Technology and Sensemaking in the Modern Military Organization

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Abstract

New technologies play a central role in the realization of Network Centric Warfare (NCW) but few can envision, design and afford the implementation of a completely new NCW organization. For years to come, new and old practices and technologies will coexist. Until now, the supposed value and capacity of new technologies rest on a series of hypotheses regarding design and benefits. We need a better understanding of the relations between human action and technology including previous design rationales, if new forms of organization shall succeed. Sensemaking, the process of creating situation awareness in situations of uncertainty, has two related aspects: to understand a situation and the available methods and technologies to handle it. Research has to develop means and methods to make sense of NCW, to penetrate both ‘informationlore’ and the ‘fog of work’, supporting those who have to cooperate during the design of new practices and technologies. The paper demonstrates one such approach. Through ethnography, we produced data about command work and sensemaking. We put the NCW concept in context, concluding about future research, organizing and information systems design (ISD).

1. Background and Framework

1.1 Introduction

The concept Networked Centric Warfare (NCW) implies exploitation of new technologies that necessarily (by themselves) produce new capacities. One of the later NCW analyses and discussions of central issues introduce the well-known concept of sensemaking as a means to explain what is important in the future command and control systems [Alberts et al., 2001]. This and other discussions/analyses of the NCW concept seem to miss the point that Beniger [1986] launched: every new technology means a control crisis, and requires new layers of control. The NCW concept, we assume, and the thinking behind it, represent a search for the ultimate control layer. It is the vision of a new ‘friction-free’ control technology in a situation when chaos threatens. However, there are new NCW-promoted control crises ahead of us. We must try better to understand both sensemaking and technology in order to handle them.

When people face a new situation, trying to understand it, they engage in a sensemaking process, which means to interpret, cooperatively, the environment and to design suitable courses of
action. But there is an additional challenge hidden. Those who intend to use any technology (and to survive with the help of it) have to make sense of not only the (battle) environment but also their technologies. The latter are means to make sense of, understand and influence the former. Few situations are transparent, without uncertainties. In any organization, especially in coalitions, which more and more will be part of the military landscape, it is likely that partners interpret both the environment and technologies in many ways. Previous knowledge, mission and perspectives influence situation awareness. Survival depends on the outcome of this dual sensemaking process (Figure 1) where we make sense of an environment through technologies.

![Figure 1. Sensemaking of technology and the environment through technology](image)

Technologies designed by humans, at an accelerating pace, mediate human thought and action [Orlikowski, 2001]. Sometimes outcomes surprise us. In short, language or communication and weapon systems only permit or even define as possible certain kinds of actions. This is a new version of the ‘Law of the Hammer’: Give a small boy a hammer and he finds everything worth hammering on. We have to understand such constraints (especially a quick, largely unreflective turn to technology) and manage them as part of the sensemaking process. The mutual relationship between technology and action means that technologies designed for action also structurally affect the organizational environment, and us as operators [ibid.; Walsham, 1993]. Operators have to be able to make sense of their tools and artefacts (organizations) and therefore have to understand this mutuality. Similarly, research has to make sense of the military domain in order to provide support for knowledge development and organizational design. The approach behind this paper and the discussion of sensemaking exemplify what such research can achieve.

1.2. The Purpose of the Paper

This paper contains results from a research approach paralleling the one proposed by a recent CCRP (23–25 October 2001) sensemaking symposium [Leedom, 2001]. The paper first comments on the result of this symposium and on the NCW concept, then introduces a theoretical view on technology based on modern sociology, especially Anthony Giddens’ work [Giddens, 1991] which has inspired Walsham and Orlikowski. Perspectives on work, research and technology are also borrowed from ethnographic research and design theory, such as [Bucciarelli, 1988], [Berg, 1999], and [Nyce and Bader, 2002].

The first case is an example of sensemaking with far-reaching consequences. Current efforts to develop new artillery fire-control equipment and procedure, linking sensors and shooters, indicate a need for additional synchronization and coordination mechanisms. The next one is a
brief overview of how efforts to build a Common Battlespace Picture (CBP) were a partial success but also created a new series of frictions not anticipated by developers and designers. Here, initial understandings of what constitutes such a “picture” led to what is, in a mobile network, very complex computer operations and data communication. This case raises the question what a relevant CBP is. The paper then describes a related case where practitioners, tactical network operators, were able to create a CBP, understand and exploit their technologies in spite of unfavourable initial conditions. We discuss empirical data, describing operators’ sensemaking through their interaction with control technologies.

These cases illustrate action within the physical (material) and the information domains respectively, two of those forming the work and control context (the third is the cognitive domain) in NCW [Alberts et al., 2001]. We will use the cases to discuss visualization and ISD, significant issues when it comes to realizing the NCW vision. Finally, we outline possible directions for future military research for support of technological and organizational design.

1.3. The Concept of Sensemaking

In the CCRP sensemaking symposium [Leedom, 2001], sensemaking was for the most part treated as though it was the same thing as cognition. Participants reported that there was a growing need for addressing the sensemaking process and its contribution to effective command and control. Derived largely from the corporate sector in the US, the NCW idea and its equation with the networking of sensors, decision makers and other actors, NCW signifies increasing combat power through shared awareness, faster command and execution of operations, lethality and survivability and a degree of self-synchronization. However, these potentials will remain unrealized without adequate understanding of the socio-technical issues and “deliberate reengineering of the cognitive and information domains within the organization” [ibid., p. 2].

We agree that there is a need for a more informed understanding of sensemaking and how it is shaped by technology but reducing it to cognitive factors might lead to misinterpretations of what goes on in the world. Other equally important factors, elements of military work such as bureaucracy, leadership, and responsibility are taken for either granted or remain invisible.

One analysis had revealed that in decision making prior knowledge was less influential than emotions, beliefs, cognitive factors and mental models. These attributes are on the invisible part of our social world. For obvious reasons clear metrics do not exist for understanding how sensemaking at this level occurs and what promotes ‘good’ sensemaking. Even if systems engineering and human factors owe much to applied psychological research (which presumes that measuring, test and retest of cognitive models can specify what is necessary to know about humans and IT) it is difficult to define the metrics relevant for decision making.

The place ‘sensemaking’ has in contemporary writing on organization owes much to Karl Weick who, for example, has shown how the degradation of communication in an organization may quickly make it disintegrate [Weick, 1993]. However, Weick’s emphasis on sensemaking as an interpretive activity places him in the Weberian (interpretive) tradition of social inquiry that so far has had little influence on military research. His work opens the way for an alternative to way the command and control community thinks about and researches the term.

The concept of sensemaking has other proponents worth mentioning in order to widen the perspective. Leadership largely means the generation of a point of reference against which an
organization’s direction and implicit charter (its raison d’être) can emerge. Smircich and Morgan [1982] discuss leadership issues:

Indeed, leadership depends on the existence of individuals willing, as a result of inclination or pressure, to surrender, at least in part, the powers to shape and define their own reality. If a group situation embodies competing definitions of reality, strongly held, no clear patterns of leadership evolves. Often, such situations are characterized by struggles among those who aspire to define the situation. Such groups remain loosely coupled networks of interaction, with members often feeling that they are “disorganized” because they do not share a common way of making sense of their experience. (p. 258)

Usually, sensemaking occurs among collaborating systems, described as communities of practice, or communities of interest. Research on collaborative systems indicates that IT applications should focus at collaborative sensemaking, knowledge management being more important than data and information management/processing. A constructivist view of knowledge development in organizations (the stance taken here) means that different persons construct different meanings from the same situation. Therefore, mechanisms for sharing and reconciling different meanings are required. Eventually, communication is required both for the discovery and for the resolution of ambiguities. There is an interesting link to the design of applications for data analysis. Pirolli and Rao [1999] define sensemaking as “activities in which external representations such as texts, tables, or figures are interpreted into semantic content and represented in some other manner” (p. 597). Our cases illustrate this aspect of it.

Research, the symposium stated, must build from qualitative description toward quantitative prediction by using a range of investigation methods. A focus at sensemaking should complement the traditional IT-focus. In the effort individuals’ sensemaking should be tied to socio-technical and organizational issues, studies from real situations, not just laboratory experiments and simulations. Future progress was said to depend on bringing together various research perspectives in a multidisciplinary framework for the design of mission capability packages. This paper will demonstrate contributions from ethnography to this effort.

1.4. Network Centric Warfare – Visions and Hypotheses

While discussing the options of establishing the necessary conditions for NCW, [Alberts et al., 2001] do not hesitate to raise critical issues. Ideally, NCW promises self-organizing, flexible re-organizing, surgical weapon deployment and, the fundamental precondition, a relative superiority as regards situation awareness and a total one as regards communications. The authors warn against uncritical acceptance of such visions. NCW can and should even be viewed as a potentially ‘disruptive innovation’ (p. 49). They claim that practical empirical approaches are needed in order to augment the understanding of the military arena.

The NCW operations occur in three domains; the physical, the information domain, and the cognitive domain. They also identify some shortcomings in NCW research. Issues related to “how information may be perceived, what prior knowledge might exist, and how information sharing affects the process are not usually addressed” (p. 33). Put differently, what makes information valuable or not is impossible to state. We agree in that “higher quality information will improve task performance is, in reality, a set of linkage hypotheses” [ibid., p 33]. Neither is it self-evident that operators know what is available in a technical sense. The authors conclude that humans are still required to make sense of what is collected and will continue to be so for some more time, remaining optimistic:
Technological advances in pattern recognition, analysis tools, and visualization techniques are making it increasingly easier for humans to increase their throughput as well as their ability to extract what they need from the available data and information. (p. 44)

“Information richness and reach” is a new construct. “Richness” is an aggregate measure of the quality of information and “reach” is an aggregate measure of the degree that actors share information. “Reach” implies that with new technologies it is possible to share more without degradation. Thanks to the new technologies for communication and visualization, “sharing” seems possible without degraded richness. The “meaning” of richness and reach, value creation from information, has not been systematically explored. The consequence of work mainly with symbols is that such items can be “shared”, created and distributed in real-time. However to discover and to share the same meaning, the idea of sensemaking, can and does often mean something more than just “share”.

The chain of linked hypotheses says that increasing richness is an outcome of increased reach, the (technical) networks contributing to the generation of shared awareness by enabling both richness and for it to be shared. Then the networks enable information sharing which transforms, in quite unspecified ways, shared awareness into collaborative planning and synchronized actions that create a competitive advantage. However, and we agree with Alberts and his co-writers, battlespace awareness is simply not what is on the display, rather it is what is in one’s head, experience and context. It is not static but a rich, dynamic comprehension of the military situation and the factors that drive it.

2. Theorizing about Technology

2.1 Understanding Risk Society and Human Action

In order to proceed, we have to look closer at society, technology, and work. Bryant and Jary [2001] discuss the contributions by Anthony Giddens and see three alternatives for control in modern ‘risk society’, the ‘runaway world’. These are recover or secure control, fix the big picture; resign oneself to loss, return to the private and personal; or go for limited and local control. Assume there is no big picture. Fix bits and pieces when and where possible. One condition in risk society is the loss of sure foundations for knowledge, and the erosion of authority. More knowledge might instead promote ‘ontological anxiety’ triggering still more control efforts and search for ultimate certainty with the help of technology. The end-state might be the creation of ‘protective cocoons’ in order to keep disorder and chaos at arms length.

Another societal condition is the ‘disembedding of social relations’, and their replacement by ‘abstract systems’ (symbolic tokens, money being one example, and expert systems, resting on ‘information’). The issue of trust in the computer, an illustration of Giddens’ notion of trust in expert systems, is already on the research agenda:

The human factor problem of accepting what comes from a computer as real and failing to understand the uncertainty inherent in that computer product is an important issue and must be addressed both in the training of users and in the design of information systems and representations. [Alberts et al., 2001, p. 195]

We have few alternatives but to trust our abstract systems. The construct “information richness and reach” is another way to describe this global social transformation. Abstract systems support organizing on a global scale and automation of management functions. The disembedding however establishes a dependence on technology, ‘umbilical cords’ that must be protected and
repaired if damaged. The NCW vision parallels e-business, implying globalization, using media for manipulation, and flexibility across national borders. The military concept mirrors Giddens’ view of the societal situation, social and technical options in ‘Risk Society’, including the replacement of social relations by abstract systems except that human actors manage to remain in control, being knowledgeable. Now let us have a look at the inner life of a modern command organization. We will focus on some less visible aspects of this life, revealed by ethnography.

2.2 The Role of Technology in the Modern Organization

The research revealed tensions between imposed technologies and traditional ones, and between informal and formal, technically structured mechanisms. Both ‘protective cocoons’ and ‘umbilical cords’ contributed to the control efforts. Many efforts to implement IT end in surprises, users becoming dissatisfied with what they are given. When we create structures (technology, organizations), we can become “stuck” within what is possible to express, measure, or observe. Everything outside the structure then becomes invisible, and people take technology for granted. Gray and Tagarev [1995] discuss the cultural asymmetries in information society:

We live in a world in which not everyone has equal access to the tools of the Information Age - a global culture of the inforich and the infopoor, a culture feeding into and upon imbalanced information relationships. Technology, while socially inevitable, is not politically neutral and the oppressive characteristics of technology are being seen and experienced in the global community, adding a new dimension to the intricate complex of reasons for conflict. (p. 4–5)

Berg [1998] calls the unreflective perspective technological determinism: that technology develops autonomously, causing secondary transformations in the social world. As a result, the secondary transformations always take a certain form. It is in the nature of technology to affect human life and work in specific but not foreseeable ways.

Orlikowski [2001] explains this. The concept interpretive flexibility of technology means that time and space often separate many actions that constitute technology from the actions that are constituted by the technology. Orlikowski distinguishes between the design mode and the use mode where technology is constructed technically and socially respectively. Users in the modern organization shape technology and its effects through an ongoing balance act:

When humans act in organizations, they create and recreate three fundamental elements of social interaction (Giddens, 1976:104): meaning, power and norms. [ibid., p. 64]

These elements are highly interactive and not separable in practice, especially in management and coordination work. While many technologies are perceived as fixed objects, practice shows that even “black boxed” technology has to be apprehended and activated by human agency to be effectual. Technologies mean more than tools. They are media, input and products as well.

2.3 Towards Technologies for the Future

Someone has said that we tend to overestimate short-term achievements while at the same time underestimating long-term change. Judging from the current situation, we can foresee a continued dependence on technology we must trust, and a succession of both immediate surprises, some being unpleasant, when we face aggregated control challenges and technologies, and future ones when fundamental changes occur.

Often in the military, staff is left on their own to understand their environment and to exploit technology for their survival. The reasons for this vary. One of them is that central features of
military work often remain invisible to vendors because of biased design interests, and negligence by organizational research. Moreover, there is a dichotomy between top-down organizing and disciplinary interests and pragmatic low-level performance requirements. A kind of socio-cognitive blindness leaves important aspects of the work practices in the dark, often because we lack proper concepts or theories to handle them.

It is hazardous to try to envision future scenarios and requirements on technology. The traditional view on technology as passive objects needs a complement from modern sociological perspectives on technology and action. If not, the relations between technology, human action and ultimately sensemaking might well be misunderstood. The concept of (technological) frames [Orlikowski and Gash, 1994] can guide us: we make sense of or interpret technologies according to particular frames or schemas, some being consciously created, others reflecting uncritical or naive common sense perceptions of technology, practice and context.

Unfortunately, it is very hard to make the system-operator interaction intelligible for those not directly involved in military operations. Often what is not readily visible may be of vital importance in real life to the organization and operators. We will further discuss the need for perspectives and models that render visible what operators take for granted. Moreover, the NCW organization does not come ready-to-use. It has to be fielded in an evolutionary process and when deployed in action flexibly reconfigured so as to meet new, unexpected requirements. Therefore, some components have to be resources for redefinition and reconfiguration - ones practitioners can use within their mission contexts.

3. Research and some Results

3.1 Method, Data and Cases

Ethnographic fieldwork in a number of exercises produced data of various kinds such as notes, audio recordings, photos, and captured artefacts such as documents and other papers. In all, there are hundreds of photos, tens of hours of audio recordings, and extracts from orders, memos, overviews and printouts from the information systems [Persson, 2000]. Stepwise, over the last years, ethnographically oriented analyses have revealed several examples of how people interpret and subsequently use technology.

A number of cases illustrate how people tried to make sense of their technologies, primarily computer-based, while trying to achieve desired operational results. Several cases demonstrate how new technology, even if well specified, fell short of requirements, illustrating how and why the procurement process had missed essential details and effects of unrealistic expectations regarding technology. During peacetime training when operators come together, the combined effect of new technologies and non-systemic relations sometimes lead to breakdowns for them. This occurred not only in the central functions but also in ‘less glorious’ ones in the networked organization, such as in network control and the administration of computer systems. One aspect of the modern organization is that all components and actors are highly dependent on each other. Reduced performance in any node affects the rest.

With few exceptions, operators succeeded in overcoming many constraints, demonstrating a considerable capacity for ‘bricolage’. While unconditional trust in abstract systems was often assumed we found operators often ended up distrusting their tools. One explanation is that users’ situated social re-construction of technology (in use mode) made the technology appear less
satisfactory. New procedures and additional/alternative technology were required. Cases also show how a less satisfactory understanding of the modern organization and the role technology has in it (as theorized by Giddens) leads to a large need for ‘repair work’ in order to make the organization work. When the abstract systems become too abstract, not just tools for richness, reach and remote control – extending and disembonding social relations – they become easy targets for enemy counteraction. Another word for this is information warfare, an evolving risk.

3.2 The Physical Domain: Artillery, Linking Sensors and Shooters

Recent trials to develop new methods and tactics within artillery provided data for this case. It illustrates the statement that every new technology leads to a control crisis that requires a new ‘control layer’ [Beniger, 1986]. One of the central NCW issues is to connect sensors and shooters and achieve new opportunities for very rapid (and precise) impact from weapons. However, as we shall see, what seems technically feasible requires careful implementation and might have unexpected consequences. The history of artillery fire control is one of large formations, centralized planning and detailed control procedures all along the chain of command [Holley, 1988; Persson, 1999]. The centralized planning tradition has focused on detailed control for security reasons of the artillery support, i.e., where and when to fire, and minute preparations in order to be able to fire fast and precise. Special missions such as firing at prioritized targets have been centrally controlled and executed. Openness has existed for requests for rapid and concentrated artillery fire from lower echelons when possible although coordination of forces, action and resources usually has been part of a larger battle plan.

The long way first reporting ‘upstream’ the artillery command chain, then ‘downstream’ two command chains (artillery and troop) has often meant delays and tedious procedure. It has become attractive to try to automate data transmissions. Forward fire observers for example use data report terminals for digitized target data. The latest step has been to link sensors directly to the weapons and munitions, making them ‘smart’. To do this is technically feasible and not very complicated. Now, it is technically possible for forward fire observers or controllers to point at a target with a laser pointer, and get reasonably exact positions. Tactical communications systems allow fast and accurate communication of target data together with the reporting unit’s position. However, as we shall see, some surprises may grow from this solution. Observations and events during recent exercises indicated difficulties and risks for accidental fire. Conversations with colleagues and fire-control officers revealed more, confirming some conclusions.

Because the fire can be directed at small targets (and not just at large-area targets) and executed outside a well-coordinated artillery support plan, friendly fire can hit unexpectedly, difficult to distinguish from enemy fire: Who is firing at what? The controllers have to assess the laser data and decide what the relevant measurement is, then make sure one’s own forces are not too close. If they are, they then have to warn own forces in some way, even if they are involved in combat. In urban terrain, this may be very difficult, and the desired fire support may turn out to be an illusion. In short, there are new conflicting demands to negotiate: Who is to judge and make priorities? What we can learn from this is that de-contextual technical control procedure and technologies may add the uncertainty and complexity.
3.3 The Information Domain: the Case of the Common Tactical Picture

3.3.1 Background

Knowledge representation of static and dynamic elements in the battlefield is central in the military requirements lists [Whitaker and Kuperman, 1996]. Many think that it is possible to externalize and distribute knowledge about complex situations and get/transmit an adequate understanding about what in the external world these representations express. We often call this understanding “situation awareness”. Ideas about real-time assessment and data fusion in the “system of systems data stream” from surveillance systems upwards express the needs, but the discourse has been abstract (less coordinated with military practice) and to some extent still is. We will elaborate on some abstractions and continue with empirical data and a case.

One of the most desired, discussed, and central NCW constructs is the Common Battlespace Picture (CBP, ibid.), sometimes called Common Tactical Picture (CTP) or Common Operational Picture (COP) depending on the situation. According to a current US source, one or more CTPs build a COP [DISA, 2001]. The notions vary between dynamic mental images or models [Kahan et al., 1989], computerized environments having the potential to produce pictures or views [DISA, 2001], and shared information spaces being media helping people share worldviews [Whitaker and Kuperman, 1996]. Several sources agree that it is not a plain picture, rather data supporting visualization, for example related to Group Decision Support Systems, GDSS [ibid.].

The conclusion about technical media capacity rests on how people make sense of them. We recall other perspectives on representing and communicating knowledge that illustrate the difficulties, and have found useful concepts for thinking and research guidance. Some are the descriptive fallacy, the fallacy that language has only or mainly descriptiv e purposes [Goldkuhl, 1995], and the resemblance fallacy [Scaife and Rogers, 1996]: We know little about a graphical representation’s cognitive value; instead, interactivity between internal and external is what counts. Iconic qualities cheat us – the ‘mental image construct’ is fuzzy. Our first case is about knowledge representation, while the second describes such interaction.

3.3.2 Current Experiences

The search for a suitable technical solution for the distribution of situation data and the visualization of tactical situations goes on. Previously, the military have met this need more or less with the help of liaison officers, reports, later with local HQ ‘televised’ map pictures. Today, it is commonly believed that traditional maps will be replaced by some or a number of new electronic media. During the last years, there have been a number of efforts dedicated to these artefacts, pictures (images), platforms and tools to implement them. Promoters describe these products as the “silver bullets” preventing confusion, mental overload and force degradation.

The Swedish military, for example, has stated that a decisive precondition for force coordination is a distributed common (electronic) image/picture of the current situation. Now the army has a prototype where situation data (position and status) about units are stored in networked distributed databases, being potential symbols on electronic maps. The databases automatically replicate changes across the command structure. The command support system helps produce and distribute data. Operators can augment an electronic map with overlay symbols representing additional information (terrain, planned action, enemy etc.). Full functionality presupposes very complex and distributed database management and interruption-free communications between
computers and servers. Still, it is up to the individual operator/user, once the technical updating is complete, to chose how much (or little) of the “image data” should be visible as symbols on the screen. Figure 2 shows old and new technologies used in parallel during an exercise.

Figure 2. Work with traditional and electronic maps, overlays representing current tactical situation.

How to interpret overlay data and symbols when operators (close by and remote) are connected by a set of ‘disembedded social relations’ [Giddens, 1991] is an issue that has received little attention so far.

In summary, the COP is supposed to support all users and various instantiations of control and command work, distributed or in the same HQ. Technically the production and real-time updating of an image requires considerable computer power, integrated reporting and position-generating subsystems. Theoretically it seems to rest on the conviction that it is possible to capture knowledge about a battlefield situation, represent it in digital data which becomes an image, transmit it, and when ’unpacked’, provide viewers with “useful”, “accurate” knowledge.

This kind of engineering raises a number of issues. The DISA 2001 report points out how component commanders often do some of their job outside the COP and CTP. Second, the commander may maintain his/her own specialized databases of support data to aid in their battlefield analysis. Further, despite the fact that the commander is obliged to add the results of his/her planning analysis into the COP, the commander may create his/her own, non-COP view of the battlespace – one preferred instead of the CTP or COP. If so, interest in maintaining the CTP could become lower priority and the quality of the aggregated COP could rapidly suffer, in turn making it less reliable for the whole organization. As we will see, there are other examples on meaningful representations and sensemaking.

3.3.3 Controlling the Technical Communication Systems – and People

The next case illustrates how operators controlled a tactical radio network and what they used. Network control is usually organized from specially equipped centres (nodes, trucks) forming the mobile command structure. Usually, these systems are looked upon merely as a “unproblematic” technology. Human operators as controlling, mediating and executing agents receive little attention, being merely invisible also in the literature. During a winter command post exercise (CPX) in Northern Sweden operators willingly described their work and troubles, i.e. the management of technical communications networks. The continuous control operations sometimes require urgent handling of technical breakdowns or personnel matters. To meet
requirements, operators produce and use a variety of artefacts and tools, including communication media, computer based tools, Post-it notes, spreadsheet tables and documents.

In this work, they used map-oriented computer graphics (showing nodes and links), technical capacity graphics for details about routers and processors, constantly interacting with nearby and remote fellow operators. Operations were hardly possible to co-ordinate in a plan because nodes, a few vehicles and operators, were often on the move. Radio communications depend on geography. Nodes movement sometimes meant frequency constraints (dropouts). Technical planners therefore has to integrate physical (terrain features) and frequency coordination (partly terrain dependant) using special planning tools which calculate capacity based on detailed terrain data, also supporting tactical decisionmaking. One control system could present the network with its links (capacity, operations) with or without terrain features. Because of the winter conditions, operators had additional work, for example monitoring and recording weather data. Moreover, HQs often wanted to remain on favourable positions (there was a shortage of good positions) while tactical manoeuvres (with combat units on the move) followed battle plans and orders. In addition, some of their control computers were outdated and slow, further complicating the work. Figure 3 shows a view from a computer system standard control tool.

Figure 3. Example of the CBP for computer systems administrators, curves showing processes to be controlled.

In order to carry out their work, operators themselves designed additional tools based on MS Office-products and ‘freeware’ from the Internet. One example was a spreadsheet where from distributed node operators documented and assembled vocal reports about technical operations and technical resources were. This was a kind of operator-specific dynamic situation overview. As one operator said, “Only we can use it”. Operators did not have the time to design and implement a new system-wide application during exercises but had several ideas. They realized that an intranet web interface had allowed each operator to type his report, instantly compiled into an Excel spreadsheet. A further step in speeding up the reporting would have been to get data from (currently autonomous) data systems, computer monitor this data and thus be able to control, without operator intervention, some aspects of the technical system.

The CBP-visions (previous section) drive development of mechanisms for real-time updating of situation databases, but the real requirements vary considerably. Some operators’ lists contained a few hours old data. Others were real-time views, automatically retrieved from technical systems and machinery (figure 3). We have to remind ourselves that his capacity to solve problems, sometimes with the help of remote colleagues, presupposes communication richness, reach and motivation, shall the databases be updated and tactical operators get their CBP data. In spite of operators’ efforts, node movement could not be totally controlled. Operators had to fight
frictions in the field and in cyberspace, trying to make sense of what was going on, be it inside computers or units. Some frictions were outside their reach. People got sick. One brigade HQ wanted to withdraw its resources (parts of the total network) prematurely when the exercise was about to end. One operator’s yelling into his telephone expresses his needs:

*I want to know after milliseconds about link movements or interruptions!*

While these operators form the backbone for any tactical move, relay decisions and repair errors, their needs have seldom been addressed when tools for tactical decisionmaking have been designed and developed. The often-invisible network control operations are taken for either granted or outright neglected, not the least because the operations are so complex. Few high-level designers/operators have enough experience really to understand them. “We are in the hands of technology”, sighed a senior operator during a 1998 CPX.

4. Technologies for Sensemaking and Visualization

4.1 Concluding about Alternative COP Approaches

The fieldwork revealed how operators worked with map-oriented (graphic) pictures and traditional tables/spreadsheets. Several other less complicated IT artefacts coexisted with these pictures and spreadsheets: traditional maps, dedicated simple common tables and templates, electronic messaging systems, and text documents. Most represented alternative or partial COPs. Operators used some as coordination tools within their co-located or distributed teams, functioning as collective resources and artefacts. Others were individuals’ tools.

With them, operators communicated, outlined and sketched future actions. They also fed in new information (symbol data), measuring and calculating action. Operators’ mental processes and individual activities certainly are initiated and affected by these different representations but at present we know little more than this. Again, much of this work has been invisible to developers and designers. In other words, the focus at decisionmaking (read: tactical) makes certain actors and their requirements invisible and outside best-practice research and ISD methods. We believe that all actors require relevant, appropriate tools and to achieve this requires design and development methods be rethought. The second case illustrates some differences between the perspectives of practitioners and designers are as regards what kind of work to support and the design and implementation of an artefact. There is a parallel here to what often happens when new kinds of military organizations are argued for. Systems designers only consider certain aspects of operator thought and action because of a biased understanding of military practice. We wonder about possible bias behind NCW.

Compared to the COP (CBP), spreadsheet-systems and graphics give another kind of ‘picture’ of the current situation, replicating a strategy well known in accounting, one that allows overview, comparisons, illustrating relations between resources and action. They were not, however, in this context primarily tools for calculating. Rather, they supported coordination and control through the use of aggregations and “economic abstractions”, had considerable social value, allowing ‘selective awareness’ and control, and were intelligible to people in their work. Control system designers cannot easily anticipate social aspects in use mode when being in the design mode. Only during action do the operators’ actual skills and the evolving frictions caused by own forces and enemy appear. Certainly, a technical redesign of control technologies can help people in
their work, but a considerable portion of this redesign has to handle actors’ communication, negotiation over meaning, and situated action in this kind of work.

### 4.4.2 Visualization and Information Systems Design

Card et al. [1999] pointed out the role of visualization for sensemaking of the external world. They defined two kinds: scientific visualization, which is the use of interactive visual representations of scientific data, physically based, and information visualization, the use of interactive visual representations of abstract, non-physically based data, both aimed at amplifying cognition. Their reference model of information visualization is this:

1. Transformation/translation of raw data into data tables, relational descriptions of data including metadata.
2. Raw data are used, combined, connected for view transformations, creating more data (tables, relations) to be visualized.
3. Visual mappings transform data tables into visual structures, adding graphical structures.
4. Humans interact with visual structures creating views and view transformations by specifying graphical parameters.

Additional data tables (phase 2) are an important intermediate step in information visualization and information work because while “raw data” tables are abstractions, they do not have direct spatial components. The parameters of the various mappings create an ‘information workspace for visual sense making’ [ibid., p. 33]. The model presumes that operators actively control the parameters of these transformations, restricting the view to certain data ranges or changing the nature of the data transformation (like the network operators). In real life, visual sensemaking combines these steps into complex loops because human interaction with the information workspace reveals new properties of the information and this in turn lead to new choices, one outcome of sensemaking.

Tables are a way to rationalize and provide structure in domains that otherwise would have been too complex to penetrate. When operators engage into information work, this work both reflects the conditions in the social domain (they use telephone, talk to fellows and shout to subordinates). If operations are not too complex (rapid, distant), tables can act as co-ordinating agents. When complexity grows, visualization of different orders (often confused by designers and developers) becomes prerequisite for informed control actions. Unfortunately, technically fascinating visualization is easier to create than what is relevant and make sense in a specific control situation. Fallacies easily interfere [Goldkuhl, 1995; Scaife and Rogers, 1996].

It is possible to give operators better tools if designers take into account all the steps in the reference model while maintaining a clear view of what operators have to control, including the social context. In the network case, computers produced enormous amounts of raw data about technical process. Operators used some for process control (cp. Figure 3). Operators also exploited this data and even tried to get hold of and use more. They tried frenetically to visualize very rapid and crucial technical processes, thereby achieving the capability to control them. Using Weick’s [1995] words, when confusion threatens, more information is of less help than a different quality of information.

People also need mechanisms that enable debate, clarification, and enactment more than simply additional data. In many projects aimed at providing support for commanders’ decisionmaking, the CBP/COP-concept has been uncritically accepted as the “best” solution but we understand
too little of the socio-cognitive processes involved in command decision making to even make best guesses about what to stimulate, represent or to support. Because we lack basic knowledge of these processes, both the representations and solutions embedded in them are hard to verify or validate. It “makes sense” to use map-based pictures and metaphors because maps have long been part of the military toolbox. However, within the CBP-concept, maps are not just models of the terrain. Maps are devices for both kinds of visualization, but say more [Card et al., 1999]:

The map is not just a calculator but also a storage device, storing for access enormous amounts of information about the earth’s irregular features naturally located near where they are needed for calculation. (p. 4)

Maps are calculators that portray solutions but the premises (rules) upon which they operate are derived more from “common science” than science, electronic maps easily being ‘black-boxed’.

5. Discussion: Concluding about Future Research

Management principles resting on rational decisionmaking has led to a dominant top-down view on management (command work), and subsequently to a search for coordination mechanisms and decision supporting technologies that are centered on the chain of command. The NCW vision is no exception. Control still is about attention management, reliable performance and secured command authority across widely distributed units, but modern ISD-research [Hoffman et al., 2002] has recognized the need to design for specific humans in specific contexts, not certain ideal roles, and that computers

do things with symbols that reflect the meanings of these symbols, forcing us to rethink the relationship between machines and humans - the cognitive fit as well as the physical fit and how these two relate. (p. 62)

This concerns also researchers’ sensemaking. The proposed [ibid.] unit of analysis for cognitive engineering and computer science is a triple: person (cognitive and perceptual capacities, goals), machine (computational and interface capabilities), and context (requirements, constraints, opportunities).

There is a risk that sensemaking connoted to leadership [Smircich and Morgan, 1982] will become a non-issue when powerful visualization technologies become still more important for the command and control community. Another possible risk, or at least a consequence of the new technologies and control efforts affecting leadership and sensemaking, is that we surrender, surprised when faced by a penetrating machine-bureaucracy evolving from network and computer control tools and the guardians of networks, veritable ‘social fire-walls’. Too much structure can stifle an organization.

There is a need for research methods that make cognitive issues and decision making equally visible, making sense of man-machine interaction. To do this, command and control research has to include modern society and social theory in its framework. Ethnography, as we demonstrate, can contribute both to understanding operators’ doings and to work design [Bucciarelli, 1988]. It can open the door, as a method and form of analysis, to what other researchers have either not seen or not regarded as significant [Nyce and Löwgren, 1995].

Researchers involved in evaluation of organizing face additional expectations and difficulties. They have to defend themselves from demands for technical evaluation. They have to start from the position that the concept itself (‘NCW’) requires clarification and that evaluation includes the context. Because technologies are socially constructed in ‘use mode’, they have to address issues related to both entry (at what time) and when they have “seen” enough. Lastly, when studying how
meaning, power, and norms are constantly created in organizations, researchers have to be close at hand. Without the active participation of operators and experts in the field, qualitative research is almost impossible to carry out. The task (and one qualitative research can handle) is to identify what the core business of command and control is on the ground, making analytic sense of it. To do this, qualitative researchers must understand politics, managerial practices, accounting, cultural issues, and how such factors affect both themselves and what they study.

6. References


