

The Role of Artefacts in Creating a Common Operational Picture During Large Crises

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ABSTRACT

This paper is about the work that takes place during large police operations in different command post settings, and how artefacts are used in the collaborative process in creating a common operational picture (COP). We apply “artefactual multiplicity” as our analytical lens. An interpretative research approach has been applied in form of ethnographical field studies using observation and informal interviews as data collection techniques. The artefacts that have been studied are definable as common artefacts, i.e. artefacts that are commonly available in our work environment. Based upon the five separate studies, the artefacts studied are found to be very important as collaborative tools and many also have embedded visualization functionalities. The main contribution from this research is 1) extensive knowledge about how the artefacts are used in the establishment of the COP during large police operations, where the process of establishing the COP is, to a very large extent, dependent upon the artefacts' collaborative and multiple functions; 2) the proposal and suggestion to study the whole staff and the artefacts used by the staff as one heterogeneous unit, as a record of activities. Studies of single artefacts in isolation reduce the possibility of seeing the full multiplicity of all the artefacts used within the staff, and the complexity of the intertwined web of artefactual functions.

Artefactual multiplicity, Artefacts, Common operational picture, Temporal command setting, Police operations, Staff

INTRODUCTION

This paper aims to contribute a better understanding of the complex work environment in which a collaborating group of emergency response actors establish a common operational picture (COP) in emergency command centers during extraordinary events. The establishment of a COP is one important aim during large police operations, and the COP “is created by an actor and consists of a selection of important parts of the available information, in form of descriptions and predictions of what is going on, and related information as e.g. resources, actions, prognosis, and perceptions” (Translated from Swedish from Borglund et al., 2014). To successfully manage a large crisis or extraordinary event it is necessary to attain a common understanding of what is going on (Nylén, 2006; Svensson, 2007). The COP should be seen as an important basis for an organization's capacity to meet the challenges brought by a larger crisis or extraordinary event (Borglund et al., 2014), and to reach what Harrald (2006) defines as “agility” i.e. the capacity an organization has to move quickly and adapt to new situations during extreme events. From a more operational aspect the COP aims to help the commander in charge to make better decisions and to help the authorities involved to balance their efforts in relation to the actual situation.

The focus in this paper is on the creation of the common operational picture (COP) that is established during large police operations (extraordinary events) in which the police organize themselves in a *staff*. The staff is a temporal, intermittently activated command construct, that must be separated from the more permanent kind of staff organizations that exist and are running more permanently as e.g. joint of staff. From now on, when the term *staff* is used in this article it refers to these temporal, intermittently activated command constructs. In the set of rules and regulations for the Swedish Police on how to manage situations that are out of the ordinary, there are instructions on how to set up the staff. In the same instructions, cooperation is described and stated as being a central component for successful management of large police operations (Nylén, 2006).

In academic outlets and databases, it is difficult to find research on these kinds of temporal organizations focusing on the Police or other organizations involved in crisis management. The temporal organizations studied in this research have similarities with project organizations see e.g. (Lundin and Söderholm, 1995). CSCW (Computer Supported Cooperative Work) and CHI (Computer Human Interaction) articles found involved studies in more traditional control rooms, or dispatch centres, such as the Swedish National Emergency Centre (Pettersson et al., 2004), control rooms in London's underground (Heath and Luff, 1992), urban traffic control (Filippi and Theureau, 1993), in command and control rooms (Luff and Heath, 2000). These studies all focus on permanent organizational constructs, and not on the temporal organizational construct of the staff, which is the focus in this paper.

The COP should be achieved and shared through cooperation among actors within the police (Nylén, 2006). Nylén's manual (2006) suggests artefacts should be used to make management of the crisis and establishment of a COP easy. However, the manual does not say how this should be done. Departing from, and inspired by the concept of Socially Embedded Technologies (SET) the *aim of this paper is to increase knowledge about the role played by artefacts found in the staff during large police operations, and how they are used in the collaborative work process of establishing a COP*. The concept of artefactual multiplicity (Bjørn and Hertzum, 2011) will be used as an analytical lens to better understand how the creation of COP is established in a staff setting. This will facilitate study of the interaction between the heterogeneous artefacts found in a staff context and the actors participating in the creation of a COP. SET is an approach that springs from the CSCW community and "is based upon the fundamental assumption that we need new ways to conceptualize research on design, which takes into account peoples' social practices without limiting the human interaction to an individual computer-user relation." (Bjørn and Boulus-Rødje, 2015, p. 341). The long-term goal of this research is to be better able to design technology supporting the collaborative and complex work taking place in similar temporal organizational constructs as the staff. This research, with its rich empirical material encompassing 5 separate studies, contributes with new design implications and insights in this domain, and should be seen as contribution to other stated normative research contributions in which very limited empirical data have been used (e.g. Turoff et al., 2004).

This paper is structured as follows: first we further present COP, and the theoretical lens applied. Second, we present the research approach and the research method applied, a presentation about the construct of staff within the police and the artefacts one could expect to find there. Third, the results are presented, followed by a discussion and final conclusion.

SETTING UP THE THEORETICAL FRAMEWORK

As addressed in the introduction, this paper aims to increase knowledge about the role played by the artefacts found in the staff during large police operations, and how they are used in the collaborative work process to establish a COP. In this section the term *COP* and the staff will be discussed in relation to some of the work found in the CSCW domain.

The COP has similarities with intelligence (c.f. Agrell, 2012) as Intelligence is often presented as being the product of a step-wise process meant for action, where information is gathered, analyzed and presented. The COP is also a product of a step-wise process during which a selection of available information is aggregated, analyzed and presented. The COP is intended to be a basis for action, which in a crisis consists of operational, tactical, and strategic decisions (Borglund et al., 2014). A COP has similarities with what Endsley (1995) defines as Situational Awareness. A COP is not primarily about perception, it is the product of a process in which information is collected, captured and analyzed for the purpose of presenting an analyzed picture of what is going on (Borglund et al., 2014). A COP can be seen as both an end product, which can be distributed and shared and also the ongoing process through which information is selected, analyzed with a purpose to better understand what is going on. The concept of a COP is applied in smaller single incidents, as well as in large complex emergency situations (Borglund et al., 2014). A COP as basis for decision supports the organization's capacity to meet upcoming threats and new unwanted situations, which is important for the organization's agility (c.f. Harrald, 2006).

The term COP centres on awareness of present events and, according to Dourish and Bly (1992), awareness involves "knowing who is 'around', what activities are occurring, who is talking to whom". For tactical and operational decisions the awareness is central for the police and the work being undertaken (Svensson, 2007). One example from the Swedish Police is the Gothenburg Window (figure 1) with four squares that give information about the place, direction, resource, and trend. Place is the physical location of the situation, Direction is a brief description of what is going on, Resource is a summary of the police units at site, and Trend indicates in which direction the police operation is going, e.g. status quo, escalating or calming down. The Gothenburg Window is inspired by staff guidelines, such as those found in Svensson (2007). The 'window' is

intended to be put on a whiteboard in the staff meeting area where it supports easy visualization of the situation.

Place	Direction
Trend	Resource

Figure 1. The Gothenburg Window

Implicitly, this research also argues that the work of establishing a COP is based upon collaboration between actors involved in the management of large police operations. In the staff the goal is to establish something “common” which is difficult to achieve without collaboration. Amongst practitioners, the COP is necessary for strategic, tactical and operational decisions during a crisis.

The theoretical concept of artefactual multiplicity (Bjørn and Hertzum, 2011) has been used as an analytical lens to enable interpretation and understanding of the intertwined web of heterogeneous artefacts and the interaction between them in a staff context. In a staff, several artefacts are used during an extraordinary event and it is important to understand their relationship and multiple functions if modern information technology is being designed to support staff work. Bjørn & Hertzum introduced the concept of “artefactual multiplicity” in 2011, declaring that it “can be used as an analytical lens for identifying the multiplicity of collaborative artefacts.”.. The concept “identifies not only the multiple functions of heterogeneous artefacts but also the *relations* between these multiple functionalities” (Bjørn and Hertzum, 2011, p. 118). They demonstrate that artefacts can hide complex multiple functions and relations between them, which must be understood if one aims to design better IT-support in an operations room, for example. Bjørn & Hertzum (2011, p. 99) argue for the notion of multiplicity due to the fact that “there is no one reality; instead multiple realities co-exist” and therefore it is important to investigate the various existing practices and realities of the artefact. “It is when multiple people engage in various practices involving the single artefact that it becomes a multiplicity” (2011, p. 99). In a police staff, many people with distinct roles (representing different communities) will interact with the artefacts. Yet another argument for applying the artefactual multiplicity is rooted in the underlying ideas in SET (Socially Embedded Technologies). The technological and the social are entangled and “people and artefacts become bounded in practice” (Bjørn, 2012, p. 98).

The contextual settings of interest in this paper are the temporal command settings that are set up during large police operations. In the CSCW literature, as presented in the introduction, there are examples of research where collaboration within permanent command settings have been studied (Filippi and Theureau, 1993; Heath and Luff, 1992; Luff and Heath, 2000; Pettersson et al., 2004). Even when the temporal command setting is using a permanent and physical room, it is still defined as a temporary organization. A temporary organization is characterized by its aim to deal with one specific purpose (Lundin and Söderholm, 1995), which for a police staff is about the management of the police operation.

This research studies what can be called common artefacts, i.e. the artefacts that are commonly found in a large police operation, and in the more temporary premises used for housing e.g. command posts, support of staff etc. Robinson (1993, p. 199) defined common artefacts as having certain characteristics that “... can support co-operative working in all its routine troubles without a need to anticipate particular contingencies, or the order in which they might arise”. These common artefacts have the ability to provide a common information space (Schmidt and Bannon, 1992), as they make it possible for many users to work on the same information in collaboration. Examples of common artefacts are: flip charts, white boards, word processors, maps, video projectors. Common artefacts are not artefacts used by a small unit within the police as e.g. software for intelligence analysis used only by the P2 function (explained below).

According to Robinson (1993) a set of five dimensions form the characteristics of the common artefacts, which are:

1. They are predictable for the people using them.
2. There is peripheral awareness about what the artefact should be easily able to show, e.g. changes.
3. Implicit communications endow the artefact with the possibility to almost communicate by itself.
4. Double level language occurs when the implicit communication is combined and supported by explicit communication.
5. They can provide an easily interpretable overview of parts of the work space (Pekkola, 2003).

RESEARCH APPROACH

The paper rests upon qualitative research carried out as ethnographical field studies (Van Maanen, 1988), where five studies of varied length have served as data sources. Each study has contributed a separate data set. The use of artefacts used in police practice, are best studied in their context, i.e. in the organization (Braa and Vidgen, 1999) which is the reason why this study is based upon a qualitative research approach (Taylor and Bogdan 1998) and is taking place in-context, in the police organization. All five studies A, B, C, D, and E are the basis for this paper. Study A occurred during the EU Energy- and Environment-Ministers meeting held in Åre in 2009, between July 23 and 25. The meeting was a very large police operation managed by the smallest regional police authority in Sweden. The research was carried out between July 20th and July 25th. Study B covered a large regional disaster training exercise that took place in April 2010 in the County of Jämtland. The scenario was an airplane incident in which a Boeing 737 from Arlanda Airport crashed during landing at Åre-Östersund Airport. The exercise involved almost 1,000 participants, and aimed to test the region's capacity to manage a large crisis. During this training exercise the data collection was confined within the police authority, but it also included two preparation days arranged by the police. Study C was a three-year longitudinal research project, Gaining Security Symbiosis (GSS) where the project's main focus was to run three training exercises for the Norwegian and Swedish police, fire departments, municipalities, county administrative boards, and medical services. Study D was an educational exercise in a mid Sweden police authority. Study E consisted of active participation in two educational courses at the National Swedish Police Academy, each one week long. The two courses were "Introduction to staff work", and "Chief of staff". The researcher participated as a student in the first course and as one of the teachers of the second course. All participants in the course were informed of the researcher's presence and that the researcher was there to collect data. The data was gathered during all of the minor exercises undertaken as part of the courses. When the researcher was a student the data was collected from a participant's point of view, but during the second course it was collected as an observer rather than participant.

A summary of the studies together with data collection methods is presented in Table . The five studies have supported triangulation of the findings (as e.g. described in Myers, 2009).

Table 1. Summary of research studies

Study	Research context	Extent	Data collection
A	Police work during EU Energy and Environment Ministers meeting	6 days	Observation Interview
B	Police work during large regional disaster training exercise	1 day exercise 2 days preparation	Observation Interview
C	Collaborative cross national developing project focusing on arranging training exercise	Total 12 days	Observation Interview Network analysis Radio communication
D	Local police authority education and training	1 day	Observation Interview
E	Courses "Introduction to staff work" and "Chief of staff"	10 days	Observation, Interview

The data collection methods were primarily various forms of field studies with participatory observations. Short notes were taken in a notebook during the observations. At the end of each day the collected notes were summarized (see e.g. Taylor and Bogdan, 1998). In order to revisit areas of interest as well as gathering experiences from events not covered by the aforementioned observations, informal interviews were done (Kvale, 1997), recording these situations for clarification. Questions and answers were later transcribed in a notebook. During each study an on-going analysis was done with the goal of making sense of the activities observed and studied. The ethnographic approach has a strong research tradition within CSCW (Blomberg and Karasti, 2013; Schmidt and Bannon, 2013) and is very helpful in identifying design implications (Dourish, 2006; Dourish, 2007).

The main focus of the study and the data collection was to see how information was managed, i.e. created, captured, and used. This automatically included the study of the artefacts involved in the management of information.

The analysis of the data has been iterative, where the notes from the research have been manually revised and patterns and structure in the data were identified. The empirical data from studies 1-5 were re-analyzed by overlaying the theoretical concept of artefactual multiplicity upon the five data sets. The findings have also been discussed with two police superintendents who have been in charge of many large police operations, not only to verify the findings but also to identify any weakness in the data. The concept of artefactual multiplicity is not well tested theory and have not broadly been applied as an operational concept that can easily be put as a lens upon empirical data. Rather, the concept is a meant to help the researcher to look for the multiple functions and the relationships between the functions of the artefacts. A deeper understanding of how artefacts are used during extraordinary events implicitly provides design implications. Artefactual multiplicity as an analytical lens gives new flavours to the "tales from the field" (Van Maanen, 1988) that ethnographical studies normally provide.

HOW POLICE ORGANIZE THEMSELVES IN A STAFF

Below is a presentation of the way in which the police organized themselves as a staff in studies A-D. In Study E this structure was the one taught and trained. There were, of course, minor differences but for the purpose of this paper, this description covers the general strategy for organization used by the Swedish in order to give the reader a contextual awareness and knowledge of the research at hand. There is also a generic description of the workflow of the police staff, which is not normative, but is provided as an example of how the temporal work rhythm flows in a police staff.

The staffs were organized following the National standard for how large police operations should be arranged (Nylén, 2006), and had the following competences and units:

Chief of Staff

P1 – Human resource manager: Responsible for making sure there are enough police officers, that they get to rest when required etc.

P2 – Intelligence: Responsible for intelligence work during the extraordinary event.

P3 – Operational management: Responsible for coordinating the operational police work.

P4 – Logistics and equipment

P5 – Planning and co-operation: Supporting planning and establishing co-operation with other authorities

P6 – Operational analysis

P7 – Information: Responsible for information sharing with press and information gathering from the press.

P8 – Various tasks: Dependent upon the event, this position can have various aims.

P9 – Documentation: Responsible for capturing important decisions in the staff, and document them according to internal instructions.

The staff is normally located either in a specially designed room with lots of technology or in a room more like a conference room. Experiences from larger catastrophes and crisis in Sweden indicate that it is often common that the staff will work in a room that not is designed for the purpose of hosting a staff. It is not uncommon for the room where the staff meets and works to look like Figure 2 below: i.e. a room with white boards and video projectors. Sometimes the staff works in operations rooms specially designed for that purpose, equipped with dispatch operation tables, fixed large whiteboards or mobile whiteboards, and video projectors.

On a daily basis 4-6 ordinary staff meetings were held (including meetings where staff teams take over from each other). During these meetings, the chief of Staff and the P1-P8 were gathered in the staff room and each of the support of staff members presented what new information had been received since the last meeting. The staff meeting was always documented in a word processor document that all were able access through the police intranet. Normally the staff meetings are where a more official COP is formed. Each P-function is represented and an aggregation of available and relevant information is made, to form the COP upon which all participants can agree. One can say that the COP developed during the staff meeting is a time stamped, shared, and documented understanding of what is going on.

Between the staff meetings each P-function reported all events judged as important to the Chief of Staff. It was then up to the Chief of Staff to decide if the entire support of staff should be gathered. This was communicated face to face, by telephone or by mail even if that was very rare. If the P-functions needed to document their work

they used the ordinary police IT-systems available for this purpose. The P3-unit was the unit that had the main responsibility to manage and update the common operational picture, as it had operational responsibility for all police units on duty. The P-3 unit was divided into 3 subunits, *P-3T* responsible for the traffic, *P-3O* responsible for all other police units, and *P-3C* responsible for criminal investigations. The P-3 units had at least 2 dispatch operators that managed the radio traffic among the police units. The dispatch operator also recorded all on-going events in the command and control system. The P-3 unit plotted all upcoming events on whiteboards. For example in study A, they had the preliminary schedule of when they expected each minister to arrive at Östersund Airport. Every change was added in a different colour on the whiteboard.

Collaboration is embedded in the structure of the roles expected of staff. For example, Operational Management (P3) are reliant upon correct information from Intelligence (P2), and Logistics and Planning (P4) need to collaborate with the Human Resource Manager (P1).



Figure 2. The operation room, with all P-functions gathered around the table

Between the staff meetings each P-function either works in the room for the staff or they return to their own offices. If the situation is time-critical and the stress level is high, a higher tendency to stay in the staff room has been observed. When the staff room was a well-equipped operations room (as in studies A, B & D) the members of the staff tended to stay in the room throughout the entire operation. There are also some events that require the staff to work in the same room for security reasons. This requires functioning staff logistics supporting the staff with drinks, food and other necessary equipment.

USE OF ARTEFACTS

Use of the artefacts is presented in this section.

Computers and the documentation systems

Two computer-based systems were used for documentation and to share on-going activities. **1.** The command and control system (STORM is the name of the system), was used to record and log all operational activities. For example, if groups of police officers were sent to an address, this was logged in STORM, together with the reason. **2.** The more tactical and strategic decisions were documented using word processor software, and the documents were stored in common folders on the police intranet. All minutes were written and documented with a word processor, and stored in a common folder, or at a given location in the structure of common folders. In

addition to the minutes, each P-function could write a “diary” of on-going activities, but not all P-functions did so. When the whole staff was gathered, there were discussions about what to document and if all agreed to document a situation, this was done. STORM could be running on a computer in the staff, and could also be projected on a wall with a video projector to enable sharing the content of the system. STORM is not available to everyone. It is normally used only by trained command and control central dispatchers. Therefore it is often projected upon a wall with a dispatcher controlling the system. The Chief of Staff uses STORM to record important operational decisions.

The word processor is used more as a hidden repository, since very few police officers read what others had written. Although each document was accessible from any computer connected to the police intranet, and each document had a file name and a time stamp, they were rarely used during the on-going work in the staff. However the documents were an important source enabling each P-function to update themselves at the start of a new shift. During longer crises the work in the staff can cover many days, and the documents served as a very important source for understanding what has happened and how the crisis has evolved, particularly for new personnel joining the staff. Going through the documents is time consuming and it is not easy to gain an overview. However, the documents were often found to be rich in information.

Whiteboards and flipcharts

Whiteboards are important in large police operations, which was very apparent in these studies. There were whiteboards used as operational plotting tools in every room used by the staff.

During Study A whiteboards were used to plot all planned events in chronological order. The plotting of planned events helped the staff to be prepared for the future and increase their knowledge of what was to come. If there was a change in the program, the information was updated and also marked as “updated”.

Often whiteboards are used to plot the important decisions given either by the police operational commander or the strategic commander (which of course could also be found in documents in the common folders on the police intranet). However, when the decisions are shown on a whiteboard, all participants in the staff room are easily made aware of them.

The ease of documentation on a whiteboard makes them attractive for plotting important events that take place, i.e. as a timeline of the activities that affected the police operation. An example of such timelines can be seen in Figures two and three. If whiteboards are not available, adhesive “magic charts” are used instead (See figure 3). Whiteboards are often magnetic and therefore pictures or printed documents can be attached to the whiteboard with small magnets. These additional documents always relate to the text on the whiteboards.

When a whiteboard was filled with content as can be seen in Figure 3, they either prioritized documenting the content in a word processed document, or another whiteboard was brought in, upon which they continued to write, so the traceability was of high quality. Snap shots with a camera were sometimes used to document the content and the pictures stored with the documents in the shared folder.

The whiteboards were where the important information about on-going activities during the police operation was recorded in aggregated form. One whiteboard was also designated for the strategic commander to share a copy of the general decisions about the whole police operation, so all staff members could easily access and read the decisions.

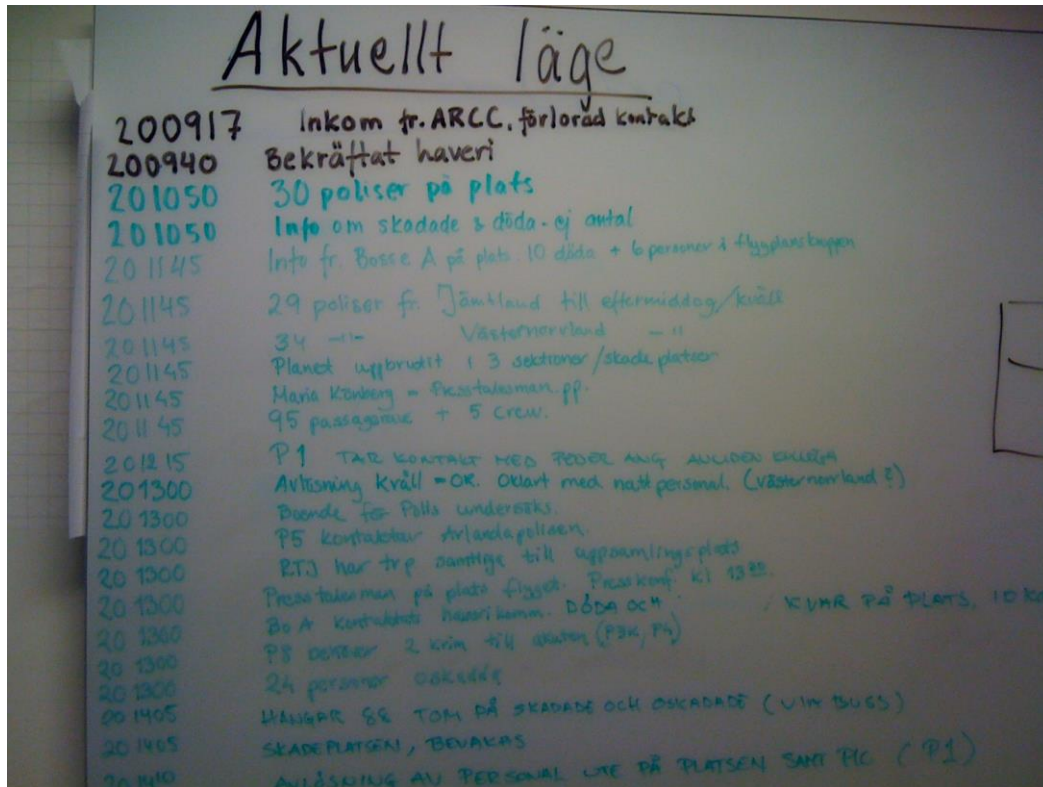


Figure 3. One whiteboard is used to plot all events in chronological order

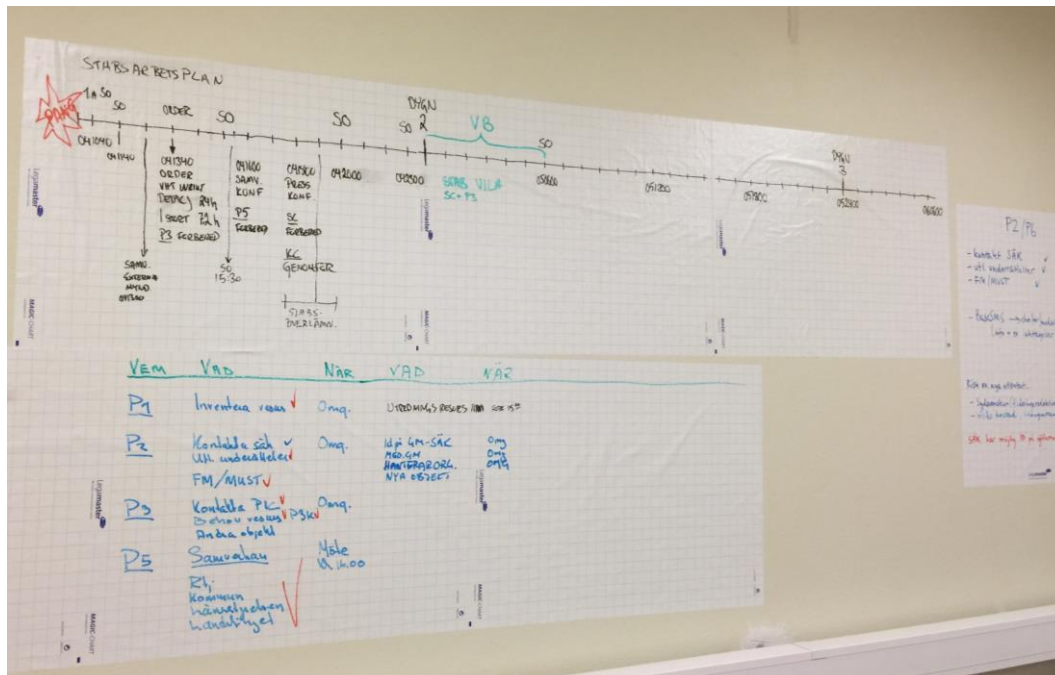


Figure 4. "Magic chart" used for plotting (picture from Study E)

During stressed and more chaotic situations it is common for the white boards to play an important role in documenting on-going activities and decisions taken. The person could write on the whiteboard at the same time as he/she was giving and receiving information over the mobile, and everyone in the room could immediately see what he/she wrote. In this research two of the studied staffs used three white boards as presented above. If something extra needed to be documented in the same way, the flip charts were used. The flip charts were used when there was a temporary need for urgent and easy documentation.

For example, during the training exercise (Study B) records were compiled of how many uninjured, injured,

severely injured, dead, and missing people there were from the simulated plane crash site. This was plotted on flipchart papers instead of trying to find room on a whiteboard. Another example of flipchart use was when it was important to map out the location of all available police units.

Flipcharts were mostly used to document needs of a more ephemeral character. During the police operation in Åre (Study A), telephone numbers, call signs on the radio and flight numbers were the information most frequently reported on the flipcharts. When the information on the flipchart (or the charts on the wall) was no longer important for the management of the police operation, the chart was torn off.

Maps

Maps are artefacts traditionally used by the police. Every time a police unit intervenes in the surrounding society, a geographical location for the incident is documented and used for visualization in the police command and control system. During Study A the map was used to visualize and plot the locations of all the ministers, and of the police distance protection units in real time, in case a worst-case situation arose. They also used a map of the entire Jämtland region to plan alternative escape routes for the motorcade, landing sites for the police helicopter and other spatial plotting needs. In Study A the same map was used by different P-functions for different purposes. During Study B, maps were used to plot rescue units' locations and the correct coordinates of the crashed airplane in order to gain an overview. Permanent plotting was done on an electronic map and projected on one wall. But when the map was used as basis for decisions, the staff sometimes used a printed map instead, and the persons involved put the map on a table and stood around the map, discussing, pointing, but not drawing on the map. Figure 2 shows both a map with plotting and a picture of the same area taken from a helicopter. In Study C, where the underlying aim of the project was cross-border collaboration, the maps always played an important role, aiding decision makers when asking for help from across the border. Sometimes maps were printed and put on the walls in the room to visualize the area of interest, for tactical reasons. When staff work is taught (in Studies D & E), maps are always exemplified as being an important tool for visualizing spatial challenges during a crisis.

AWARENESS AND COMMONNESS

An important component of the COP is promoting awareness of what is happening. The artefacts presented above and the ways in which they are used play an important role in creating this awareness. Whiteboards are artefacts that are an easy means of sharing awareness. In all studies, the rooms in which staffs were placed were sufficiently small to allow each person in the room to read everything written on the whiteboards. The whiteboards also created awareness of on-going situations because they were quite easy for everyone entering the room to read. For example when the County Commissioner arrived, he could immediately update himself on what was going on by simply reading the whiteboard. The flipcharts similarly contribute to awareness. Text written on flipcharts is as easy to read as the whiteboards, but flipcharts also contribute to awareness in another way. When the flipchart is used only when there is an out of the ordinary need to document something visual, the flipchart will implicitly signal that something unusual has happened. When a new staff team started their shift they immediately realised that it had been a stressful session while they rested because there were so many flipcharts on the wall. All staff members know that the strategy is always to try to use only the whiteboards, and if they become filled with text, then that text is captured in either a document or a photo. Maps were used as static visualizations of an event, but it was also possible to make the map less static, and awareness that something was happening was created when things changed on the map. For example, small icons representing police units could be moved around on the map, so all could see them. The command and control system STORM, if projected on a wall, made everyone in the room aware of what was happening in the district (or what is recorded in the system). If it is not projected, each and every person is required to log into the system to keep up to date.

DISCUSSION – ARTEFACTUAL MULTIPLICITY

The discussion section presents identified multiple functions of the studied artefacts, the multiple roles that have been found, challenges encountered during establishment of a COP, and the presentation of the staff as an artefact.

Multiple functions

The main reason for using artefactual multiplicity as an analytical lens is to understand the multiple functions of the studied artefacts and the relationship between these functions.

For the whiteboard, the following functions were identified:

- **Documenting:** the whiteboard was used to document on-going activities, and was also a container for information waiting to be documented in a word processed document or recorded as a picture.
- **Scheduling:** plotting available resources, and the work schedule.
- **Planning:** plotting planned activities related to the police operation.
- **Signalling:** whiteboards covered in writing signalled that there is a need to transfer the documentation to other formats, as e.g. a word processor.
- **Increased importance:** when the police operation moved towards a more critical phase, the whiteboard became very important for the creation of the COP, and for documentation.

The word processed documents served as documentation of the police operation, and as a complement to the command and control system. It had two important functions:

- **Documentation of decisions** in the form of a 24-hour diary, but also recorded minutes from all meetings during the police operation. The documents were stored in command folders.
- **Indication of activities.** The sum of documents found in the common folders gave an indication of how much is going on at the other temporary command settings. Many documents indicate more activity and fewer documents indicate the opposite.

The maps were artefacts that had functions that meant to either support awareness or position police units or activities. But the maps also served as basis for operational and tactical decisions.

The flipcharts had the following functions:

- **Temporary documentation.** When there was a need to document activities, upcoming events, decisions etc. temporary flipcharts were used.
- **Emergency documentation.** Flip charts can also be seen as emergency documentation. If there was a need to document things more permanently, but documenting it in a word processor document was too time consuming, the flip chart was a good alternative. Once used, they could be torn down and saved as evidence.
- **Alert signal.** Due to the fact that the flipcharts were often used when something out of the ordinary takes place, the flipchart itself acts as a signal for all actors to be alert, and make sure to keep themselves informed about the situation.

Examples of the studied artefacts several functions are presented above. One of the reasons the artefacts are able to take on several functions is the multiple roles existing in the staff.

Multiple roles

Among the staffs studied there are ten pre-defined roles, all with a specific assignment and a specific area of responsibility. Thus there are ten roles also using the artefacts for ten different purposes. For example the P-3 function used the command and control system (STORM) to document important operational activities, but the P-1 function used the system to find information about who was working, and which police units were assigned to certain tasks. Each role can be argued to represent one internal police community, and that means that they also apply different functionalities to the studied artefacts. It is not only the use of the artefact that differs. The artefacts also “signal” different values to different P-functions. The data reveals that each P-function creates a commonly shared operational picture within the domain of their own P-function.

The way in which large police operations are managed and how the staff is organized is highly complex. It can therefore be concluded that a multiplicity perspective is preferable for describing how artefacts are used. This also implicitly supports the understanding of the establishment of the COP.

Common Operational Picture Challenges

The COP is the product of a process in which information is gathered, selected, analysed and presented. Based upon the data presented above the artefacts studied played an important role in that process. Artefacts could be used both to present a COP, but also to document the gathered information and highlight the selected

information. In the process of creating a COP awareness cannot be neglected. The information gathering and the information selection is important, and depends upon awareness. In the staff it was obvious that each P-function needed to be aware of what other P-functions did, and what information they had gathered and selected. The awareness was therefore more about what was going on within the staff than about what was going on in the crisis situation for which the staff was initiated). However, there is a problem with ensuring awareness because of the analogue character of the studied artefacts. The whiteboards and the flipcharts, and to some extent the maps, all have limitations when it comes to the reach of the information and awareness to which they are able to contribute. It is important to understand that each of the studied staffs in this research create their own COP. This means that the "common" is only common for the actors of each staff, but in the definition of "common" other actors involved in the police operation are also included. This is, however, not new knowledge, but it confirms the results presented by Alvinus, A., Danielsson, E., Kylin, C., & Larsson (2007) where they claim that it is a challenge to manage one single COP based upon the many actors' different situation awareness. The artefacts studied are used both as the product of a COP, i.e. the result of the process in which information is gathered, selected, analysed and presented, but are also used as parts of each step in the COP-building process.

As indicated above the artefacts used in the staff are also used differently in relation to the temporal structure. When the situation is calm and everything is under control, much can be documented more permanently, and then also be accessed by others more easily. Things documented in a word processor in common folders have a longer reach beyond the staff than does a whiteboard, for example. The documentation is also more permanent. When a police operation turns into a more time-critical structure the ease and immediacy of using whiteboards and flipcharts increases the use of those artefacts.

One staff as one heterogeneous artefact

By applying the artefactual multiplicity, we understand that the web of artefacts used by, and in the staff, have multiple functions, and different actors use each artefact differently. The artefacts have links between them, as for example the links between the words on a whiteboard, which is, documented in a word processor file later on. It cannot be said that one type of artefact is more important than the others in the creation of the COP. It is possible to see the COP as a process; as an aggregation of all documented activities found in all artefacts. No single artefact is more important than any other. To understand the work that takes place in the staff one cannot study single artefacts in isolation. During large police operations, the work carried out in the staff and its use of artefacts is very complex. Each of the artefacts can be defined as being heterogeneous, part of an intertwined web of artefacts with links between them. To fully understand how these heterogeneous artefacts are used and how the collaborative work creates the COP the entire staff should be seen as one heterogeneous record of what has been going on, and the staff work should be understood from a holistic worldview. Treating an entire large artefact as a single record over complex activities is not new: the FBI did this when they treated the UNA bomber's entire cabin as a record of his criminal activity (McKemmish et al., 2005). However, this is a challenge when designing support for staff work.

CONCLUSION

This paper aimed to increase knowledge on what role is played by the artefacts found in the staff during large police operations (where the staff is the temporal organisational construct, established during extraordinary events to support their management) and how they are used in the collaborative work process to establish a COP. The paper focused on studying the interaction between the heterogeneous artefacts commonly found in a staff context, and applied the concept artefactual multiplicity (Bjørn and Hertzum, 2011). The purpose has been to understand how a COP is established in that setting. It is argued that the COP of one staff is documented in the intertwined mix of artefacts, and that awareness of what is happening cannot be visualized without this understanding. Without the use of artefacts it would be very difficult to establish a COP, especially if the artefacts did not offer functionalities allowing visualization of on-going activities.

This research implicitly aimed to contribute an understanding of how collaborative technologies could be designed to support the establishment of COPs. The research also contributes a deeper understanding of factors in designing for the facilities in which staffs work so that they are spaces with potential. In summary, two contributions have been made. First, knowledge on how the artefacts are used in the establishment of the COP during large police operations has been provided. Second is the proposal to study the whole staff and the artefacts it uses as one heterogeneous unit, which would thus provide a record of the staff's activities. Studies of single artefacts in isolation reduce the possibility of seeing the full multiplicity of all the artefacts used in the staff, and the complexity of the intertwined web of their artefactual functions.

This research has focused upon situations where the COP is established for one single staff. During large extraordinary events, it is not unusual for the police to establish separate staffs at national, regional, and local

levels. How a COP is established between several staffs has not been studied, nor how the artefacts are used to collaboratively establish a COP between various staffs. These are potential topics for future research.

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