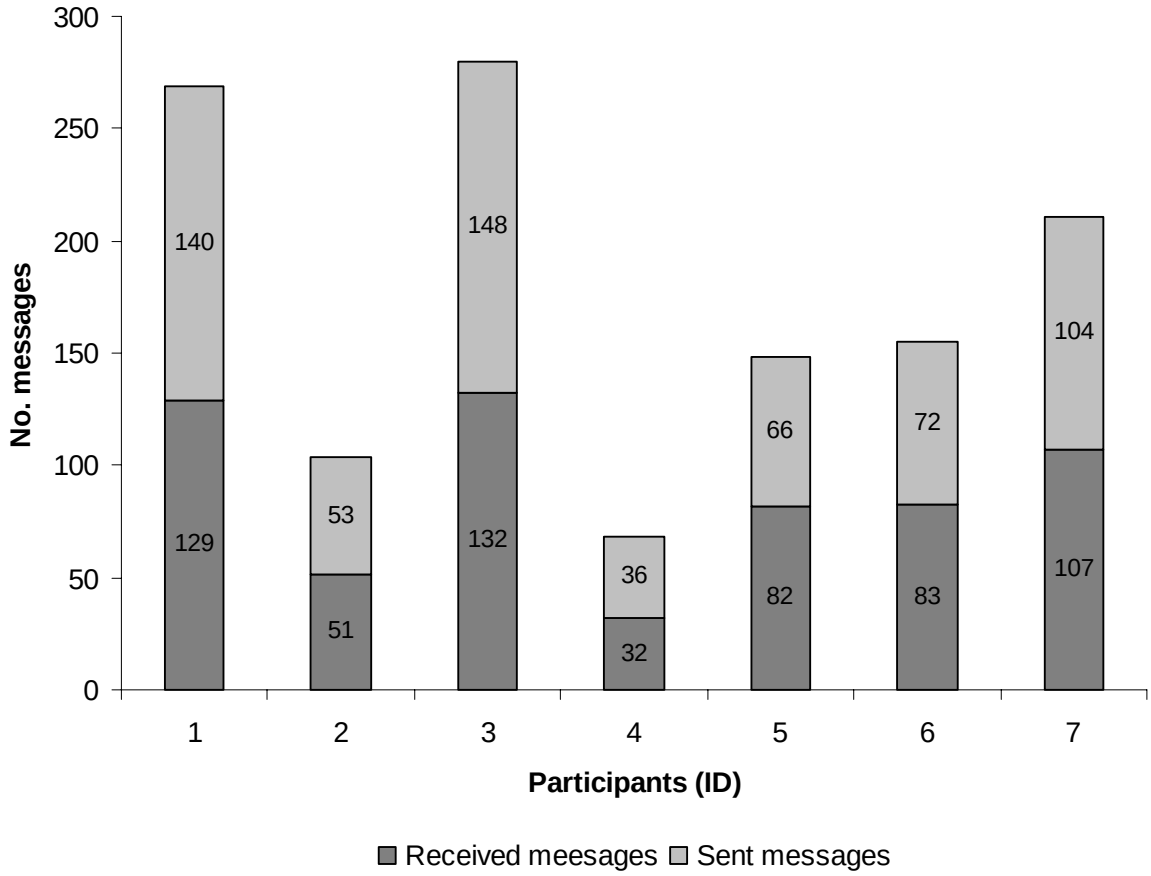
Finally, all the material used in the RPE was archived. This includes notes participants, RPE staff, and observers made as well as paper maps used during the RPE.

4 Results and discussion

The results presented in this section concern communication data collected in the form of text messages during the RPE and data from the AAR. The quantitative and qualitative data analysis focuses on the communicative practice and information seeking of the participants during a collaborative emergency response operation. For further discussion on the settings, including implications of text communication, of this RPE see Trnka & Jenvald (2006).

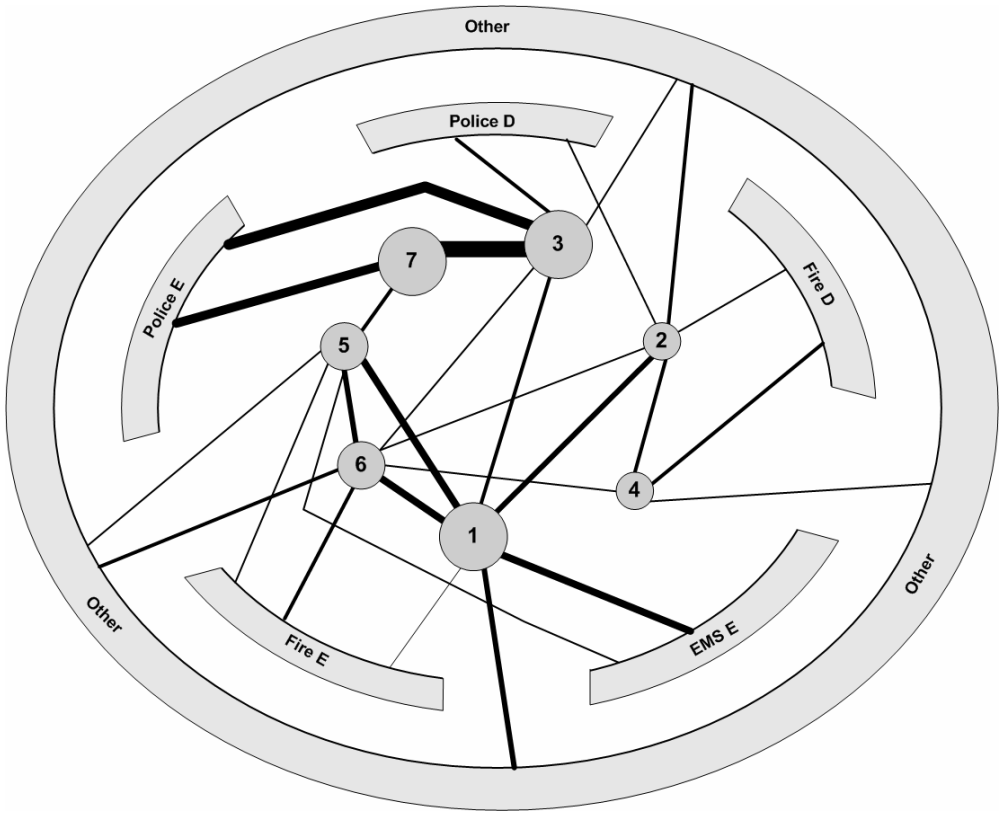
4.1 Communication density

During the two hours that the RPE lasted, the total number of sent messages was 849. This figure includes communication between the participants (seven commanding officers) as well as between the participants and RPE staff (six members of the staff communicated with the participants). By decomposition of the communication per participant the communication workload on each participant can be documented (Fig. 4). The directions and extent of the communication are mapped in Fig. 5. Both figures show that even if the main incident in the RPE was a forest fire, the highest communication workload was on the 112/911 call-center, police dispatch and police on-site incident commander in the Eric county.



Participants (ID): *1* – 112/911 call-center (Eric county); *2* – 112/911 call-center (David county); *3* – Police dispatch (Eric county); *4* – Fire & rescue on-site incident commander (David county); *5* – Fire & rescue on-site incident commander (Eric county); *6* – Fire & rescue dispatch (Eric county); *7* – Police on-site incident commander (Eric county);

Fig. 4: Communication density distribution among the RPE participants



Legend: *1* – 112/911 call-center (Eric county); *2* – 112/911 call-center (David county); *3* – Police dispatch (Eric county); *4* – Fire & rescue on-site incident commander (David county); *5* – Fire & rescue on-site incident commander (Eric county); *6* – Fire & rescue dispatch (Eric county); *7* – Police on-site incident commander (Eric county);

Police E – police incident response units (IRU) in Eric county (RPE staff); *Police D* – Police dispatch & police IRU in David county (RPE staff); *Fire D* – fire IRU in David county (RPE staff); *Fire E* – Fire IRU in Eric county (RPE staff); *EMS E* – Medical IRU in Eric county (RPE staff); *Other* – emergency callers, other EM organizations, etc. (RPE staff)

1-15 messages; 16-30 messages; 31-45 messages; 46-60 messages; 61-75 messages; 76-90 messages; 91-135 messages :

< 120 messages (no. sent and received messages); 120-200 messages; > 200 messages

Fig. 5: Communication directions and extent between the participants, and the participants and RPE staff

4.2 Communication pattern

Besides the quantitative analysis of the communication density, we also analysed the qualitative dimension of the communication. All the messages sent by the participants were categorized according to nineteen categories (see Tab.1). These nineteen categories were developed from a modification of the thirteen categories used by Brehmer & Svenmarck (1995) in a study of distributed command and control. This analysis was performed so that the actual content of the messages could be revealed, giving valuable insights to the information needs of the commanding officers as well as the work load on the individual command posts. The classification was performed by a temporarily employed assistant that was trained in the method. This was done in order to avoid researcher bias.

Questions	Information	Commands	Other
(1) About other subjects intention	***(5)*** About own intentions	***(12)*** Mission order	***(15)*** Request for clear command
(2) About location of an incident	***(6)*** About other subjects intention	***(13)*** Direct order	***(16)*** Request for help
(3) About other subjects activity	***(7)*** About an incident	***(14)*** Adjustment of order (navigation)	***(17)*** Offer of help
(4) About other subjects location	***(8)*** About own location		***(18)*** Acknowledgment
	(9) About other subjects location		***(19)*** Miscellanous
	(10) About own activity		
	(11) About other subjects activity		

Tab. 1: The categories used for message classification.

Most of the categories in the Tab. 1 are self-explanatory. However, the distinction between the three different commands needs clarification. By “Mission order” (12), an order with a high degree of freedom is meant. “Direct order” (13) is an order with a high degree of precision which leaves little room for own initiative. “Adjustment of order” (14) is a term used to describe when an earlier command is slightly altered, but not changed in term of the overall goal, i.e.,: “continue towards X-town, but take a look at Y-village when you pass by it”.

As can be seen in Fig. 6 (below) there are some apparent peaks in the communication pattern. Categories 7 (“Information about an incident”), 10 (“Information about own activity”) and 18 (“Acknowledgment”) clearly stands out. This indicates that the participants often informed their colleagues without being requested to do so. This is an important characteristic of their C^2 work since it indicates a will to be pro-active, serving other commanding officers with information that is assumed to be relevant.

In the quantitative analysis of the communication we observed that three participants, 112/911 emergency operator, county police dispatch officer and county police on-site incident commander in the Eric county, experienced a high communication volume. If we look at the communicative pattern of these participants (Fig. 7), we can see the difference between the 112/911 call-centre and the two police command posts. The police dispatch and on-site incident commander have two very similar patterns, while the 112/911 call-centre shows a relatively higher level of information dissemination.

Thus we primarily focus on these three participants in further discussion. We discuss to which extent their communication is the expected practice, if not, in what way it conflicts with the expected, and what the potential causes are.

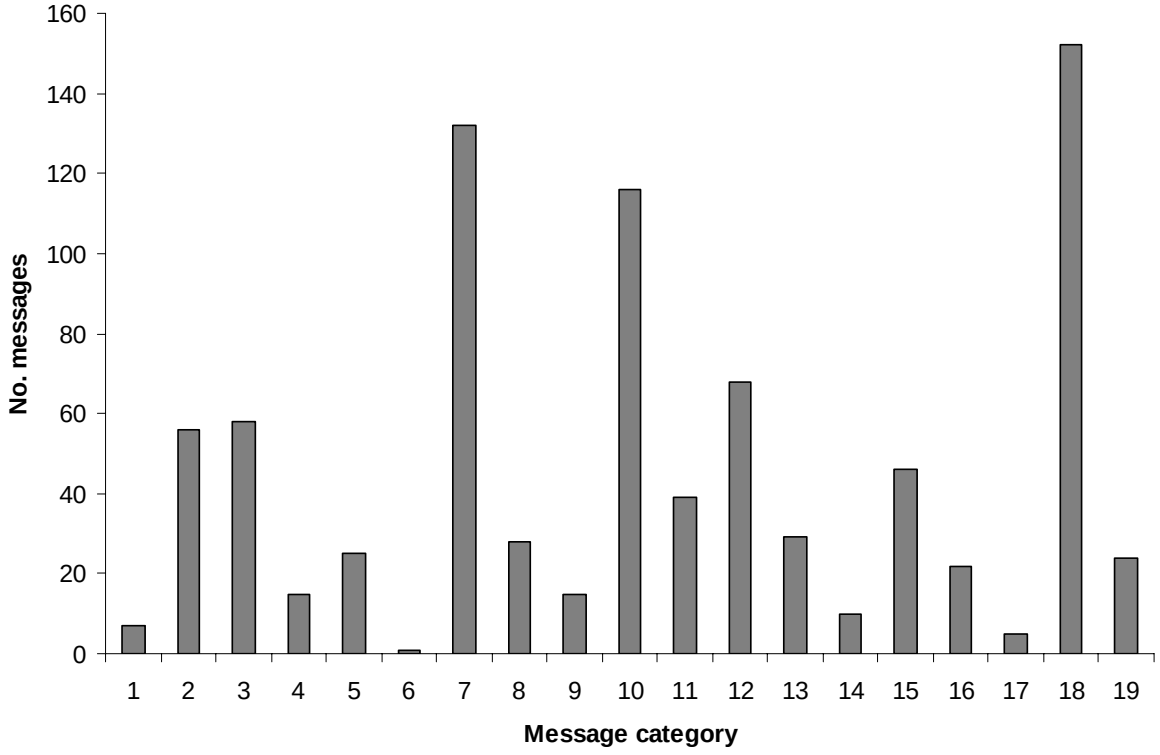


Fig. 6: Communication structure – all participants

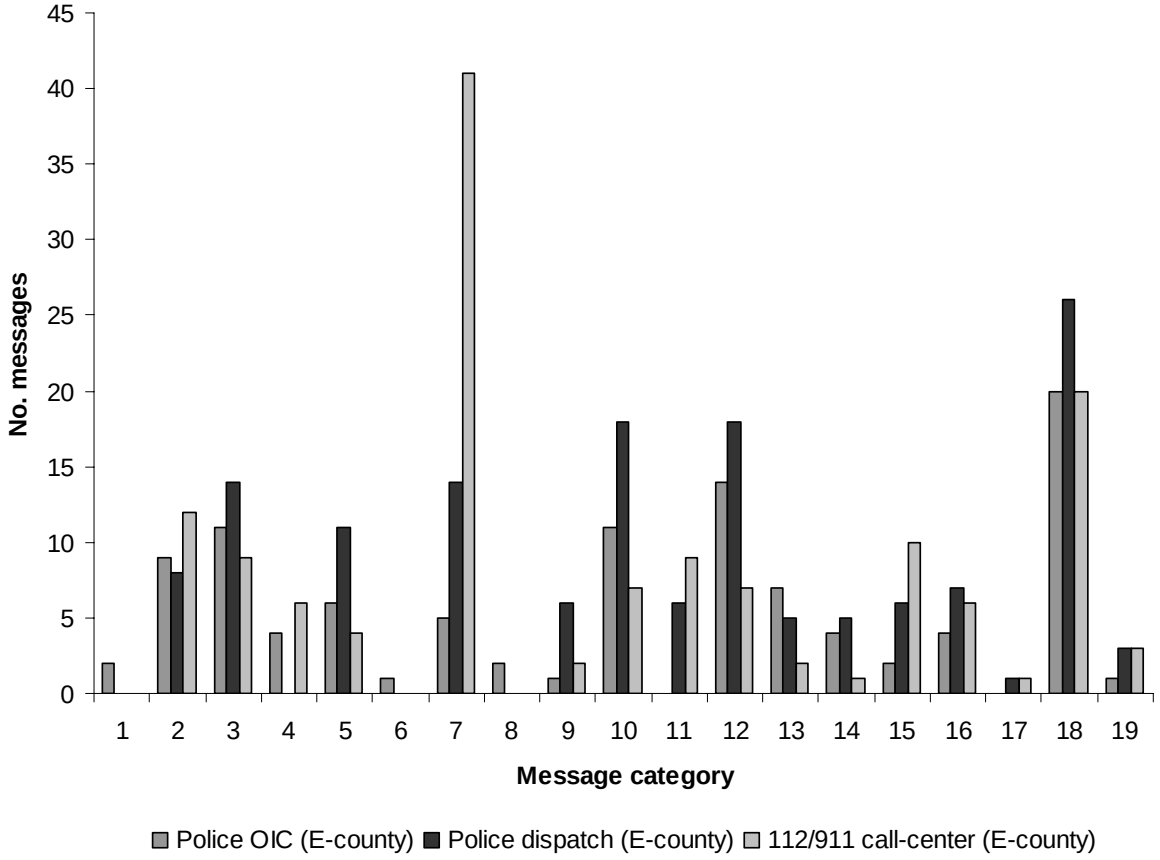


Fig. 7: Communication structure – single participants

4.3 Differences between planned and actual work at the 112/911 call-center

In rea1-life, the 112/911 call-centers carry out following tasks according to the official arrangements with other EM organizations: [a] receive 112/911 calls, [b] dispatch EMS incident response units (alarming, prioritizing and coordinating), and [c] dispatch fire & rescue incident response units (alarming). It is important to notice that 112/911 call-centers do not have any C^2 functions, such as emergency medicine C^2. In the RPE the 112/911 performed these tasks. However, besides the tasks according to the arrangements the 112/911 call-center also carried out other types of C^2 work in the RPE. This included distribution of information relevant to other involved commanding officers (see Fig. 7). An example of such information dissemination follows below:

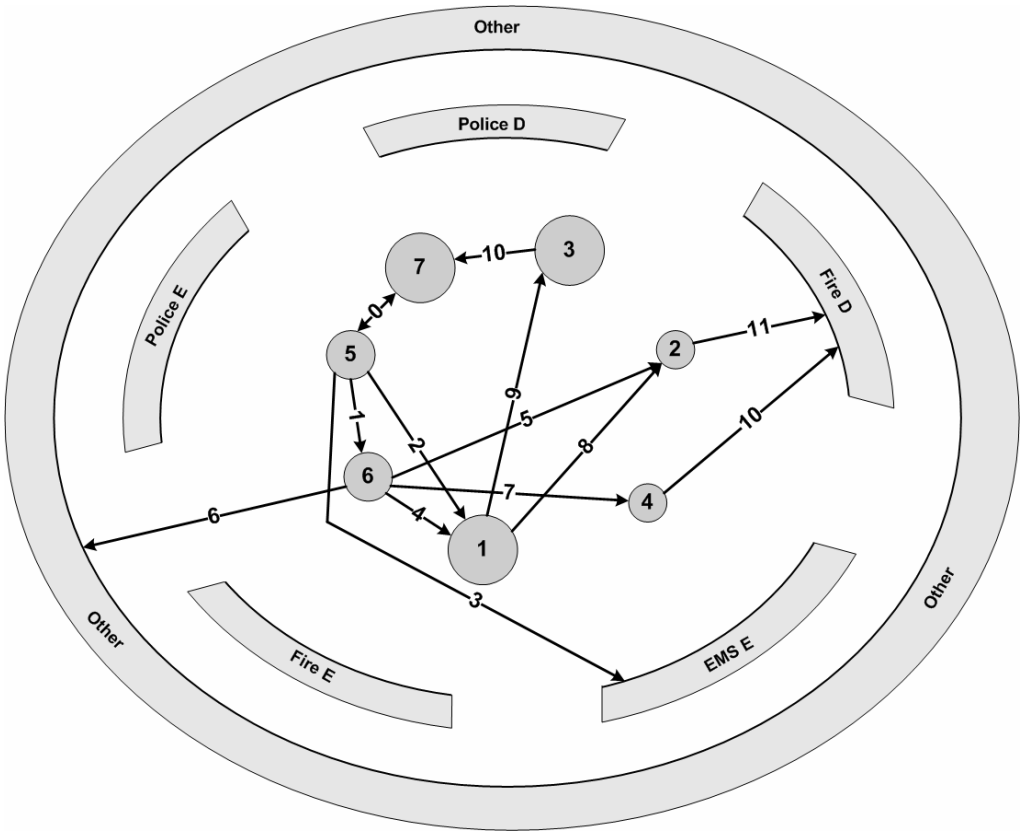
Police dispatch (E) to 112/911 call-center (E) [00:00]: "To your notice, the police on-site incident commander C. Johnson decided that reporting location for police forces is a part of parking place outside the Zoo."

112/911 call-center (E) to Fire & rescue dispatch (E) [03:17]: "To your notice, the police on-site incident commander C. Johnson decided that reporting location for police forces is a part of parking place outside the Zoo."

112/911 call-center (E) to Fire & rescue on-site incident commander (E) [03:21]: "To your notice, the police on-site incident commander C. Johnson decided that reporting location for police forces is a part of parking place outside the Zoo."

Fig. 8, shows another example how 112/911 call-center received and further distributed information. In this case this was information that joint command post between police and fire & rescue was established and its location.

It seems as the 112/911 call-centre's primary task was to support the other participants and the incident response units with relevant information. The 112/911 call-center had also the role of being a contact point for public and other organizations wishing to get in contact with responding EM organizations and their commanding staffs. It requires further investigation if this type of C^2 work is also carried out in similar way in reality. For example, as the 112/911 emergency operator highlighted during the AAR the faced workload in the RPE would be shared with other colleagues at the 112/911 call-center in reality.



Legend: *1* – 112/911 call-center (Eric county); *2* – 112/911 call-center (David county); *3* – Police dispatch (Eric county); *4* – Fire & rescue on-site incident commander (David county); *5* – Fire & rescue on-site incident commander (Eric county); *6* – Fire & rescue dispatch (Eric county); *7* – Police on-site incident commander (Eric county);

Fig. 6: An example how and in which order information about establishment of a joint command post by police and fire & rescue and its location was distributed among the participants

4.4 Collaborative C^2 work within the police forces

The police forces in the Eric county – police dispatch, police on-site incident commander and their incident response units (IRU) – had high communication volume compared to the fire & rescue services and EMS. This was probably influenced by two factors. First, the location, additional incidents and availability of the police resources in the RPE (which was corresponding to the reality) had impact on the relevance of the situation for the police forces. The police dispatch and police on-site incident commander had to call in IRUs from neighbouring municipalities and counties to handle the situation as well as to deal with the minimum necessary coverage for those areas. In other words, their C^2 work involved coordination of resources and negotiation of additional units. This was done based on situation reports from the police IRUs and situation judgements of the police dispatch and police on-site incident commander in a cooperative matter. Second, the police forces work with IRUs, which are continuously on move compared to the EMS and fire & rescues' IRUs, which are in most cases stationed. This was also reflected in the communication as the police IRUs had to report their location and status more often. Furthermore, the police dispatch actively distributed information about the status of operations and IRUs to the own IRUs and other involved commanding officers on the push-basis more frequently than other participants. During the AAR, the police dispatch officer and the police on-site incident

commander, both, saw the way they communicated very similar to the communication in reality. Two examples of the police communication are shown below:

Ex. 1) Active distribution of operative information on push-basis:

Police dispatch (E) to IRU-024 [00:00]: ”Be ready to go to North-town to support IRU-054, which is the only one unit in the town. We have a fire at the Giant-mountain where IRU-050 is on the way. We have IRU-020 responding to a traffic accident with HAZMAT at R22 between South-town and West-town. I will come back to you when you have to go.”

IRU-024 to Police dispatch (E) [01:19]: ”Understood”

Police dispatch (E) to Police on-site incident commander (E) [01:25]: ”I have found something called Giant-mountain close to the Coal-garden-area. I don’t know if it is correct. I will contact 112/911 call-center regarding that. I will come back to you. I have informed IRU-024 to be ready to support in North-town. They are however left in Fin-town now.”

Police on-site incident commander (E) to Police dispatch (E) [02:28]: ”Understood”

Police dispatch (E) to Police on-site incident commander (E) [02:59]: ”We have a forest fire at Giant-mountain and I want you to go there too. IRU-024 will move to North-town. IRU-050 is on the way to the Giant-mountain”

Police on-site incident commander (E) to Police dispatch (E) [03:40]: ”Understood. We are on the way there. Is it in the Coal-garden-area as you thought?”

Police dispatch (E) to IRU-024 [03:41]: ”Go to North-town. We have a forest fire at the Giant-mountain. IRU-054 and IRU-050 are on the way there. You are the only one unit in North-town.”

Police dispatch (E) to Police on-site incident commander (E) [03:55]: ”I will come back to you.”

IRU-024 to Police dispatch (E) [04:22]: ”Understood”

Police dispatch (E) to IRU-024 [04:52]: ”Thank you. If it will be something bigger we call in units from the Low-town.”

IRU-024 to Police dispatch (E) [05:17]: ”OK”

Police dispatch (E) to IRU-050 [06:03]: ”I have not got it confirmed from the 112/911 call-center but keep going towards the Coal-garden-area and village, and turn towards the Minning-village and continue on that road. So you will get to the Giant-mountain”

IRU-050 to Police dispatch (E) [06:35]: ”OK. Any further information about the fire?”

Ex. 2) Collaborative actions of the police dispatch and police on-site incident commander in Eric county:

Police on-site incident commander (E) to Police dispatch (E) [00:01]: ”Understood. I take me there and take a contact with the fire & rescue squad leader from Crown-village. If they like my suggestion regarding the reporting location we take it.”

Police dispatch (E) to Police on-site incident commander (E) [00:37]: ”Reporting location is OK. IRU-024 is on the way there. They will report when they reach the location.”

Police on-site incident commander (E) to Police dispatch (E) [01:10]: ”Understood.”

Police dispatch (E) to Police on-site incident commander (E) [02:08]: ” Have you contacted the fire & rescue on-site incident commander? Is it the reporting location same for all responding units from all organizations?”

Police on-site incident commander (E) to Police dispatch (E) [02:31]: ”I don’t know yet. I am going to talk to him about it now”

Police on-site incident commander (E) to Police dispatch (E) [03:31]: ”I have spoken with the fire & rescue commander and waiting for answer.”

Police dispatch (E) to Police on-site incident commander (E) [05:46]: ”Is the situation under control on the site?”

Police on-site incident commander (E) to Police dispatch (E) [07:00]: ”I need further resources to evacuate parts of the parking lot where the reporting location will be.”

Police dispatch (E) to Police on-site incident commander (E) [07:14]: ”OK”

Police on-site incident commander (E) to Police dispatch (E) [07:30]: ”I don’t know the extent of the fire but lives could be in danger and we must have more people.”

Police dispatch (E) to Police on-site incident commander (E) 08:08]: ”I talk to Police dispatch in David county.”

Police dispatch (E) to Police on-site incident commander (E) [08:34]: ” Fire & rescue IRU-191 on the site. Heavy smoke between Cow-valley and Newland. They met one of our units”

Police on-site incident commander (E) to Police dispatch (E) [09:45]: ”Understood. When we get resources from David county can they take care of traffic control in Crown-village?”

Police dispatch (E) to Police on-site incident commander (E) [09:57]: ”OK”

Police on-site incident commander (E) to Police dispatch (E) [10:32]: ”I want the IRU-024 to take care of the reporting location and begin to evacuate the north part of the parking lot.”

Police dispatch (E) to Police on-site incident commander (E) [12:07]: ”Now I have IRU-030 in North-town. I have asked IRU-014 to send IRU-154 to the Coal-garden Zoo. So I have IRU-014 left in Low-town. IRU-020 will not arrive from the traffic accident at R22.I have not heard anything from the Police dispatch in David county.”

Police on-site incident commander (E) to Police dispatch (E) [13:54]: ”Good, I want IRU-030 to begin steer the traffic from the Zoo towards crown-village. They shall take position at the Beach-junction in Crown-village”

4.5 Information seeking patterns

In the RPE the attention was also given to how the participants search for external information, such as weather, traffic conditions, property owners, etc. Interestingly, such information was searched only once during the entire RPE. This information concerned weather forecast and forest fire risk status, and was requested by the fire & rescue on-site incident commander in the Eric county. During the AAR the participants highlighted that it is their local knowledge and experience from similar events what influence their decision-making and consequently information seeking. To search other than operational information is seen as additional. The information seeking also depends on the dynamics of an event and workload of the commanders. In the RPE both dynamics and workload were assumed as high by the participants with respect to their involvement in the operations.

5 Conclusions

The performed analysis resulted in a range of findings providing us with new insights on C^2 work in distributed C^2 structures. From the range of findings made in this research, several can be emphasized as essential:

- Distribution of communication density was not directly related to the commanding functions and the type of scenario/responded incidents;
- Commanding officers communicated pro-actively, distributing information on push-basis;
- Differences between planned and actual C^2 work were found;
- Resource allocation and availability has impacts on communication volume;
- Information seeking is dependent on local knowledge, experience and workload;

The method of RPE thus made it possible to investigate the work and interaction that emerged in collaborative processes during an emergency response. The multiple sources of data available in this approach resulted in a number of findings presented above. Experience from using the RPE shows that the data collected during the RPE provides the researchers with information about participants' work and collaboration processes. It is also obvious that the participants experience dynamic decision-making. Moreover, the participants themselves created dynamic problems during the RPE. Thus the essential contribution of this role-playing exercise approach is in its possibilities to document and identify differences between planned and intended C^2 processes and the real C^2 work.

Acknowledgement

This paper is based on research funded by the Swedish Emergency Management Agency (SEMA).

References

Brehmer, B. (1987) System Design and the Psychology of Complex Systems, in Rasmussen, J. and Zunde, P., *Empirical Foundations of Information and Software Scienc*e, Plenum Publishing Cooperation, New York.

Brehmer, B. and Svenmarck, P. (1995) Distributed Decision Making in Dynamic Environments: Time Scales and Architectures of Decision Making, In Caverni, J. (Ed.), *Contributions to Decision Making* (pp. 155-174), Elsevier Science, NY.

Burgess, R.G. (1984) *In the Field: An Introduction to Field Researc*h, Routlege.

Carter, N.W. (1991) *Disaster Management: A Disaster Manager's Handbook*, Asian Development Bank.

Cooper, D.F. (1979) The Superior Commander: A Methodology for the Control of Crisis Games, *Journal of the Operational Research Societ*y, Vol. 30, No. 6, pp. 529-537.

Cooper, D.F., Klein, J., McDowell, M.R.C. and Johnson, P.V. (1980) The Development of a Research Game, Journal of the Operational research Society, Vol. 31, No. 2, pp. 191-193.

Crichton, M.T., Flin, R. and Rattray, W.A.R. (2000) Training Decision Makers – Tactical Decision Games, *Journal of Contingencies and Crisis Managemen*t, Vol. 8, No. 4, pp. 208-217.

Crichton, M. and Flin, R. (2001) Training for emergency management, *Journal of Hazardous Materials*, Vol. 88, pp. 254-266.

Denzin, N.K. (1978) *Sociological methods*, McGraw-Hill, New York.

Gestrelius, K. (1998) *Simulering och utbildnings: Upplevelsebaserad uppbyggnad av erfarenheter* (3rd ed.), SAAB Training Systems, AB.

Granlund, R. (2002) *Monitoring Distributed Teamwork Training* (Diss. No. 746), Linköping Studies in Science and Technology, Linköping University, Linköping, Sweden.

Green, W.G. (2000) *Exercise Alternatives for Training Emergency Management Command Center Staffs*, Universal Publishers.

Jaiswal, N.K. (1997) *Military Operations Research: Quantitative decision Making*, Springer.

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.

Jungert, E., Derefeldt, G., Hallberg, J., Hallberg, N., Hunstad, A. and 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.

Lewis, E. and Barlow, M. (2005) The Use of Games to Investigate tactical Decision-making, *Proceedings of the SimTecT 05*, Sydney, Australia.

Kaji, H., Matsumura, K., Kaneda, T., Kanegae, H., Ishibashi, K., Yahagi, M. and Mihira, J. (2005) Use of Gaming for Training Emergency Headquarters in Responding to Earthquake Damage: EQRES/SAITAI – Virtual Earthquake Responses, In Shiratori, R., Arai, K, Kato, F., *Gaming, Simulations and Society : Research Scope and Perspective*, Springer.

Klein, J.H. and Cooper, D.F. (1982) Cognitive Maps of Decision-Makers in a Complex Game, *Journal of the Operational Research Society*, Vol. 33, No. 1, pp. 63-71.

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.

Rochlin, G. (1999) Safe operations as a social construct, *Ergonomics*, Vol. 42, No. 11, pp. 1549-1560.

Rochlin, G. (2000) A Rational Choice of Error: Comments on the JCO Accident Report, *Cognition, Technology & Work*, Vol. 2, pp. 232-234.

Rochlin, G. and Demchak, C.C. (1991) The Gulf War: Technological and Organizational Implications, *Survival*, Vol. 33, No. 3, pp. 260-273.

Rubel, R.C. (2001) War-gaming network-centric warfare, *Naval War College Review*, Vol. 54, No. 2, pp. 61-74.

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.

Shen, S.Y. and Shaw, M.J. (2004) Managing Coordination in Emergency Response Systems with Information Technologies, *Proceedings of the 10 th Americas Conference on Information Systems*, New York, NY, USA.

Shubik, M. (1972) On the Scope Gaming, *Management Science*, Vol. 18, No. 5, pp. 20-36.

Thomas, L.C. (1984) *Games, Theory and Applications*, Courier Dover Publications.

Trnka, J. and Jenvald, J. (2006) A real-time role-playing exercise as a methodology to support command and control research, *Proceedings of the 3rd ISCRAM (Information Systems for Crisis Response and Management)*, Newark, USA.

Waugh, W.L. (2000) *Living with hazards, dealing with disasters: an introduction to emergency management*, M.E.Sharpe.