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FROM FUNCTION TO FORM IN THE DESIGN OF C2 SYSTEMS

Topic 1: Concepts, Theory, and Policy

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In a series of papers I have outlined a general design perspective for the study of command and control (C2). It is based on the a design hierarchy starting with the purpose of C2 (to provide direction and coordination). It then specifies the functions that need to be fulfilled to achieve that purpose, (which I suggest to be three: data collection, sensemaking, and planning), and it ends up in form (the concrete C2 system which consists of the organization, methods, procedures and support systems that are required to fulfil the functions). The step from functions to form expresses the creativity of the designer, but there are constraints. I describe five constraints: technology, C2 requirements, C2 possibilities, command culture and legal requirements that affect the final form of the C2 system. These factors are defined, and examples are given which illustrate their effects on the final form of the C2 system. Whereas the functions explain the similarities among C2 systems, the constraints explain why actual C2 systems differ, especially with respect to the extent to which C2 is centralized or decentralized as well as its agility. The framework of functions and constraints provides a general framework for analyzing and characterizing C2 systems.

C2 is the function that provides *direction* and *coordination* of a military operation. When this function is fulfilled by a commander and his/her staff, it is performed within a C2 system comprising the organization, methods, procedures and support systems used to perform C2 (Brehmer, 2007). Understood in this way, the C2 system is one of the factors that shape C2, and to understand it, we must understand the C2 system and the factors that affect it.

As I have argued in earlier papers in this series (Brehmer, 2006a, 2007, 2008) C2 systems are *artifacts*. As such, they can they best be understood in terms of the logic of design, that is, in terms of the purpose-function-form hierarchy illustrated in Figure 1.

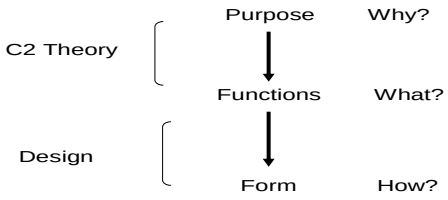

Figure 1. The logic of design appliued to C2 systems.

[1] I am indebted to the C2 seminar at the Swedish National Defence College and to Keith G. Stewart and Russell Bryant for their comments on an earlier version of this paper.

In this hierarchy, the level of purpose answers the question about *why* the system exists, the level of functions the question of *what* the system needs to do to achieve its purpose, and the level of form, finally, answers questions about *how* the functions are fulfilled (see Brehmer, 2007 for further discussion).

In the case of C2, the step from purpose to function is a matter of C2 theory in that it is concerned with what is required for successful C2, i.e., what is required to achieve direction and coordination. As the functions constitute a theory of what C2 requires they also provide a means for understanding why the level of achievement turns out to be what it is, it depends on the extent to which the functions are fulfilled. It also provides a foundation for understanding what C2 as an activity involves: it is to achieve the functions. These functions are, of course, theoretical constructs, and it is not necessary that the commander and his or her staff think in the terms of these functions. However, whatever they do can be described in terms of these functions, and can be related to these concepts.

The step from function to form, on the other hand, is a matter of design and it involves finding ways to achieve the functions. This step relies on theories of many kinds, but insofar as the functions are general, these theories are not necessarily theories of C2 as such. In this respect, the design of C2 systems does not differ from the design of other artifacts. For example, in designing a car, the theory specific to the car is that relating the purpose of the car (to get from one place to another) to the functions required to fulfil the purpose (propulsion and the possibility to change direction and speed), but there are many ways in which the functions can be achieved, as they are more general and apply in many more contexts than that of designing a car.

If the design of a C2 system was only a question of taking the step from function to form in isolation and finding the best way of achieving the functions, we would expect all C2 systems to be quite similar. At least they would be expected to converge towards greater and greater similarity, limited only by the competence of their designers[2]. But in fact C2 systems differ considerably, and this is true also for systems that are supposedly designed for the same purpose, such as military C2 systems (see, for example, Alberts & Hayes, 1995, for six quite different kinds of C2 systems in military circumstances). This suggests that the step from function to form is affected by more than the creativity of the designer. A descriptive theory of C2 systems (and C2 as an activity) must identify these other factors. It is not sufficient to consider only the purpose-function-form hierarchy[3]. In this paper, I want to take a step towards a general descriptive theory of C2 systems, and I introduce five factors that affect the step from function to form and serve to explain the form that an actual C2 system takes. Specifically, these factors are chosen to explain how and why C2 systems *differ*, in contrast to the concepts in the design hierarchy which explain how C2 systems are, similar. The five factors may be seen as constraints on design driving it in this direction or that. I will then use these factors in an attempt to explain how C2 systems differ with respect to centralization of command, which seems to the most obvious dimension along which C2 systems differ.

I start with a discussion of the factors that make C2 systems similar. It is based on the design perspective introduced in earlier papers (e.g., Brehmer, 2006a, 2007, 2008), and it is therefore quite brief. I then proceed with what is new, viz., the account of the five factors that make C2

[2] The term "designer" should be taken in a very general sense here, and to refer to each and everyone who affects the C2 systems, be they officers, engineers or scientists.
[3] For design purposes, however, the hierarchy should be sufficient.

systems different. A full account of these factors is beyond the space limitations for a paper such as this, and the discussion of the five factors is limited to describing each factor and giving examples. I then combine the design perspective and the five constraints on design into a general model. Finally, I then apply the model to the problem of centralization of C2.

Factors that make C2 systems similar

From the design perspective described in earlier papers in this series (Brehmer, 2006a, 2007, 2008), C2 systems are similar because they are designed to achieve the same purpose: direction and coordination of resources to perform a mission successfully, just as cars are similar because all cars are designed to achieve the same purpose[4]. To achieve the purpose of C2, the C2 systems need to fulfil the functions that are required, that is the "whats" that the system needs to fulfil to achieve its purpose. As a consequence C2 systems will exhibit similarities. Above all, in so far as we agree that the purpose of C2 is to achieve direction and coordination, it can be analyzed in terms of the same functions, and the extent to which C2 achieves its purpose, it can be understood in terms of the extent to which these functions are achieved.

The question of which these functions are is a matter for C2 theory. According to the theory that I have proposed in earlier papers (see, for example, Brehmer, 2007), three functions suffice: *data collection*, *sensemaking* and *planning*. These functions specify what the C2 system actually needs to do, and if any of these functions is not achieved, the C2 system will obviously not achieve its purpose[5], i.e., the C2 system must be able to collect data, it must be able to produce an understanding of the mission in terms of what need to be done in the situation at hand to accomplish the mission, and it must be able to produce a plan which expresses how this should be done in orders (for further discussion, se Brehmer, 2007).

As noted above, the functions also provide a guide to understanding what the commander and his/her staff actually do when performing C2. In so far as all C2 systems are designed for the same purpose (viz., to achieve direction and coordination), what is being done in all instances of C2 can be understood in terms of the same functions (data collection, sensemaking and planning in our model), and the extent to which the C2 system achieves its purpose is dependent on the extent to which the functions are achieved. This does not mean that the functions are achieved in the same manner, or to the same extent, in all C2 systems, however. How functions are achieved (or how the commander and his/her staff attempt to achieve them) is described by the form of the system. How C2 is actually performed is thus a matter of how the C2 functions have been translated into the form of the C2 system, that is, the actual organization, procedures, methods and support systems that have been designed to fulfil the functions. While the fact that all C2 systems are designed to achieve the same purpose, i.e., direction and coordination, and because this is possible only if the requisite functions are fulfilled, C2 systems and consequently C2 as an activity, will be similar in all cases that demand command and control. Consequently C2 as an activity may nevertheless differ from case to case, just as form of other artifacts such as cars differ. We now turn to the factors that produce the differences in the design stage.

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[4] Of course, cars differ too, because the design of, say, a sports car will also fulfil purposes that are different from those of a family sedan.

[5] An alternative conception of the requisite functions is suggested by Alberts and Hayes (2007), who combine sensemaking and planning into one function, but this is not the place to discuss the relative merits of these two positions (see Brehmer, 2007).

Factors that make C2 systems different

If theories of the requisite functions of C2 were developed to such an extent that the one best way to achieve the functions were known, all C2 systems would presumably be identical, or at least not very different. This is, alas, not the case, and as a consequence existing theories relating to the requisite C2 functions is only one of the factors that guides the design of a C2 system[6]. This leaves room for other factors and considerations in the design process. These factors and considerations (together with possible differences in theories of how the functions should be achieved) introduce differences among C2 systems. In this section we will be concerned with these "other factors".

According to the model proposed here, five factors contribute to making C2 systems different. The first, and perhaps most obvious, is *technology*. This factor may be seen both as a factor that creates possibilities and as a factor that introduces constraints. The following four factors are mainly constraints. The first of these factors we call *command requirements*. It is a constraint that serves to dimension the C2 system. The second is called *command possibilities*, a factor that affects the form of the system mainly by the more or less ingenious ways in which designers of C2 systems try to transcend the limitations. The third constraint we call *command culture* and it refers to the culturally received view on how C2 should be performed and on "how it is has always been performed". The fourth is *legal requirements.* We now turn to a discussion of each of these factors.

Technology

A full account of how technology shapes C2 systems is a subject for a book of its own, and books on the subject have indeed been published (see, .Van Creveld, 1985, and Keegan, 1987, who discuss this factor in some detail, and the series of books from the Command and Control Research Program (CCRP) project that detail the new possibilities for C2 in the information age, e.g., Alberts, Gartska & Stein, 1999). Here we will limit our discussion to some general remarks on the subject to illustrate its impact.

In the case of C2, the term technology must be taken in a wide sense. Thus, perhaps the greatest technological advance relevant to C2 was when military commanders learned to read and write in the 14th century (van Creveld, 1985). This made command at a distance possible. But the distance was limited initially by the speed at which messages could be transmitted. For example, during the Napoleonic wars, it was not possible to effectively command a front exceeding 8 kilometres because of the time required for a messenger on horseback to reach the flanks of the army[7]. This changed with the advent of the telegraph, radio and telephone as described by Keegan (1987), and is now being further transformed by the advent of high speed, asynchronous communication by means of e-mail.

The increased possibilities for command at a distance are not only relevant to command on the battle field, as exemplified by how the German forces were able to use radio communica-

[6] Indeed, C2 systems may not be designed on the basis of explicit theories of data collection, sensemaking and planning at all. As noted above, the functions are theoretical concepts, not concrete psychological or physical porocesses, even though they are realized in such processes. The theories used in design of C2 systems relating to the functions are generally implicit, and one factor that produces differences among C2 systems. To analyze also this factor is beyond the scope of this paper, however.

[7] Van Creveld, M. Lecture at the Swedish National Defence College, 2008.

tions during the Second World War. It is also important in that it introduces new means of political control. It also creates possibilities for tighter political control of the commander in the field. For example, Hitler could reach his field commanders via telephone, and frequently availed himself of this possibility, not always to the benefit of the conduct of the operations (Keegan, 1987) and Leonhard (1991) has described how the political leaders will soon be able to be virtually present on the battle field by means of modern electronic communications.

Technological developments affect all functions of the C2 system. It has made it possible to collect and transmit information about the state of the battle field faster and faster and over greater and greater distances supporting faster and better sensemaking and planning, and faster transmission of orders over greater distances. For example, the United States operations in Iraq could be commanded from Florida at no great inconvenience, while Alexander, operating in the same region of the world could only do so by being personally present on the battlefield. It has also made it possible to command larger and more complex forces. Here it has been aided by the development of accounting systems, now aided by computers, which make it possible to handle greater amounts of data, allowing the C2 function to cope with greater complexity.

In short, two forms of technological developments seem important here: The ability to transmit information faster and faster and the ability to process large amounts of information. Both of these developments have affected what forces can be commanded and how these forces are commanded. One consequence of this has also been the need for more abstract conceptions of battle to help the commanders at higher levels to conceptualize what is actually going on in the battle space. Thus, the development of military theory and doctrine become more important. C2 in modern warfare looks quite different at different levels of the military hierarchy, despite that it still involves the same functions at every level.

An important factor here is also time. Larger forces necessarily move at a slower pace and take longer to position and equip, requiring different time horizons than smaller forces. This calls for different forms of planning at, say, the army corps level than at the battalion level. Yet the object of planning remains the same at all levels; to determine how an objective should be achieved.

Technology thus has a pervasive effect on C2, affecting both the scope of what can be commanded and the form of the C2 system. The effect is so pervasive that it is easy to loose sight of the fact that despite the differences in form between, say, C2 as exercised by emperor Alexander and General Schwartzkopf operating in the same region of the world, the C2 systems in the two cases nevertheless served the same purpose by achieving the same functions. This makes it possible for us to understand Alexander’s problems, but it would obviously be a mistake to believe that because the two commanders had the same problems at a general level, their problems were also the same at a more concrete level. In short, there are lessons to be learned from history, but history does not provide all the lessons that we need to learn.

Command requirements

Perhaps the most obvious way in which contemporary C2 systems differ is with respect to sheer size. This has to with what the C2 function needs to actually do to fulfil its purpose. Specifically, it has to respond successfully to two kinds of challenges: those that stem from within the system to be commanded and those that have their origin in the task to be solved. Thus C2 requires a double focus as is illustrated by the Janus face in Figure 2.

Figure 2. Janus face (from Wikipedia)

The inward looking aspect is the aspect most often mentioned in official definitions of C2 (Brehmer, 2006b). It concerns the need to handle the resources, human as well as the various systems, made available to the commander. As military forces have grown in size and capability the complexity of this aspect of C2 has increased and makes greater and greater demands on the C2 function. As a consequence, the size of C2 systems, especially staffs, has increased. However, this is not a one way street. The size of the forces under one commander have also increased because technology now makes it possible to command greater and greater forces (cf. the discussion of "command at a distance" above).

The outward looking aspect concerns the problem to be solved with the resources at hand. More complex problems require more capable C2 systems, and that often means larger staffs. Even very small forces may be receive very complex tasks and require very capable C2, and consequently very large, C2 systems. Peace support operations provide an example.

That the command requirements are determined by both the inward and the outward looking aspects is not new. Already Sun Tzu expressed this insight in the well known quote:

> *If you know the enemy and know yourself, you need not fear the result of a hundred battles. If you know yourself, but not the enemy, for every victory gained, you will also suffer a defeat. If you know neither yourself nor the enemy, you will succumb in every battle*. (Sun Tzu, 2008, Ch. III, 18).

It is also expressed in our definition of sensemaking as the function that produces an understanding of what needs to be done to accomplish the mission in the situation at hand (Brehmer, 2007). This definition is based on William James's (1907) pragmatism, which we think provides a more adequate philosophical basis in matters relating to C2 than the empiricistic orientation that characterises so much of the current work in the area. After all, C2 is about deciding what to do, rather than just deciding what is the case. This action oriented perspective on understanding requires a consideration both of the problem to be solved and the means that are available for handling the problem, and this must be reflected in our understanding of what C2 systems do, as it will shape these systems.

Command possibilities

This factor refers to the possibility of effectively fulfilling the C2 function of providing direction and coordination. The most obvious factor is, of course, the possibilities to obtain the information that is required. However, our interest here is not in the performance of the C2 system and the limitations introduced by lack of information but upon how designers have sought to overcome the limitations they face, and how this affects the form of C2 systems. The most obvious example here is how the C2 system handles the uncertainty that is created by lack of information on different levels of the military system which affects the tactics employed. *Mission command* is a solution to this problem.

Another important aspect here is how forces are organized to make effective C2 possible. Specifically, as the control span problem makes it impossible to handle very large forces, they must be divided into more manageable units. Napoleon's division system is an example of how this problem can be handled, as is the general hierarchical organization of the armies into platoons, companies, battalions and so on. Another example from Napoleon is his use of the "directed telescope" in the form of trusted staff officers who would report to him about the state of his troops (van Creveld, 1985).

The nature of the forces available is also an important factor here. It is instructive to compare the methods of command used by American and German commanders in the Italian campaign in the Second World War. The American troops were generally fresh from basic training and their commanders inexperienced while the German troops consisted of battle hardened veterans with very experienced commanders. As a consequence the command methods differed. American commanders were forced to rely on command by plan, while the German commanders could rely on mission command[8].

The resulting form of the C2 system is thus very much influenced by the ways in which their designers try to solve the problem of obtaining the information that is required for effective sensemaking and planning, and their attempts to overcome the limitations that they face.

Command culture

The concept "Command culture" refers to the set of beliefs relevant to C2 in the armed forces of a country. These beliefs are based on experience of that country and its armed forces as well as on the culturally conditioned beliefs about the nature of war and people. In finds at least in part, its expression in the C2 doctrine, if such a doctrine has been formulated.

As for the first aspect of a command culture, i.e., the beliefs about the nature of war, armed forces differ with respect to the extent to which they think of war as predictable and controllable. At the one extreme, war may be seen as essentially chaotic and impossible to control, making detailed planning futile; all that can be done is to provide resources to those in the field and hope that they are capable of realizing what opportunities present themselves. This point of view finds a clear expression in von Moltke's well known view on the fate of plans in

[8] This is, of course, only one of the factors here. Differences in command culture were also important, together with the fact that the American commander, General Clark, was a "staff general" with experience as a planner rather than an experienced field commander. The German commanders were not only experienced field commanders, they also came from a very different command culture that had been developed from the early 19th century in the German army with an emphasis on individual initiative and mission command.

war ("No plan survives contact"), and it was a cornerstone in the German approach to C2 in the Second World War. This concern was also manifest in the central/decentralised control approach and the functional vs. divisional organization structure. At the other extreme, war is seen as something that can be controlled, calling for a management approach based on clever and detailed plans to be followed by subordinates to the letter, a view that finds its clearest expression in the French "methodical approach" to warfare in the First and Second World War. While no armed force has probably subscribed to any of these views in their most extreme forms (whatever their rhetoric), there is nevertheless a tendency to lean to towards the one or the other of these views.

As for the second aspect, the nature of people, at the one extreme, an armed force may look at its officers and men as capable individuals who can be trusted to seize initiative when an opportunity presents itself, thus needing little guidance except a general sense of what is to be accomplished. Alternatively, an armed force may look upon its personnel as passive, incapable of initiative and in need of detailed guidance.

This seems to leave four possibilities, but in actual fact not all combinations seem to materialize. Thus, no armed force seems to hold the belief that war is chaos and that its officers and men need detailed guidance, perhaps because such a combination seems to make any rational approach to war and C2 impossible.

Obviously, the two aspects generate very different approaches to C2. Thus, if one believes that war is chaotic but ones personnel are capable, various forms of decentralized control seem to be the C2 approach of choice, as it was for the German *Wehrmacht* in the Second World War, or for the Israeli Defence Force in more recent times. If, on the other hand war is seen as predictable and ones personnel in need of guidance, more centralized forms of C2 seem to be the system of choice, as is the case in, for example, the current Chinese Armed Forces (Alberts & Hayes, 1995). Such beliefs also seem to have been prevalent in the United States Armed Forces during the Second World War. But this is a complex matter, and many other factors need to be considered as well, such as the political system and the willingness to delegate authority to persons outside the political chain of command (remember the political commissars in the Soviet Armed Forces), and the problems of training an armed force manned by conscripts to a level of competence that is required for successful mission command (definitely a factor of importance for understanding the forms of command used in the United States armed forces during the Second world War☺

It is, of course, not so easy to distinguish cause from effect in these matters, for there are factors that will work in favour of the one or the other approach being viable. For example, for a country with vast resources, war becomes a more predictable affair than it is for a country lacking resources, and a country that has a well a trained armed force accustomed, and expected, to display initiative will be able to rely on its subordinates in a way that a country that has armed forces that are not experienced or well trained can do. Alberts and Hayes (1995) described six different "command arrangements" that have been employed to cope with differences in what we have called "command culture" and the reader is referred to their excellent book for further discussion.

In this context, it is also important to note that command cultures do not only differ between countries. It also differs among the three services, i.e., the Army, the Navy and the Air Force. This is, at least in part, due to the different circumstances under which they operate, and probably to historical circumstances as well. In this respect it is interesting to compare naval

and army command in the 19th century, remembering that there are substantial national differences as well, as illustrated by the differences between Nelson's and ,philosophy of command with that of Villeneuve at the battle of Trafalgar.

Legal requirements

With the right to make decisions and have them obeyed follows responsibility for these decisions. It is therefore not surprising that the practice of C2 is surrounded by various forms of legislation, in national law as well as in international law relating to war, that specify the rights and duties of a commander. Such legislation will, of course, have little impact if it is not possible to find responsible persons, i.e., commanders, whose task it is to make sure that C2 is exercised within the legal limits. This tends to lead to centralization of command, for no commander will, of course, want to be held responsible for what he, or she, cannot influence.

The model

We are now ready to summarize the discussion so far in a general model of C2 systems, a model that will account both for the factors that contribute to the similarities among C2 systems and to their differences. The result is shown in Fig. 3.

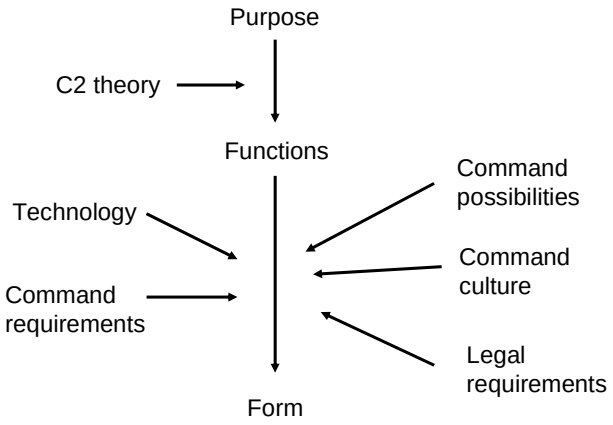

Fig. 3 Model of factors that affect the form of C2 systems

The model combines the design hierarchy and the constraints on design discussed above into one framework which should make it possible to account for the actual form that a C2 system takes. It provides concepts that will make it possible to compare C2 systems and understand their similarities as well as their differences, and for evaluating them and accounting for their effectiveness (or lack thereof). We will now illustrate this by discussing one aspect of C2 systems, the degree to which C2 is centralized to a commander. The discussion of centralization will also reveal that the five factors are not independent. For example, the technology factors will have effects and so to say set the stage for the other factors. This does not make these other factors unimportant, however. For example, factors such as command command culture also contribute to the definition of the problem that must be solved by the designer of a C2

system. This problem is thus not only a question of finding the optimal way to perform the functions of , data collection, sensemaking and planning, for the C2 system is developed within the constraints of technology, command requirements, command possibilities, commad culture and legal requirements.

Effects on centralization

In addition to sheer size, the most obvious way in which C2 systems differ is probably with respect to *centralization*, i.e., with respect to which C2 is the result of a single commander or command unit. In the present model, centralization is a *dependent variable*, i.e., it is seen as a result of the other factors that cause C2 systems to be different, rather than as another independent variable. Thus, the degree of centralization is a factor to be explained by the model. In this section, we will discuss how the factors in the model affect the degree of centralization of C2.

Remembering that C2 is a function that can be achieved in different ways, one of which is by a commander and his or her staff, we need not take centralized forms of command as our point of departure.

Starting with the design hierarchy it does not have any implications with respect to this issue. The only question here is whether the requisite functions can be achieved, and there is evidence that they can be achieved by C2 systems that differ widely with respect to the extent to which they are centralized or not, including systems characterized by selfsynchronizing, at least under some circumstances (see Brehmer, 2009). The question from the design perspective is only the extent to which a system can be designed that will achieve its purpose. How this purpose is achieved is limited only by the imagination of its designers. Thus, the design perspective implies no special position with respect to centralization, albeit a fact that it is far easier to design a centralized C2 system than a decentralized one, not to mention a C2 system that would adapt to changing circumstances. Instead we will have too look to factors that influence the step from function to form in the model to find the explanations for centralization.

Technology

As noted above developments in technology have created possibilities of command at a distance; the commander no longer needs to be personally present to make sense of the situation and to issue orders. Interestingly, while these developments in technology first made a disassociation between commander and the commanded possible, current developments reverse this trend. As described by Keegan (1987), the telephone made it possible for Hitler to talk directly to his field commanders wherever they were and this trend is further strengthened by the new possibilities offered by the new communication systems that allow the commander-in-chief to be virtually present everywhere (Leonhard, 1991). This means that the possibilities for centralization of command seem to increase. However, even being virtually present takes time, and a commander cannot be everywhere, even if his or her presence is virtual. This suggests that these possibilities only can be used in small-scale military missions, such as a peace keeping. Indeed, for large operations, the new forms of technology with their vast possibilities for transmitting near real time detailed information to the commander may well lead to increased decentralization, for the simple reason that the commander and his/her staff simply cannot process all the information that is made available. Without effective support systems to handle all the information that is being made available (an no such systems seem to be on the

horizon), it does not seem likely that it will be possible to translate this development into greater centralization, except in small missions or at lower levels in the hierarchy.

At the lower levels, however, the new forms of technology make it possible for the commanders to obtain a better picture of the situation, making effective centralized command possible, but also enable the units in an area to selfsynchronize (Brehmer, 2009).

The effects of technology on C2 systems are thus not simple. Technology can used both for increasing centralization and for increasing decentralization. What the effects are likely to be will depend on the extent to which the central command units will be able to process the information that becomes available and the speed of command that is required by the military mission and the tactics that are employed (see Alberts & Hayes, 1995, for further discussion of this point).

Command requirements

This factor does not seem to have any specific implications for centralization. However, the distinction between the inward and outward looking aspects captured in the Janus model is important for understanding the possibilities introduced by information technology, the possibilities obviously being easier to realize with respect to the inward looking aspects more closely associated with control than command, than for the outward looking aspects that is more closely associated with command. This has indeed also been the case.

Command possibilities

As noted above, this factor has its greatest impact on C2 systems by how designers of C2 systems try to circumvent the limitations they face in C2. The most obvious of these is lack of the requisite information and complexity.

The latter problem is generally solved by organizational means, the force is divided into units so that the demands on the command function are kept within the limits set by the commander's control span. Specifically, this means that the number of units making demands on the commander's attention is kept at the level of 3 to 4 units, a scheme found in most military organizations. This leads to a hierarchical system.

The hierarchical organization introduces a problem: the information available at the lower sharp end of the organization where the fighting is done is different from that at the higher, blunt end where planning and coordination is done. Specifically, commanders at the lower level, who are in direct contact with events will have more up-to-date information about the local situation, but they will have less overview of the battle as a whole, while commanders at higher levels will have a better overview, based on reports from many local units, but their information will be somewhat dated, making direct real-time control of the battle difficult. The problem is well known, as is its solution: *mission command.* This philosophy of C2 makes it possible to get the best of both worlds by allowing the local commander freedom to act according to circumstances within the limits set by a mission received from the higher level, a mission formulated on the basis of the better overview available to commanders at this level. Of course, this solution is not always possible, it requires trust among commanders at different levels and competence at all levels, but the philosophy of mission command nevertheless illustrates how command possibilities shape the C2 system via the designers' attempts to overcome limitations.

Command culture

Command culture has a very direct effect on the degree to which the C2 system is centralized or decentralized. When armed forces believe that war is chaotic and not susceptible to management by plan, they will generally develop decentralized forms of C2, and vice versa, and when the higher levels of command, for whatever reason, do not trust their subordinates to take initiative and seize opportunities, the C2 systems will tend towards centralization.

Legal requirements

Legal requirements seem to be a factor that definitely works towards greater centralization, for the simple reason that it will be much easier to find those responsible for failure or success in such as system, and because they will be held responsible, they will also want to be able to exercise command. However, just as the new forms of information technology make it possible to introduce more distributed forms of decision making, e.g., in the form of selfsynchronization, it will also make it possible to track responsibility in computer based war diaries that register decisions made at all levels. Thus, the legal requirements may not be such a strong pressure towards centralization of command that it now is.

Conclusions

A conclusion from the model and the discussion above is that even though technology is an important determiner of the form that a C2 system will finally take, other considerations are important as well. The room for these other factors to affect the form of the system will be all the greater because the current technology has a number of limitations, limitations that stem, in part, from the fact that we simply do not know the best way to achieve the functions that are necessary to fulfil the purpose of a C2 system, Hence, we cannot design an optimal C2 system. But there are also aspects that will have strong effects on the design of C2 systems that have nothing to do with technology as such. Especially important here is the command culture, i.e., the beliefs we hold about the concrete problem to be solved by the C2 system, i.e., our beliefs about the nature of war and about those whom we command. These beliefs tend to be self confirming, because we will organize our C2 and fight our wars according to our beliefs in these matters. This makes it difficult to introduce new forms of C2 that seem not to be compatible with prevailing command cultures. Network Centric Warfare concepts with its promise of radically different conditions for warfighting is a case in point.

References

Alberts, D.S., Gartska, J.J. & Stein, F.P. (1999). *Network centric warfare*. Washington, D.C.: CCRP.

Alberts, D. & Hayes, R. E. (1995). *Command arrangements in peace support operations*.

Alberts, D. & Hayes, R. E. (2007). *Planning: Complex endeavors*. Washington: D.C.: CCRP.

Brehmer, B. 2006a). One loop to rule them all. Paper presented at the 11th ICCRTS, Cambriudge, England, September 25-28, 2006.

Brehmer, B. (2006b). Ledning handlar väl o matt åstadkomma något? *Kungl Krigsvetenskapsakademiens Handlingar och Tidskrift* (6),64-70 .

Brehmer, B. (2007). Understanding the functions of C2 is the key to progress. *International C2 Journal, 1,* 211-232.

Brehmer, B. (2008). *Command and control reserach research is a science of the artificial*. Paper presented at the 13th ICCRTS, Bellevue, WA, June 16-18, 2008.

Brehmer, B. (2009). Command without commanders. Paper to be presented at 14th ICCRTS, Washington, June 15-17, 2009.

James, W. (1907). *Pragmatism*. New York: Dover.

Keegan, J. (1987). *The mask of command.* London: Jonathan Cape.

Leonhard. R. R. (1991). *The principles of war in the information age.* Presidio Press.

Sun Tzu (2008). *The art of war. The oldes military treatise in the world*. (Translated by Lionel Giles). North Clarendon, Vermont: Tuttle Publishing. (Translation originally published 1910).

Van Creveld, M. (1985). *Command in war*. Cambridge, Mass.: Cambridge University Press.