A Command Post for Complex Operations

Professor Berndt Brehmer, Ph.D.

Vice President, National Defence College,
Stockholm, Sweden.
e-mail: berndt.brehmer@fhs.mil.se

S. Anders Christensson

National Defence College,
Stockholm, Sweden.
e-mail: anders.christensson@fhs.mil.se

Berndt Brehmer is Professor of Command and Control Decision Making and Vice President of the Swedish National Defence College in Stockholm. He is a member of the Royal Swedish Academy of Letters, History, and Antiquities. He is actively involved in the development of theory of dynamic and distributed decision-making as well as of methods for the study of these types of decision-making in entities called microworlds. He also takes part in the development of the Rörlig Operativ Lednings Funktionn (ROLF), the new Mobile Joint Command and Control Function for the Swedish Armed Forces. He has published more than 100 articles on various aspects of decision-making and has edited five books. Brehmer has a Ph.D. in Psychology, and has been Assistant Professor of Psychology at the University of Umeå, Associate Professor and Professor of Psychology at Uppsala University, and Head of the Division of Human Sciences at the Swedish National Defence Research Establishment.

Anders Christensson is Technical Project Manager for the AQUA project and the Rörlig Operativ Lednings Funktionn 2010 (ROLF 2010) activity at the National Defence College, Stockholm, Sweden where he is developing a laboratory in C4ISR- research with a concentration on visual language technologies in conjunction with the Department of Operations and Tactics, Research and Development. He is also Project Manager for the Strategic Management System (STRATMAS) Phase II project funded jointly by the Swedish Armed Forces and the United States Joint Staff (J8) which is producing an evolutionary analysis tool for civil-military operations and civil-military force construction. Christensson is a Member of the Royal Swedish Academy of War Sciences. At the Defence Material Administration (FMV), Christensson was initiator and technical project manager for the FMV C3I-lab, the Reference Laboratory (Version 2), the Virtual Reality Laboratory, and the Interaction Laboratory. These facilities are now used for production activities at FMV. Christensson has a M.S. in Aeronautics from the Royal Institute of Technology, Stockholm, Sweden. He is currently a Ph.D. candidate in the research area of visual languages in the Department for Numerical Analysis and Datalogy at the Royal Institute of Technology, Stockholm , Sweden.

INTRODUCTION

The operations faced by today's military are getting more and more complex. This is especially true of the operations involving peace support and peace building. In these kinds of operations, the military have to co-operate with various civilian units, including NGOs and PVOs, and they are no longer are in absolute control of the operation. Moreover, the enemy may be hunger and lawlessness rather hostile troops. As a consequence, the demands on a command and control function increases to handle the added complexity Fortunately, modern information technology offers more and more sophisticated means to support that function in these, and other, complex circumstances. Thus, there is a wide range of sensors, as well as increasingly powerful forms of processing the information that has been collected and displaying the results.

In these developments, it is important to remember those who are to use these new command and control systems. Command and control will never be exercised by the command and control system; it will be exercised by people, by the commander and his or her staff. The system must therefore be tailored to the needs and capabilities of those who have to exercise the command and control function, and it should be designed to that it helps them solve *their* problems. It should not be designed in such at way that the people will have to help the command and control system solve its problems.

There are at least two approaches to this problem. One is to look at the existing technology and see what it can be used for. The alternative approach would be to look at the users and develop the technology that they would need. The first alternative could be seen as a question of manning the equipment, the second as equipping man. In an area developing as fast as the information technology does, the first approach means that one will always be behind: when the C^2 system has been developed and tested, new forms of technology will already be available. A better alternative, therefore, is to follow the second approach and develop a prototype command and control system based on an analysis of what the users will need, and wait for the technology to catch up, and perhaps even influence how the technology develops. This is the approach we have followed in the work reported here.

In this paper, we describe our attempt to develop a general command and control concept called ROLF 2010 and its embodiment in a first prototype, ROLF Mark I. ROLF 2010 is a Swedish acronym that stands for Mobile Joint Command and Control Function for the year 2010, a project at the Swedish National Defence College supported by the Swedish Armed Forces. However, even though the project is carried out at the request of the Armed Forces, it is not limited to military operations in the traditional sense. It is designed to be useful for all four tasks of the Swedish Armed Forces:

1. Peace support operations.

2. Defence of the country against armed aggression.

3. Operations to uphold territorial integrity.

4. Operations involving support to society during severe crises, such as large accidents.

In our analysis, all of these tasks make similar demands on the C^2 function. Thus, all four tasks require people to co-ordinate the use of assets in highly complex and dynamic conditions under conditions of uncertainty and time pressure.

ROLF 2010: THE ESSENTIALS

ROLF 2010 concentrates on developing the command post, that is on how the information available should be presented, and how the command team can interact among themselves and with the information systems at their disposal to arrive at a decision. The important question of how, and in what form, the information comes to the command post is not part of the project.

Figure 1 shows an artist's impression of the interactive environment and its essential features of the ROLF 2010 concept. The following three things should strike the reader, we discuss them each in turn.

- The staff is small.
- The seating of the ROLF personnel.
- The interactive environment.

THE ROLF STAFF IS SMALL

As can be seen from the figure, the ROLF staff is small, comprising some eight people. A first reason for this is to make it mobile. It should fit into a flexible container that can be moved by ordinary means of transport, such as trucks or trains, or helicopters. Mobility is desirable for protection of the staff unit. It is necessary in peace support operations. For such operations we cannot foresee where the operations will take place, so we cannot prepare command posts in advance.

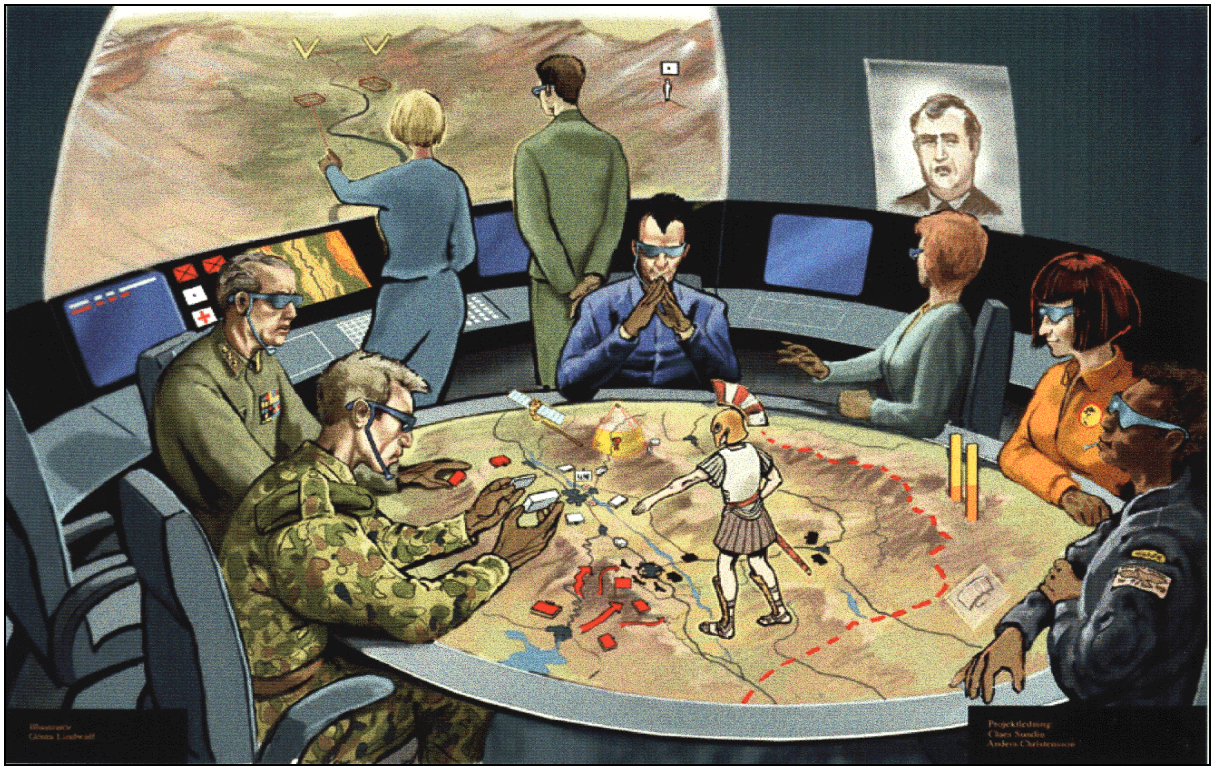

Figure 1: An artist's impression of the ROLF 2010 concept.

For some applications, only one of these units may not be sufficient. For example, in military command and control up to four units may be required, one for planning, one for execution, one for follow-up and one information center, where the command can hold conferences with his subordinates, and where visitors and press can be briefed.

The small size of the staff must be compensated for by information technology that does the work that would ordinarily have been done by other staff members. The small size of the staff together with a fast and complex information flow creates a very intense interactive working environment. We cannot expect the command team to work for more than a few hours. This makes it necessary to have a number of shifts and to find ways of updating the new shift that enters work. This requires special forms of information technology. We will return to this question below. The small size has one definite advantage. It facilitates communication and discussion. This is also facilitated by the seating arrangement, to which we now turn.

THE SEATING ARRANGEMENT

As can be seen from the figure, the staff members are seated in a conference grouping around a display. This is an important feature of the ROLF 2010 concept.

First, the seating creates a *common focus* for the staff members in the form of a shared view of the situation, which expresses their shared operational picture. This should facilitate communication about the common problem as well as agreement about what the problem is. In the stressful conditions during a military operation or a peace support operation, communication functions best, we believe, when it is close and physical.

Second, the seating enables the staff members to maintain eye contact. This should minimize the "psychological distance," compared to the situation if the individuals had to be in contact via, e-mail, for example (Wellens, 1986).

Minimizing the psychological distance is important because the staff members will often find themselves negotiating. We see no prospects in the near future for successful automatic data and information fusion at the level that is required for staff work of the kind discussed here. Too many theoretical and philosophical problems remain unsolved. The information reaching the staff is likely to be uncertain and contradictory most of the time, and the staff members will have to negotiate a common understanding and operational picture, to be represented in the display in front of them. We therefore need skilled operators who are able to evaluate and fuse data and information from many sources into one picture that is relevant to the staff's needs.

Moreover, in peace support operations, the ordinary military hierarchy will not characterize the relations among military and civilians, such as NGOs. A course of action involving co-operation between different components of the mission will therefore have to be negotiated, rather than ordered.

We have therefore chosen a seating arrangement that should facilitate negotiation.

The minimal psychological distance and high cohesion to expected especially under conditions of stress and time pressure is not without its problems, however. There is always the danger that "group think" (Janis, 1992) will eliminate the gains. Therefore, special staff procedures will have to be developed to insure that the reality orientation, creativity and possibilities for real negotiations will be not be destroyed by the group dynamics. Within the staff procedures there will be a need to better understand different meeting types and their use in order to have in the situation, fruitful meetings.

THE INTERACTIVE ENVIRONMENT DISPLAYS

The command post in ROLF 2010 should be characterised as an interactive environment where there are three principal forms of information displays with different controlling devices. The first is called the Visioscope™ and it is the display around which the staff members are seated. The second is called the Visionarium™, and it consists of the large screens that surround the staff. Finally, each staff member has his or her own workstation located immediately behind him or her. Three types of mediating control tools are elaborated for future integration to support the information-navigation in the setting.

THE VISIOSCOPE™

The Visioscope™ is planned to be a 3D display. When fully developed it will be an auto-stereoscopic 4D display, making it possible, together with the information and simulation systems under development, to predict the future and replay the past. The latter function is important to support shift changes and enabling the new shift to get a good understanding of the current situation by seeing how it has developed. It should also be useful to reveal slow tactical operations of the adversary.

The 3D, or 4D, display with auto-stereoscopic capabilities is not primarily because we want to support map interpretation for the military staff members; if there is one thing that officers know, it is how to read maps. However, such support may well be important for the civilian members in a staff in, say, a peace support operation. Instead, we have two other reasons for wanting a 3D displays.

The first is that, for military applications, we want to display the battle space as a *volume* and volume dependencies of time, rather than as a flat and static field. In joint operations, it is, of course, important to think in all four dimensions so as to be able to integrate the capabilities of air, sea and land components over time. With a traditional map display, the battle space will be a mental concept only, possibility specific to each individual staff member. This is a potential source of misunderstanding and disagreement. It would be better, we think, to get the fused details out in the open, and thus facilitate the development of a common, shared understanding of the battle space as a volume as it develops over time. We are trying to do this by developing an auto-stereoscopic 3D display for the staff.

A second reason for developing a auto-stereoscopic 3D display is that we want the staff members to be able to interact with the objects displayed directly, grabbing them and moving them around. This is hard to do with 2D objects. This should facilitate the negotiation among the staff members about the current state of affairs when constructing the common operational picture. A minimum requirement is that the staff members are able to point, activate, drag and drop the ideograms ("I want that tank in this position"), and have the resulting command executed. Individually each member will have these capabilities of dragging and dropping ideogram wherever in the interactive environment. But this is not sufficient.

We also want the 3D representation to support a *visual interactive language*. That is, instead of developing, say, the commander's intent in terms of words, the commander should be able to illustrate the desired End State by constructing a visual image of how he wants the situation to look at the end of the operation. Associated with this image there is the appropriate dynamics. Thus, he should be able to position his units and the enemy units, as he would like to have them. By building a picture of the desired End State, and then transmitting this to his subordinates the subordinate can do inquiries of dynamic nature to the associated dynamics in the images. This is important for there is research to show that verbal statements of the commander's intention is often subject to misunderstanding (Klein, 1994).

The communication issues take on additional importance in combined operations where the staff members come from different armed forces that may not use the exact same symbols, and where a new set of easy to understand symbols will be needed. The communication issues are, of course, even more of a problem in peace support operations where the staff will comprise both military and civilian personnel, who have no commonly understood set of symbols. The symbols may be intuitive and easy to understand for the military but they will be a complete mystery to the civilian personnel. Moreover, for peace support operations and non-traditional operations, such as counter-drug operations, the military symbols will not suffice to construct a complete picture of the situations. It is important, therefore, not to be stuck with the traditional military symbol set and methods for constructing a common operational picture. By additional dynamic ideograms, symbols and sign integrated with an additional grammar (Christensson and Woodcock, 1996, 1997) needs can be meat as the nature of the operations and the composition of the staff changes. A visual interactive language may be the best way of solving this problem.

THE VISIONARIUM™

As can also be seen from the picture, large screens surround the Visioscope™, creating what we call the Visionarium™. This provides opportunities for displaying other forms of information that the staff members might want, such as special maps, text, e.g., rules of engagement, information about the logistics situation, and so on. Most importantly, however, it makes it possible to display and interact with the situation shown in the Visioscope™ in different ways, thus proving the staff members with alternative perspectives on their problem. This should help freeing them from being locked up in a specific perspective, and increase their creativity in solving the problems facing them.

THE INDIVIDUAL WORKSTATIONS

Behind each staff member is his or her own personal workstation that can be used for communication, calling up decision support systems and have direct access to the rest of dynamic engagement system. These work stations are placed behind each staff member so that he or she would have to turn away from the Visioscope™ when using them, thus signaling in a direct way to the other staff members that they are temporarily out of the common discussion.

DECISION SUPPORT

Having the possibilities of displaying in new and innovative ways is important, but not sufficient to help the staff solve the complex problems they are facing. There is ample evidence that people have problems coping with complexity and dynamics at the levels relevant to the staff work in both traditional military operations and peace support operations (see, e.g., Brehmer, 2000, for a summary). Consequently, decision support is required.

One form of decision support planned for ROLF 2010 is shown in Figure 1 in the form of the avatar of Roman general. This avatar is a 3D auto-stereoscopic display, and is the interface to a critiquing system, which will mediate criticisms of the plans proposed by the staff, looking for possible problems, make inferences based on historical experience about, for example, aspects that the staff members may have forgotten or overlooked. The avatar is mediating results, alerting the staff when this is needed through synchronized aural speech and gestures. The avatar's comments are related to the zone in focus on the Visioscope™. Thus it is fully synchronized part of the staff environment and enables a natural dialog between the critiquing system and the staff.

Other forms of support include simulation tools that can help the staff members understand and cope with dynamics processes. Such simulation tools, based on system dynamics, exist today, e.g., POWERSIM™ and STELLA™. Using such tools, the staff members can either construct simulations for the specific problem they are facing or call up a model useful for the problem at hand from a library of process models and study the consequences of different possible courses of action. We have found that it is easy to teach the use of such simulation tools (see for an example of what can be achieved in a three week course, see Woodcock and Schalling, 1999).

However, to deal with the complexity of problems such as force composition for an operation, other kinds of methods and tools are needed. Specifically, these methods and tools should make it possible to analyse troop engagements and their implications for problems that the staff faces. For such problems, it is obvious that commanders and his or her staff need support to develop optimal solution to their problem. Process simulations, and spatial simulations alone typically do not provide the optimal solutions sought by the staff; they only provide a set of possible solutions to a problem. Genetic algorithms offer new possibilities here, and a tool called STRATMAS (Woodcock, Hitchins & Cobb, 1998) based on such algorithms is being developed for use in the ROLF environment. This tool will support real-time modeling, enabling the staff to rapidly investigate a large domain of outcomes. This

may, for example, result in a force that is better composed if, and when, an intervention is authorised.

HOW FAR HAVE WE COME?

Figure 1 shows the ROLF concept. This concept has now been embodied in a first version, ROLF Mark I. It is shown in Figure 2.

As can be seen from the picture, many of the essential elements of the ROLF 2010 concept have been implemented in Mark I. Thus, we find a small staff seated around an electronic display table, a first version of the Visioscope™ (99”), surrounded by four large (72”), touch sensitive screens, a first version of the Visionarium™, and there are individual work stations behind each staff member.

Figure 2: ROLF Mark I during an exercise at the National Defence College.

The first version of the Visioscope™ is only a 2D display, in the form of an electronic map. The Visionarium™ is also limited to four 2D displays, and, perhaps, not as elegant as those in Figure 1, but the Visionarium™ has the functionality that has been planned for, it have the individual workstations. Decision support is as yet rudimentary, and is limited to MILPLAN, a standard planning tool used in the Swedish Armed Forces.

Despite its somewhat primitive nature, ROLF Mark I can, and has, been used in a number of exercises. Figure 2 was taken during one of them. From these, we have learned:

- That it can be used for effective command and control, both in military and civilian contexts, involving both force on force and support to societal missions

- That the users like it and feel comfortable with it. This is important, for the participants in these exercises, i.e., the students at the National Defence College are the future users of this command post

- That old habits die slowly. Thus, officers easily slip back into their standard hierarchical mode of working in the ROLF environment. Obviously, some experience will be needed before all of the benefits from the seating arrangement in the ROLF staff will be obtained.

WHAT LIES AHEAD?

ROLF Mark II is currently under development. It will consist of a number of smaller development environments designed to try out different solutions. For example, two potential solutions to the 3D problem will be compared, stereoscopic based on polarized light (and requiring special glasses) and auto-stereoscopic based on holography (which will not require glasses at all). Furthermore, we need to test several mediating control devices fit for users needs. Pinch-gloves, mediating blocks, witch-pools, and haptic feedback robots are potential control devices that can support the interaction and leverage the access to information. Since there are ten individual computing nodes, four computing nodes for the Visionarium™ and three additional servers they all have to have a client server architecture and support for the staff members' drag and drop commands that are issued from one node but executed by another node in the LAN.

CONCLUDING REMARKS

To continue work on decision support for the ROLF 2010 it is essential that the staff process matures so it can utilize the computer support in an optimal fashion. Since its social processes that are in focus for a staff and they often reason in system theoretical terms, its essential to elaborate theories that support a systems theoretical approach to the relevant social sciences. From this methodology software tools can then be developed to support these processes. This means that induction through data mining, coding and statistical and non-statistical models for analysis have to be integrated to provide content to be manipulated by several mathematical tools.

Induction gives a good start for systems modeling temporal and spatial processes. Deduction with the support of a computer model will then provide model-based data as output. Statistical comparisons based on real data and model-generated data will give indications about how close the staff has captured the dynamics in a STRATMAS simulation system. Based on this check on the simulation output, an optimization can be obtained so the staff will have a suggestion on a balanced force to interdict with if appropriate. This will, however, require considerable theoretical development efforts if we shall succeed. But

nothing else will do if we are to succeed in giving the commander and his staff the tools that they ill need to cope with the complex problems that they now face.

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