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The Future of C2

Understanding the Functions of C2 Is the Key to Progress

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Understanding the Functions of C2 Is the Key to Progress

Berndt Brehmer (Swedish National Defence College)

Abstract

Command and control (C2) is always performed as part of a C4ISR system. Such systems are artifacts and best understood in terms of the logic used to construct them: the logic of design. This implies an analysis in terms of purpose (why the system exists), function (what the system needs to achieve to fulfill its purpose), and form (how the system is supposed to fulfill the functions), but as for all systems designed to support human activity, we cannot assume that they will function as they were designed to do, so a distinction between form (how the system was designed to function) and process (how it actually functions) is also necessary. It is argued that the function concept is central both to understanding C2, for it is shaped by the functions to be achieved as well as for designing C2, or C4ISR, systems that support the attempts to achieve the functions. Our current conception of the requisite functions as embedded in our general normative model of C2, the Dynamic OODA (DOODA) loop and the nature of the process of designing C2 systems are discussed to exemplify how the function concept can free us from the dead hand of tradition.

Understanding the Functions of C2[1]

Command and control (C2) is a *function* of the military system (Van Creveld 1985). It is a function that is necessary to produce the military effects of a mission. C2 does that by providing *direction* and *coordination* of the military effort, i.e., by ensuring that the requisite military assets are positioned as required at the time when they are needed and with an appropriate mission.[2] One of the aims of C2 research is to find ways to help the commander achieve this, regardless of whether his mission is to ameliorate, contain, deter/coerce, or destruct, to use Smith's description of the tasks that military forces can perform (Smith 2006, 320).

Military C2 today is always performed within a C4ISR system, and to understand and improve C2, we need to understand the nature of that C4ISR system because the characteristics of this system will shape C2. A useful point of departure here is to acknowledge that it is an *artifact*; that it is designed for a purpose, albeit perhaps not always in a very systematic way. Acknowledging that it is an artifact suggests that it is perhaps best understood in terms of the logic that was used to construct it: *the logic of design*. This is the approach taken in this paper.

The logic of design

The general nature of design logic is illustrated in Figure 1. It implies an analysis in terms of three levels: purpose, function, and form.

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1. I am indebted to Eva Jensen for her comments on an earlier version of this manuscript and to the anonymous journal reviewers for their insightful and extremely useful comments on the manuscript first submitted.

2. What is "requisite resources," "the appropriate location and time," and "the appropriate mission" is not a C2 matter; however, it is a matter that is decided by military theory and doctrine. Regardless of military theory and doctrine, however, C2 comes down to insuring exactly this: that the requisite military resources are positioned appropriately, at the appropriate point in time with the appropriate mission (synchronization). That is all C2 can do, regardless of doctrine.

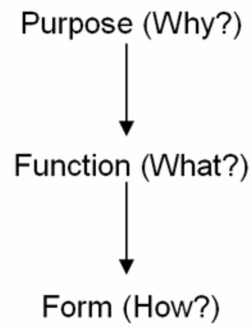

Figure 1. The three conceptual levels of a design logic[3]

As shown in Figure 1, design is a top-down process. It starts with the *purpose*. Specifying the purpose of a system answers the question of *why* the system exists (why it was made or should be made) in the first place. In the case of C2, the purpose is given by the function of C2 in the military system, i.e., it is to produce military effects by providing direction and coordination of the military forces. Thus, although C2 is a function when seen from the perspective of the military system, it becomes the purpose when we turn to the design of the system that is to achieve the purpose of providing direction and coordination.

The next step in design, and the second question to ask when trying to understand an artifact, concerns the *functions* that are required to achieve the purpose. Describing the functions answers the question: *What* must C2 do to fulfill its purpose? The set of functions and their relations constitute a theory of what is required for successful C2 generally (as distinct from a description of how C2 is performed in a given instance). As such, it must be testable. Just providing a conceptual model (however useful for other purposes) will not suffice here. To find the requisite functions, we need to ask: What must the C2 *do*

3. Some readers will note the similarity between this conception and Rasmussen's (1985) Abstraction Hierarchy. They are right. Rasmussen's conception is indeed the inspiration. I had the good fortune to work with Jens Rasmussen during the 1980s and 90s and I freely acknowledge his influence.

to provide direction and coordination of the military effort so as to produce the desired effects? Our theory of C2, the Dynamic OODA loop, or DOODA loop (Brehmer 2005; 2006a), specifies that three different functions are needed: data collection, sensemaking, and planning. That is, data must be collected via sensors and human observation, an understanding of these data in terms of what needs to be done must be achieved, and that understanding must be worked out into orders that achieve direction and coordination of the effort. We will elaborate on these three functions below when we describe the DOODA loop in more detail.

The final step in design is that of describing the *form* of the system. Detailing the form answers the question of *how* the functions are fulfilled. In the case of C2, the form of the system comprises the organization, methods, procedures, and support systems that make up the C2 system. This description emphasizes that even though C2 is the responsibility of the commander, it is usually a collective effort. As a consequence, it has social as well as cognitive aspects: it requires both organization to handle the social aspects (including means of communication and collaboration) and methods, procedures, and support systems to handle the cognitive aspects.

It is important to realize that, from a design perspective, the form of the C2 system is a *normative* concept; it specifies how C2 should be performed according to the design. There is, of course, no guarantee that C2 will be performed in that way. It is therefore important to distinguish between the form of the system, which specifies how C2 should be performed, and the process of C2 and the "command culture," which denotes how it actually is performed.

A reasonable first step in any evaluation of an existing C2 system is to compare form and process. Deviations from the form in the actual process of C2 may lead to better or worse C2 performance than would be predicted on the basis of form alone. Some improvement of C2 may well be achieved simply by bringing process closer to form, or form closer to process as the case may be. The latter alternative may, however, involve compromises on values and objectives, indeed on the ability of the military system to accomplish its missions; lowering the bar by bringing form in line with process is thus not necessarily desirable, yet it seems to be the goal of much work toward improving C4ISR systems today. More radical improvement is, however, only likely to come from finding better ways of fulfilling the requisite functions.

Two varieties of C2 research

The discussion above implies that there are two possible foci of C2 research. The first concerns how C2 *should* be performed and may be called *normative C2 research*. Specifically, normative C2 research is concerned with finding the functions that must be fulfilled to achieve the purpose of C2, i.e., the ability of military organizations to accomplish their assigned missions.

As noted above, the set of C2 functions and their relations constitute a theory of what is required for successful C2 in military circumstances. Like all theories, such a theory must be tested empirically. Normative C2 research, as understood here, is therefore not a wholly conceptual or theoretical exercise; it is empirical as well. The outcome of empirical tests may show that the assumed set of functions and/or their relations is not sufficient to achieve successful C2, or that some of the functions that have been postulated in the theory are superfluous.

The second variety of C2 research may be called *descriptive C2 research*, and it is concerned with C2 as *it is actually performed* under given historical circumstances. Descriptive C2 research thus focuses on the *process of C2*. The form of the C4ISR system is only one component here. Other components are the people involved and the circumstances under which they operate, including the military theory they subscribe to. These circumstances will not alter the purpose of C2 as such, which remains that of producing military effects by providing direction and coordination, nor will they alter the functions that need to be achieved for this, but they may well affect the efficiency of the C2 system. If so, they do it by affecting the extent to which the requisite functions of the C2 system are fulfilled. Designers of C2 systems will, of course, try to make them impervious to the conditions under which the system has to operate so that C2 will not degrade under conditions of high workload, fear, or stress. The extent to which the designers are successful will be revealed by descriptive work elucidating what the system actually achieves and how it achieves it, i.e., how close the actual process fulfills the functions, and thus the extent to which the C4ISR system is able to support achieving the functions of C2. Note that it is not necessary to evaluate the C2 system as a whole for this. It is sufficient to evaluate the extent to which the separate functions are achieved. If a given function, for example sensemaking, is not fulfilled, the C2 system cannot achieve its purpose (except by happenstance). If it achieves its purpose without fulfilling this function, sensemaking would obviously not be a critical function in C2.

There is nothing unique about the distinction between normative and descriptive C2 research. For all human artifacts, there are the corresponding two foci. For example, to use too simple an analogy, a theory that guides the design of cars is not the same as the theory that explains all the uses to which they are put. The designer of a car needs to consider both, just as the designer of a C4ISR system must.

The requisite functions of C2

The concept of function is a complex one. In the present context, it serves two purposes. First, it serves as an engineering concept that is used in the design process. As such it specifies what needs to be done to achieve the purpose of C2. The functions are theoretical constructs, and they cannot be observed directly; only their embodiments in a given system can be seen. In actual practice, they are defined by their *products*. Specifying the functions is thus tantamount to describing the products that are needed from the C2 system to achieve its purpose. Consequently, designing the system involves creating the form that can produce the requisite products. Evaluating the system, in turn, means assessing the quality of these products. It is important not to take too narrow a view of what constitutes a product. For example, if planning is seen as more important than the plan (as is often said to be the case in military circumstances), planning becomes the product and it is to be evaluated in terms of the extent to which the planning process meets the requirements of what is known to be a good example of such a process. The same goes for the other functions and products in C2.

Second, the concept of function also serves as an aid to understanding the C2 system. This is akin to how the function concept is used in biology (see Nagel 1956 for a discussion of how the concept can be used and formalized for this purpose in biology and social science). However, the concept becomes especially useful when one is trying to understand artifacts. (See Rubin's [1920] wonderful description of his attempts to understand the shutter mechanism of a camera, and how he is able to do so only by thinking about its parts in terms of their function.)

Ideally the two function concepts should be identical. However, there is no guarantee that the person trying to understand a C2 system has the same function concepts that the designer had. This is especially true today when the concept of function and that of process are not kept apart, and a person may apply function concepts that are tainted by implicit process concepts. Moreover, most C4ISR systems today have many fathers and they cannot necessarily be characterized in terms of one coherent set of concepts.[4] Nevertheless, at the highest level of abstraction, the products needed for design and understanding should be identical, provided that the purpose of C2 is understood in the same way.

4. Attempts at constructing a conceptually coherent C4ISR system are underway in Sweden so as to benefit from the new information technology. A summary of the achievements so far are given in *IDC2. Ledningskoncept for integrerad dynamisk ledning* (*IDC2. C2 concept for integrated dynamic command and control.*) Stockholm: Swedish Defence Forces, 2007 (In Swedish).

Design of C2 systems

Rasmussen (1985) called the hierarchy depicted in Figure 1 the *abstraction hierarchy* and he described how it is used top-down in design.

From this perspective, design involves a hierarchical breakdown of the functions until it becomes possible to make contact with the form. Rasmussen demonstrates how this can be done in the case of the design of physical artifacts, such as a power plant. Specifically, he describes three levels in the breakdown of the functions in the design of such artifacts. The highest level is called *abstract functions* and it is exemplified by the causal structure, mass, energy, and information flow topology of the system. The abstract functions are then broken down into what Rasmussen calls *generalized functions* as exemplified by "standard" engineering functions and processes, control loops, and heat transfer. The lowest level in the hierarchy of functions is called *physical functions*, and it involves the electrical, mechanical, and chemical processes of components and equipment. These steps represent three levels of increasing concretion.

In the design of physical artifacts, then, it is a short step from the physical functions to the form, for form is simply an embodiment of the physical functions in suitable form.[5] In the design of human systems, such as C4ISR systems, on the other hand, things are not quite so simple. As will be explained below, in such systems, as in all systems that require people, form alone is not sufficient to make the system achieve its purpose (this is why they require people in the first place). A C4ISR system is thus a system that supports people, not a system that achieves results on its own as physical artifacts do. Therefore, we cannot think of the form of the system simply as an embodiment of the functions; it is not a "C2 machine." Instead, we should think of it as a kind of *support* to the people whose task it is to fulfill the functions; that is, the organization, procedures, processes,

5. That the step is simple conceptually does not mean that it easy to take in the design of a concrete artifact, of course. Indeed, this is where we find the inventor of artifacts.

and support systems help the people to achieve the functions, but the organization, procedures, processes, and support systems do not by themselves achieve the functions and purpose of C2. C2 is done by people, not C4ISR systems.

The reason why we cannot design a "C2 machine" is that it is not possible to find algorithms for C2 corresponding to the laws of physics and chemistry. This, in turn, is because we cannot specify the exact nature of the circumstances under which the system will have to fulfill its purpose. Human interpretation of these circumstances is therefore required, and writing algorithms for this has so far proved beyond our ability. This has an important consequence: the performance of a C2 system will be unpredictable in principle. It is never possible to guarantee that a given C2 system will produce a successful outcome or even predict what the exact outcome will be because we cannot predict with complete certainty how the people in the system will interpret the data that are available,[6] even though military training goes a long way toward realizing such a goal.

The design task, therefore, first becomes that of identifying the human functions that need to be supported, then finding a form that will support the users when trying to produce the requisite products. This will require a breakdown of the requisite functions to a level that constitutes a description of what the people in the system need to achieve to fulfill the functions.[7] The end product will be a description of functions at a lower level, but it will still be a description of functions that need to be fulfilled by people. This level can be seen as corresponding to the level of physical functions in Rasmussen's hierarchy, but it cannot be directly embodied in form.

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6. Being unpredictable may, of course, be seen as an advantage in military circumstances where being predictable is generally a recipe for disaster, but it is a problem from the point of view of designing reliable systems, such as power plants, for example.
7. These are not user requirements, then, but demands that C2 makes on those who exercise it.

The extent to which fulfilling the functions required for successful C2 will need support is an empirical matter. Just because a function has to be fulfilled by a person does not necessarily mean that support is needed. Above all, it is important to avoid the trap of thinking that just because it is hard to design a system that will fulfill a given function, it is also hard for a human to fulfill that function in a satisfactory manner. Whether support is needed and will lead to improvement is thus an empirical question that should be decided on the basis of empirical results elucidating the ability of the people in the system to do what is required, not on a priori grounds or on the basis of our ability to design a support system.

To get ahead, we now need to specify the functions of C2 and their relations. We do that by presenting the current version of the Dynamic OODA loop (Brehmer 2005; 2006a), which constitutes our current theoretical framework.

The Dynamic OODA loop

The Dynamic OODA loop, or DOODA loop for short, is our current attempt to create a theory of what is required for successful C2. It is intended as a normative theory to guide the design of C2 systems; it is not a descriptive theory of C2. Despite its name, the DOODA loop has little in common with Boyd's original OODA loop, but retains the OODA part in its name because Boyd's loop was one of the points of departure for the work (Brehmer 2005). It differs from the OODA loop in that it incorporates a representation of the environment (or the military effects). This makes it possible to represent all important temporal relations, and it is evidence of the second parent of the DOODA loop: cybernetic models such as the dynamic decision loop (Brehmer 2005). Incorporating the effects in the loop constitutes a fundamental shift in focus from the traditional conception of C2 as inward looking and concerned with handling the force (as embodied in definitions of C2), to a conception of C2 as outward looking and being concerned with achieving effects (Brehmer 2006b). The second difference is that the DOODA loop provides a different, and I think richer, set of functions than the OODA loop.[8] Third, the DOODA loop is a description of the requisite functions of C2, not the processes involved in C2. In the OODA loop, the Observe, Orient, Decide, and Act components may be interpreted as functions or as processes, and this has led to considerable confusion when the OODA loop is used in discussions of C2.[9]

The DOODA loop is illustrated in Figure 2. In the DOODA concept, C2 is modelled as part of what may be called a mission system, or mission cycle, as is necessary to provide the context of C2 as a function in the military system and to close the loop, as well as for understanding what is demanded of the C2 function.

The DOODA loop as illustrated in Figure 2, is a mixture of functions and products. The C2 system is detailed in terms of three functions: sensemaking, data collection, and planning. The product of the C2 system is termed *orders*,[10] which is the form in which the requisite direction and coordination are manifested in military circumstances. The input to the C2 system is the mission (which may well be formulated the commander, but is usually given by a superior authority). The orders lead to some form of military activity (which may be yet another DOODA loop at a lower level until the level of movement and fire is reached), which is then "filtered" through the famous Clausewitzian frictions before produc-

8. It is, of course, not so easy to discuss the original OODA loop today, since the concept has undergone a variety of changes at the hands of a variety of authors so that the original concept designed to explain winning and losing aerial fighter combat has been all but lost. Boyd's own modification of his original loop is not very helpful either but a full explanation of Boyd's new concept would be a digression in this context. Suffice it to say that the modified concept is no longer a loop but a stage model.
9. Boyd is not to be blamed for this, for the original OODA loop was not designed as a model of C2.
10. The term *orders* should not be taken too literally. What is called orders may be of many different kinds and refers to whatever is used to influence the next stage. It may be a five-point, standard NATO order, or simply information passed on to the rest of the force.

ing their actual effects. The effects are then picked up by the sensors (some of which may be humans) under the direction of the data collection function.

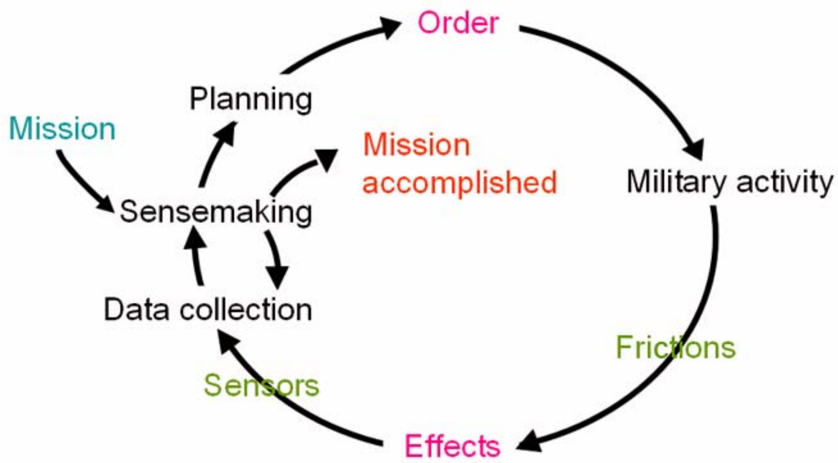

Figure 2. The Dynamic OODA loop (DOODA loop). Functions are given in black, products in red, and input in green.

The relations among functions in Figure 2 are logical relations. Causal and temporal relations belong at the level of process, not at the level of functions. Thus, the product of the sensemaking function, for example, is a precondition for planning, but it is not the cause of the plan, nor is it necessarily completely distinct temporally at the process level.

The three C2 functions in the DOODA concept

Current military models of C2, such as the U.S. Army Military Decision Making Process and its many relatives in other defense forces, model C2 as an integrated whole as indeed it is at the level of form. Each of these models is just one instantiation among many possibilities of how the purpose and functions of C2 can be fulfilled to a greater or lesser extent. To make any progress, we cannot take these models as our point of departure. Instead, we need to dissect C2 into its requisite functions and consider each function separately.

This becomes especially important when we want to realize the potential of new technology for C2. This technology may actually not do very much to improve C2 as it is *currently* performed. The introduction of computer technology in C2 systems is a case in point. If used only within the current C2 procedures, the benefits may be limited to what can be achieved by means of Microsoft Office! But there is no reason to limit the use of this new technology to support old ways of doing things, and there is certainly no dearth of evidence that new technology can lead to better and more effective ways of performing C2.

As mentioned above, our current theory of C2 specifies three different functions: *sensemaking*, *planning*, and *data collection*. These functions are meant to be descriptions at the highest level of abstraction, corresponding to the level of Abstract Functions in Rasmussen's (1985) scheme. At this level, no assumptions are made about the form or the processes that achieve these functions; everyone is free to introduce their favorite assumptions about the process.

Sensemaking

Sensemaking is the current buzz word in discussions of C2, having succeeded situational awareness (SA) as everybody's favorite concept.[11] As a consequence, sensemaking has come to acquire a variety of meanings but it seems now to be used most often with its everyday, commonsense meaning (with all the outdated philosophical baggage that this implies) rather than with its original technical

11. The concept of situational awareness tends to be a function in discussions of C2 as well, and the use of this concept and its current demise illustrates well the dangers of ignoring differences in levels of abstraction and confusing function and process.

meaning introduced by Weick (1995) as what people do in order to decide how to act in the situations they encounter. This has made the concept less useful than it could have been.

In the DOODA concept, we follow Weick (1995) and define sensemaking as the function that produces an understanding of the mission in terms of what needs to be done to accomplish it in the situation at hand.[12] The definition of the function at this level has no implications for modeling the nature of the process that achieves it. It only specifies the *product* that is needed for successful C2. The important thing in design is to break down the function so that it becomes possible to construct adequate form, that is, support, if needed. This form may, or may not, be based on how the function is fulfilled in existing systems (or "naturalistically" to employ the terminology introduced by Klein 1993). Most likely, it will be different from what is now seen as the natural way of doing things, for new technology will provide new possibilities for fulfilling it. At any rate, in the design process, the functions are normative concepts, and designing form will involve finding organizations, procedures, and methods for achieving useful sense quickly, not for supporting the current way of achieving sense (unless this is found the best of all ways to achieve sense).

Today's staff procedures provide examples of form for fulfilling the sensemaking function, and a first step in research and development of better C2 systems could be to assess the products produced by existing procedures and forms of organization. More important, however, may be to think about the new ways of doing sensemaking that become possible with the new forms of technology that are becoming available.

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12. Weick is not entirely clear with respect to the status of his sensemaking concept and whether he means sensemaking to signify a process or a function. The function interpretation seems to fit his actual use of the concept in most places, however.

The point of departure for our own work on sensemaking has been that sensemaking in military contexts is a collective activity, so it has social, organizational, and cognitive aspects, as indeed it has also in Weick's (1995) original formulation. As for the organizational aspects of sensemaking, Jensen (2007) has shown that the way the sensemaking work is organized in a command team has dramatic effects on the quality of the plans produced by these teams. Jensen also presents a first attempt at breaking down the abstract function of sensemaking into lower level functions. These results have important implications for the design of C2 procedures and organization.

As for the cognitive aspects of sensemaking, the principal alternatives are a bottom-up concept (as the popular data → information → understanding → knowledge chain implies, leading to the now popular conception that sensemaking = situational awareness + understanding) and a top-down concept (such as Klein's data frame theory [Klein et al. 2006] exemplifies). The fundamental problem here is, of course, the nature of the information available for the sensemaking process. If we believe that this information is basically meaningless (as in Endsley's [1994] conception where situational awareness is built from the primitive and basically meaningless data collected at the first level of SA into understanding by cognitive processing of these data to achieve level 2 and finally 3), meaning will have to be supplied by the commander and his staff to arrive at "sense" by some top-down process. If, on the other hand, useful information is available in what the data collection function provides, the problem instead becomes one of detecting and selecting this information. These alternatives have fundamentally different implications, both for understanding the nature of sensemaking and for designing support for this function. This problem, fundamental though it is, has not been solved, or even touched upon, in either of the two alternative approaches mentioned here. Most important, research on the cognitive aspects of sensemaking seems to have equated function and process too quickly, and little work has been directed at how sensemaking *should* or *could* be performed, compared to how it happens to be performed (see Klein et al. 2006 for a variety of examples of how sense is achieved).

In the DOODA concept, the product of the sensemaking function is a general understanding of the mission in terms of *what* should be done. *How* it is to be done is then a matter for the planning function, which transforms the product of the sensemaking function into orders. It is difficult to evaluate the quality of the methods and procedures currently used for sensemaking because existing staff procedures do not seem to require any designated sensemaking product. There is, however, a variety of products from the commander and his/her staff that may serve as indicators of the sense achieved. The most obvious is the Commander's Intent and its counterparts in other defense forces, but this product is not entirely discrete from planning products, and therefore is not as useful as it could be.

Current staff procedures with their focus on creating a plan seem to make the distinction between sensemaking and planning superfluous. Based on traditional military thinking, one could certainly make a case for considering the final plan as part of the sensemaking process (or product of the sensemaking function in DOODA terminology), and do away with the planning function, as do Alberts and Hayes (2007). The final plan is, of course, the most complete expression of the sense achieved by the commander and his/her staff. The reason why we do not take this route is, as noted above, that the final plan is a mixture of two things best kept apart: *what* should be done (the product of the sensemaking function) and *how* it should be done (the product of the planning function and expressed in the orders). However, just because this is the way C2 has been, and is, exercised does not mean that there are not alternatives. Received military wisdom, expressed by Moltke that "the plan never survives first contact with the enemy," suggests that alternatives to current practice should be sought. Our proposal, expressed in the DOODA concept, is based on a distinction between two products: the *what* and the *how*. Since these products are different, there are two functions in the DOODA concept. At the level of process, the two products may not be totally separate, of course, but that is a different matter, and a matter to be handled when constructing the requisite form of the system.

It does not seem unreasonable to assume that requiring a specified product relating to the sensemaking function would improve the quality of C2. It would presumably lead to a more disciplined, yet more creative, sensemaking process and provide a clearer input to the planning function. As noted above, today's products, such as the Commander's Intent, are often a mixture of what and how, and simultaneously working out the what and the how may unnecessarily constrain the creation of alternative "whats." Whether the distinction between the *what* and the *how* is indeed useful is a matter for empirical research.[13]

Current approaches to sensemaking tend to take a psychological view, and conceive of sense as something that is achieved by individuals and as a property of individuals. This, of course, fits very nicely with the current, centralized forms of C2 where the problem is that of supporting the individual commander's sensemaking process so that he or she can make the best possible decision. This is potentially a very limiting view. Sensemaking should not be seen only as an individual psychological process, but as a function to be achieved by the *military system*, that is, the force involved in a given mission, not only by the commander and his/her staff. Modern information technology allows the sense to be highly distributed and achieved locally, allowing local action on the basis of locally developed, yet shared, sense. Indeed, it is this possibility that promises new forms of coordination, such as self-synchronization. Our research with manned simulations, so-called microworlds, shows that self-synchronization is indeed possible, and that it may be more effective than traditional centralized forms of control under time pressure (e.g., Brehmer 1997). There is thus no longer any need to limit our understanding of C2 to that of one person giving direction and coordination on the basis of his or her sense. To work out the conditions under which self-synchronization is possible and effective is a challenge for future C2 research.

13. It is important to note that this distinction is central in planning for Effects Based Operations.

Planning

In the DOODA concept, planning is the function that transforms the overall understanding produced by the sensemaking function into orders. This means that this function has to accomplish a lot of work; an order may be a substantial document indeed. Most defense forces have elaborate procedures for producing orders. So far, we have not even started to study how a staff gets from a general understanding of what needs to be done (the "sense") to orders, and how that process can be supported (although there is certainly no lack of systems designed to support planning). It would, however, be a mistake to consider this a trivial matter. Even though military planning is a well regulated, almost ritual, process, it nevertheless has room for creative solutions, and much of what is to be done is specified only at the level of functions.

As noted above, there is wide spread recognition by the military that "no plan survives first contact with the enemy," as the elder Moltke put it. This suggests that we need a new approach to planning. The centralization ideology is one of the obstacles to creating "edge organizations"; new forms of planning are needed as discussed by Alberts and Hayes (2007).

Data collection

The data collection function provides the data required by the sensemaking function. It does that by controlling the sensors, including HUMINT, as well receiving various forms of reports from subordinates. This does not mean that the sensemaking function should have to ask for each and every datum that it needs when it needs it. The sensemaking function may well subscribe to data that are to be pushed to it if and when they are picked up by the data collection function. Nevertheless, the fundamental question here is the extent to which the data collection function should push a ready-made operational picture to the sensemaking function, or whether the sensemaking function should be in control of the data it gets. This is no easy matter. On the one hand, giving control to the sensemaking function is the most obvious way of avoiding information overload, while, on the other, pushing information to that function seems to be the best way of escaping the risk that important events are not detected. Striking the right balance here is the problem. It not obvious that there is a simple solution to this problem, and the best approach may well be a hybrid solution where the user exercises a high degree of control over what he or she receives, yet allows for urgent messages from the data collection function to be passed on to him or her.

The new service-based architectures that are now being implemented as part of the transformation of many defense forces suggests new possibilities for handling these problems. A service may be considered as the answer to a question that might be put from the sensemaking function to the data collection function. Coming up with a useful set of possible questions (i.e., services) that does not unduly limit the user is an important research task for C2 research.

Conclusion: The DOODA concept and other conceptions of C2

As the reader will note, the DOODA concept is another model in a long row of cybernetic models of C2, the most recent of which are the two, rather different models proposed in the two new books by Alberts and Hayes (2006; 2007). If it has any new value, it is thus not in the loop concept. That seems to be generally agreed to be the kind of concept that is needed to understand and model C2. What is new is that it seriously considers C2 systems as human artifacts, and that such systems (as well as C2 itself, which is shaped by the systems) need to be understood from the view of design logic and in terms of the functions to be achieved. In earlier discussions of C2, functions and processes have not been kept separate. As a consequence, functions, such as sensemaking, have been given process interpretations too early in the game. This has led to unnecessary worrying about how sensemaking is *really* done, rather than about how it *should be* done. In short, it has limited our thinking, and directed our work toward developing C2 systems that support a specific conception of how C2 is made, where normative issues (the functions) and descriptive issues (processes) are confused implicitly, or explicitly. As a consequence, much of our work has become a matter of supporting C2 as it is currently performed, rather than finding new and innovative ways to fulfill the functions of C2.

The functions that are part of the DOODA concept are, of course, only one set of possible candidates; others may well find a different set of functions more persuasive. Our conception of the sensemaking as concerned with the *what* and planning as concerned with the *how* is a case in point. Be that as it may, the important message here is not the DOODA set of functions as it is now worked out. The important message is that it is necessary to distinguish between function and process. Once we have made that distinction, we can escape from the dead hand of tradition and be free to think of new and innovative ways of doing C2 with the tools that the revolution in information technology is providing us.

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