Monitoring and Analysis of Command Post Communication in Rescue Operations

Mirko Thorstensson[1]
Markus Axelsson[2]
Magnus Morin[2]
Johan Jenvald[3]

1. Division of Command and Control Warfare Technology
Defence Research Establishment
PO Box 1165, SE-581 11 Linköping, Sweden
mirtho@lin.foa.se

2. Visuell Systemteknik i Linköping AB
Storskiftesgatan 29
SE-583 34 Linköping, Sweden
markus@vsl.se & magnus@vsl.se

3. Swedish Armed Forces, Naval Centre
SE-130 61 Hårsfjärden, Sweden
johjen@lin.foa.se

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Abstract

The performance of a command post staff has a decisive effect on the outcome of a rescue operation when it comes to coordination and management of various rescue forces. Monitoring and documentation of the internal work and communication processes that take place in a command team can increase the ability to investigate and understand cause-effect relationships between incoming field reports, operational procedures, decisions, commands and the rescue response in the field. To this end, we present a method and a software tool that enable an observer to monitor and record communication events within a command post staff. The method extends link analysis by introducing time stamping and classification of events. Thus, extended link analysis enables both cumulative measures and detailed temporal analysis of staff communication. The software tool supports configuration, monitoring, time stamping, and classification of communication events. It can also export data in standard formats for statistical analysis and visualisation.

1. Introduction

The outcome of an emergency response operation is highly dependent on intricate cooperation between different units in the task force. One major factor of success is how well the commanders succeed in synchronising the available forces. Command and control is key to mastering the dynamics of an emergency operation. However, the command and control of a large emergency response operation includes many problems. The area of operation is typically large, available resources are limited, and in many situations competing goals exist--that is, actions taken to reach one goal are counterproductive in relation to reaching other goals. As a result, analysing command and control and its effects on the outcome of an operation is a complex and demanding task.

A standard way to analyse the processes of command and control is to have observers in the staff and let these observers make subjective judgements of how command is performed. One method for supporting observers in analysing command post work is *link analysis* (Chapanis, 1959). Link analysis focuses on the number of occasions when one staff member communicates with another one. Although the idea of registering all communication is appealing in its simplicity and may turn out to be fruitful, this method only considers the number of communication occasions. Other aspects of communication need to be taken into account as well (Thorstensson, 1998). We introduce *extended link analysis* (ELA), which includes the time point when each communication event occurs together with a classification of its contents. These additions make ELA a suitable tool for monitoring the internal communication processes of command and control in emergency operations.

However, to really understand how command and control affects the activities of the field units, and conversely, how the situation in the field is perceived by the staff members, we need to document the activities in the field as well. Adding the support of an instrumentation system such as MIND (Jenvald et al., 1998; Morin et al., 1998; Jenvald, 1999; Thorstensson et al., 1999) makes it possible to document the course of events of the operation outside the command post. Thus, by combining ELA and MIND, we are able to thoroughly document essential aspects both of the activities at the command post and of the unfolding operation. In particular, we can begin to uncover complex cause-effect relationships involving both elements of command and control and units in the field. An improved understanding of the internal and external processes and their mutual dependencies will enhance possibilities to improve mission efficiency analysis (Worm et al., 1998).

The remainder of this paper is organised in the following way. We first describe the communication processes involved in command post activities. We then describe the tools we use to monitor and analyse command post communication and apply

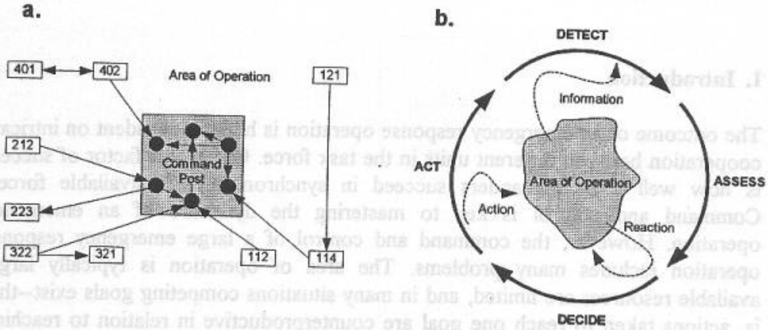

Figure 1: a. A schematic description of the communication inside the command post (grey box) and to and from the units (boxes with 3 digit numbers) in the area of operation to the command post. Each arrow denotes a communication event. b. The Detect-Assess-Decide-Act loop that describes the internal information handling process in a command team manning a command post.

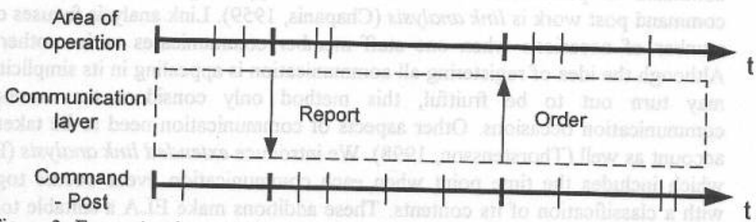

Figure 2: Events (marks on the timeline) in the area of operation affect the course of events in the command post and vice versa, therefore the temporal aspects must be measured in detail. Communication is handled in the communication layer which, for example, can be a radio channel.

them to an example. We conclude the paper by discussing our results using the method thus far and point out some directions for future research.

2. Command Post Communication

In an emergency response operation, a command post is typically manned by staff members from different organisations, with different professions, and with different responsibilities in the operation. The staff is organised to command and control the task force and synchronises the efforts of all activities in the field. To achieve a positive result, the staff must be aware of the dynamically changing conditions in the area of operation. All staff members have different bits of information from the area of operation by reports from their specific subordinate personnel. These different pieces of information must be combined to form an overview of the evolving situation, which requires communication between staff members and units in the field.

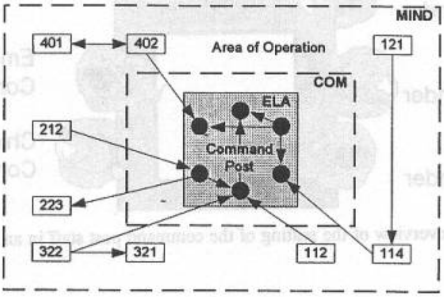

Figure 3: A graphical description of different possible tools for registering the course of events in different areas. ELA is effective inside the command post. The communication between the command post (grey box) and other units (boxes with three-digit numbers) is identified in the communication layer. A model of the dynamic course of events in the area of operation is created using an instrumentation system, for example MIND.

Furthermore, the command post is typically located away from the area of operation, making communication more complicated. The personnel in the area of operation have to describe the evolving situation to the command post by means of frequent reports. Figure 1a provides a schematic description of the communication within the command post and between the command post and different cooperating units.

In many situations, the staff is supported by one or more back-up teams that can work with specific questions of logistics or technical matters. This means that the staff mainly communicates in two directions: (1) forward to subordinated units in the area of operation, and (2) backward to the supporting back-up teams. From all these sources of information, staff members form their perception of the situation as a basis for deliberations and decisions.

The information processing carried out by a command post staff can be described using the DADA loop depicted in figure 1b. The DADA loop is a modified version of the commonly used OODA loop (Roy and Bossé, 1998). The DADA loop comprises the following steps:

- *Detection* of the evolving situation using information received from the area of operation where it was sent from subordinated units
- *Assessment* of the situation to analyse the probable future development and the likely consequences of alternative actions
- *Decisions* based on the preceding analysis
- *Actions* to implement the decisions made

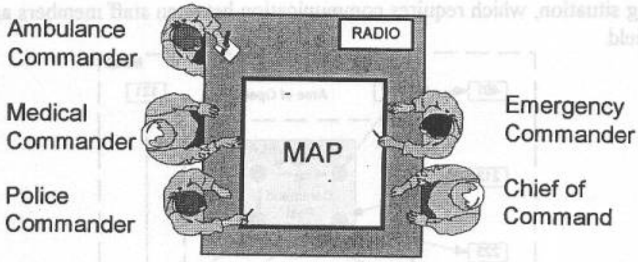

Figure 4: An overview of the seating of the command post staff in an emergency response exercise.

Actions affecting the course of events must be detected and analysed, which naturally leads to the cyclic behaviour of the process.

If we view the command post as a black box by only analysing communication to and from the staff--that is, external information--we are able to analyse the *detect* and *act* element in the DADA-loop. However, this restriction would not increase the understanding of the internal processes of the staff and of what parameters are essential for successful command and control. The internal communication between members of the staff is essential for assessing received information, for forming a common mental model of the situation, and for deciding on future actions. Consequently, we have to consider both internal and external communication when we analyse command post performance in rescue operations.

3. Methods and Tools for Data Collection

To analyse command and control in rescue operations, we need to capture the temporal aspects of the interaction between the command post and the units in the area of operation. Figure 2 illustrates the relationship between events at the command post and the area of operation, respectively, as they are linked by communication events. This type of analysis requires a detailed temporal model of the events occurring at the command post, in the area of operations, and on the communications networks. Figure 3 illustrates the data collection needs and the applicability of the corresponding support tools.

We use the MIND system to model and visualise the events in the area of operation (Morin et al., in press). It produces a computer-based model of the course of events, which can be replayed and browsed to investigate and analyse particular situations. The MIND system includes support for monitoring and time stamping voice and data communication on various types of networks (Axelsson, 1997).

To register internal communication in a command post, we use ELA, which we shall describe below. Link analysis (Chapanis, 1958) is a well-known method for recording communication events by counting the number of interactions between people--or between people and artifacts such as communication devices. The main disadvantage of link analysis is its lack of support for temporal information and message classification. ELA remedies link analysis by assigning time stamps to all communication events and attaching a classification of the contents of the messages exchanged. To implement the method, we have developed a software tool (*Link Analyzer*) to support the observers that collect the data required for ELA. To demonstrate how ELA works and how the software tool supports it, we shall provide an example.

A hypothetical command post staff is organised as shown in Figure 4. To collect ELA data, an observer, careful not to disturb the activity, monitors the command post staff. The observer has a laptop computer running the Link Analyzer. The tool has been configured to reflect the organisation of the staff. Figure 5 shows a screen from the tool with the initial configuration. The configuration phase defines all the actors in the command post that will be included in the registration. Moreover, it defines a list of message categories that will be used to classify the communication events. The observer can move the icons representing the actors. This feature allows the observer to create her own map to reflect the actual seating of the real staff. Each actor is assigned a shortcut key, represented by a large letter on the icon.

During the operation, the observer monitors the command post staff and registers each communication event using either the mouse or the keyboard of the computer. For each event, the observer enters the sender, receiver, and message classification. The Link Analyzer tool assigns a time stamp to each communication event. The time stamp is defined as the time when the first keystroke or mouse click in the registration command occurs. As an option, the observer can assign a stop time to a communication sequence.

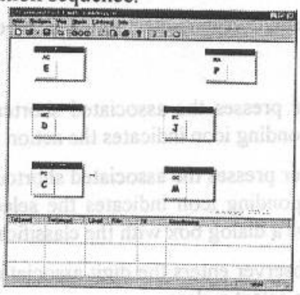

Figure 5: Configuration of the Extended Link Analysis (ELA) Link Analyzer tool corresponding to the seating of the command post staff described in Figure 4. The tool has an upper pane where all icons and observer interactions are displayed and a lower pane that contains a list of all communication events registered. Each icon represents a communicating actor in the staff. The large letter attached in the icon is the shortcut key currently assigned to the actor.

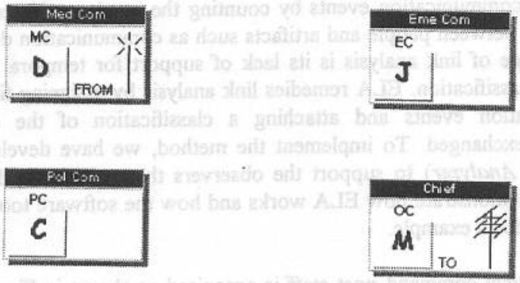

Figure 6: Antennas indicating the observer defined sender (FROM) and receiver (TO) for a communication event.

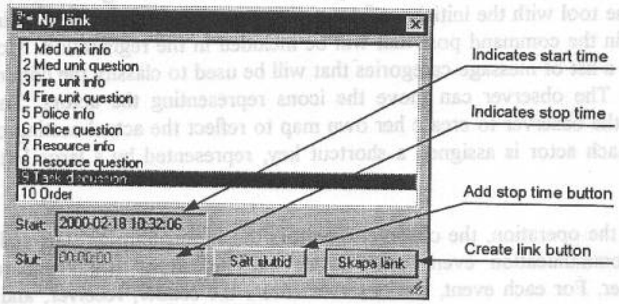

Figure 7: The dialog box with the classification list from which the observer selects an appropriate class for each communication event. Buttons and fields below the list are explained in the figure.

The observer registers a single communication event by entering information in the following order:

1. *Sender*: The observer presses the associated shortcut key. A sender antenna symbol in the corresponding icon indicates the action performed (see figure 6).
2. *Receiver*: The observer presses the associated shortcut key. A receiver antenna symbol in the corresponding icon indicates the selection (see figure 6). This command also displays a dialog box with the classification list (see figure 7).
3. *Classification*: The observer enters the digit associated with a message class or uses the arrow keys to select a class.
4. *Registration command*: The observer presses Enter. The event is now represented by a red arrow on the screen connecting the sender and receiver. A corresponding text entry appears in the event list (see figure 8).

5. *Stop time (optional)*: The observer selects an event from the event list and presses Enter. This command displays the registration dialog box (see figure 7) where the button for setting the stop time is now enabled. When the stop time is set, the arrow representing the event changes colour from red to green. The stop time enables calculations of the duration of the communication events.

The Link Analyzer tool stores ELA data in a database to support further data processing and compilation of statistics. It also supports printing of a communication log, which essentially contains the same information as the event list depicted in Figure 8.

Tid [start]	Tid [stopp]	Längd	Från	Till	Klassificering
10:32:06	10:33:47	101 s	Med Com	Chief	Task discussion
10:34:13	10:34:31	18 s	Eme Com	Amb Com	Fire unit info
10:34:38	10:34:58	20 s	Chief	Pol Com	Med unit info
10:34:47	10:35:02	15 s	Amb Com	RADIO	Resource info
10:35:10	...	...	Eme Com	Chief	Fire unit info
10:35:26	10:35:50	24 s	Chief	Med Com	Resource question
10:35:57	10:36:03	6 s	Chief	Eme Com	Order
10:36:06	10:36:17	11 s	Chief	Med Com	Order
10:36:40	...	...	RADIO	Eme Com	Fire unit question
10:36:57	...	...	Med Com	Amb Com	Med unit info
10:37:07	...	...	RADIO	Pol Com	Police question
10:37:20	10:37:33	13 s	Pol Com	RADIO	Order

Figure 8: A section of the resulting list after a registration from a command post exercise.

4. Results and Discussion

To date, we have tested the Link Analyzer tool at two staff exercises. Our preliminary results indicate that ELA indeed supports monitoring and analysing of important aspects of rescue operations. However, there are several issues pertaining to the applicability of ELA that we need to discuss.

An obvious limitation of ELA is the number of staff members a single observer can monitor. An observer can only monitor people seated in the same room. Moreover, he can only record one communication event at a time. We have applied ELA to staffs having four to six members sitting together in a room. Our results indicate that a single observer can monitor this number of people as long as the conversation is structured. Future research is needed to establish the limitations of ELA with respect to the number of people being monitored.

There are two principal ways of dealing with a situation where an observer is not able to monitor the members of the staff. First, we can add another observer. This approach is simple in the sense that the additional observer performs the same task as the first one--i.e., the method used is the same and the support tool exists. However, the observers have to divide the work between them, which introduces issues regarding the registration of communication from one area of responsibility to the other. Moreover, in a confined area such as the command post of a ship, there may hardly be room for one observer, let alone for two or more. An alternative approach may be to use a video camera to record the work at the command post. The video recording can then be used as the basis for performing ELA. Since the videotape can be replayed repeatedly, a single observer can cover the whole operation.

The classification of communication events is a complex task. The classification scheme has to be elaborate enough to cover the issues being investigated in sufficient detail, while at the same time simple enough to be practically manageable for the observer. These requirements are often contradictory. Nevertheless, it is important to enforce the same classification scheme throughout an operation in order to ensure that data collected from different staffs at different points in time can be combined and compared.

Successful ELA requires trained observers in that it is a demanding task to monitor and classify communication in a stressful environment. However, appropriate tools can greatly facilitate this task. To support the observer, the Link Analyzer includes features that help an observer to prepare and carry out his task. The most important feature is the possibility of assigning shortcut keys to actors. Shortcut keys make it possible for a skilled observer to register a communication event using only four keystrokes. Link Analyzer enables the user to define and redefine the shortcut keys assigned to each actor--for example, based on mnemonics, keyboard layout, or personal preference.

A natural next step in the development of ELA is to further integrate ELA data with data from the registration of the external communication on radio and data networks. These data can then be linked to the model of the course of events of the area of operations to form an overall view of the unfolding operations. The ability to combine the models seamlessly would greatly facilitate the analysis of assessment and decision-making at the command post in relation to the operation.

5. Conclusions

Extended Link Analysis can provide important information about the internal assessment and decision-making processes of a command post by modelling the communication between staff members. The resulting model defines the sender and receiver of each communication event together with the time point when it took place and a classification of its contents. For some events, the duration of the information exchange is defined as well. Although ELA can provide vital information on its own, its full potential lies in the possibility of linking the events at the command post to the activities of the units participating in the operation being commanded. Then it becomes possible to analyse critical situations to identify potential problems in information dissemination, situation assessment, tactics, and procedures throughout the rescue organisation involved in the operation.

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