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"Operationalizing C2 Agility"

How to Operationalize C2 Agility

Topic 1: Concepts, Theory, and Policy

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How to Operationalize C2 Agility

***Abstract**:* Alberts has offered a definition of agility and its constituent components. This paper describes where in the C2 system, or the force, the different agility requirements will have to be met, and how to measure if they are. The purpose of a C2 system is to achieve focus and convergence of some entities (the force) somewhere (the context) to accomplish something (the task or mission), together (maybe with other organizations), within a certain amount of time. These factors determine the demands on a C2 system. Rasmussen's abstraction hierarchy is used as the analytical framework, with the functions performed by C2 as defined by Brehmer. The paper discusses how to define the demands, i.e. the requisite agility, and how to assess if these demands can be met (potential agility), or have been met (manifest agility). The information requirements of a C2 system are determined by what is required of the commanded force for it to be agile in the present circumstances. The model traces the paths from the demands on the system to the parts of the system that are supposed to meet them, and makes possible the assessment of the manifest, and potential, agility of a C2 system.

Introduction

In his book "The Agility Advantage" from 2011, Alberts offers a definition of agility and its constituent components. He also discusses the necessity of being able to determine what agility various situations require, in the command and control (C2) system and in the force. Different situations demand different agility, in level as well as in kind.

Operationalization of concepts in science is a method to give the concepts definitions. An operational definition is a definition of a concept by the operations used to measure it (e.g., Christensen, 2007). According to Bridgman (1927), who introduced the principle of operational definition, concepts that cannot be given operational definitions are meaningless.

Alberts (2011) offers little guidance, however, as to what should be measured to operationally define the agility requirements to be met by a C2 system or a force. This is probably one reason for the theme of this year's conference is *Operationalizing C2 Agility*. This paper suggests such measures, and describes where in the C2 system, or the force, the different agility requirements will have to be met.

Agility

Agility has been defined as *the ability to successfully cope with changes in circumstances* (Alberts, 2011). Boyd´s (1987) Observe-Orient-Decide-Act (OODA) loop describes how this is

achieved. The changing circumstances are observed. You orient yourself, i.e., position yourself, to deal with it. You make a decision on how to proceed, and take action.

When the actions of several units need to be coordinated in order to successfully cope with the change in circumstances, C2 is required. The C2 system orients the units and decides on a course of action, which the units perform.

A living sentient being strives to adapt to its surroundings, which are always changing, more or less. With no adaptation there will be no survival. When changes in circumstances require frequent, fast and dramatic changes in a unit for it to continue functioning, the unit has to be agile. That is the situation the military and its C2 systems are presently facing (Alberts, 2011).

The definition of agility only mentions changes in circumstances, so the ability to cope with any change in circumstances, large or small, would count as agility. Requisite agility is a more useful term, since this is what is required to meet the demands of a specific situation.

There are many circumstances that may change. Alberts (2011) addresses this when he defines the six components of agility: responsiveness, versatility, flexibility, resilience, innovativeness, and adaptability. Responsiveness is the ability to react and act in a timely manner. Time pressure is perhaps not a circumstance in itself, but defined by other circumstances. Versatility is the ability to deal with significant changes in the nature of the mission or task. Flexibility is the ability to adapt the response to the situation if necessary. Resilience is the ability to withstand threats of destruction, interruption, or degradation. Innovativeness is the ability to invent a course of action in a situation where there is no known adequate response. Adaptability is the ability to perform tasks for which its established organization and processes are unfeasible.

The purpose of C2 is to achieve focus and convergence (Alberts, 2007), or direction and coordination (Brehmer, 2009), generally speaking. In the case of an actual existing C2 system, the purpose is to achieve focus and convergence of some entities (the force) somewhere (the context) to accomplish something (the task or mission), within a certain amount of time.

Today, the military is frequently involved in operations that are not carried out by the military alone, but by a number of organizations. There are, for example, medical organizations dealing with health issues, relief organizations that provide food and shelter, police that attempt to provide law and order, along with military units that provide a safe and secure environment in the operational theatre. The military is but one component among many, contributing to an overarching goal. Actions performed by the military need to be coordinated with the actions of the other actors who contribute to the mission goal. Hence, a C2 system has to interface with other relevant actors.

To summarize, the factors that determine the demands on a C2 system are: the task, the force, the context, other contributing actors, and the available time. This is also where circumstances may change.

C2 Agility and Force Agility

The demand for C2 arises when a goal cannot be obtained by only one, or a few, person(s). The task for C2 is to break down the goal into subgoals that may be assigned as tasks to be performed by different actors (commanded units) (Fig. 1).

When studying C2, it is important to analytically separate C2 from the activities performed by the force. The C2 system and the activity system (or the force) are separate systems, and should be treated as such. The quality of C2 cannot be assessed by the success of failure of a mission alone. A mission may be successful, despite weak C2, if the opponent's C2 is even weaker and/or if the force is resourceful (even if less then optimally used). Conversely, if the force lacks necessary resources, a mission will fail even with the most exquisite C2. Hence, both the C2 system and the force (the activity system) need to meet the requirements of the present circumstances, i.e., demonstrate agility, for a mission to be successful without unnecessary expenditure of resources (human or material).

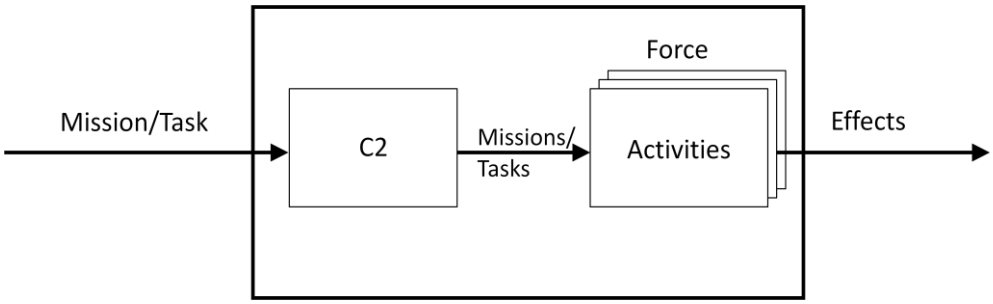

Figure 1. C2 assigns tasks to a force (a set of activity systems).

If the goal is vast, only *one* division into sub-goals may be insufficient. The sub-goals may need to be broken down further in order to be obtainable for the intended actors. This will require C2 at an additional level. This is how C2 hierarchies evolve. The subordinate level is always considered as consisting of activity systems from the perspective of the commanding level, even if these activity systems may contain their own C2 systems, i.e., the next level in the C2 hierarchy (Fig. 2). C2 hierarchies are thus hierarchically organized C2 systems.

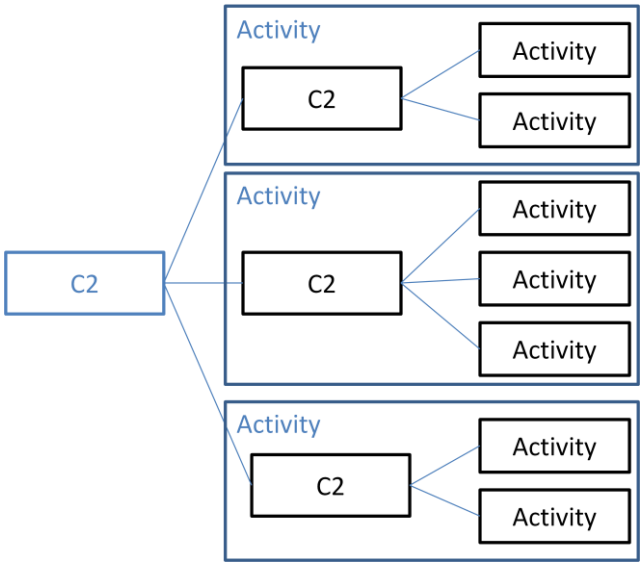

Figure 2. A C2 hierarchy.

The Study of Artifacts

Inspired by Simon (1996), Brehmer (2008) has argued that C2 systems are artifacts, and should be studied as such. An artifact is a tool that is constructed for a purpose, or a number of purposes in the case of a multi-purpose tool. To serve its purpose(s), the artifact has to fulfill functions that produce the results that are required to achieve the purpose. The functions are thus defined by their products. Artifact, or tool, in this context is to be understood in the widest possible sense. An artifact or tool can be a work procedure, or an organization, as well as some piece of technology (Simon, 1996). A C2 system does not only consist of the technical systems used for C2, but of the personnel and work procedures involved as well (Brehmer, 2006).

The functions may define what a system is expected to produce, in the case of a system requirements analysis, a normative analysis of what the system ought to do. A descriptive study of an existing system investigates what the system actually delivers. What functions does the system fulfill, and how well does it fulfill these functions, i.e., what does it produce?

What the system looks like (personnel and technical systems), and what actually does (work processes) is one specific form (among many possible) taken in order to fulfill the functions and achieve the system's purpose.

The analysis described in this paper only addresses one C2 system, or unit (one C2 box in Fig. 2), at one level of the hierarchy, at a time. When I write about a C2 system, I refer to one such C2 unit or entity.

Brehmer (2006) has presented this three-level (purpose, function, form) analysis of a system as the logic of design. It is a pedagogical simplification of the tenets of systems analysis, inspired by the Rasmussens (1985) five-level abstraction hierarchy (Brehmer, 2007).

Brehmers simplified three-level version will not suffice for the present analysis, we will have to use all the five levels of Rasmussens (1985) hierarchy. Rasmussen has not been totally consistent in his labeling of the levels in his abstraction hierarchy. Table 1 presents one version, taken from Rasmussen, Pejtersen, and Goodstein (1994), and illustrates how Brehmer's three levels are related to Rasmussen's five levels. Table 1 also lists the labels I use in this paper. I will introduce them as I proceed (see Naikar, Moylan and Hopcroft, 2005, for an introduction)

Brehmer	**Rasmussen**	**This Paper**
Purpose	Goals and constraints	Demands
Function	Priorities, Flow of values and products	Products
	General functions	Functions
Form	Work and equipment processes	Processes
	Material resources and configuration	Objects

Table 1. How Brehmer's (2006) logic of design relates to Rasmussen's abstraction hierarchy (Rasmussen, Pejtersen, & Goodstein, 1994), and the labels used in the present paper.

Alberts (2011) defines what he believes agility to be, and what abilities that are required for someone to be agile, the components. He also describes which the conditions, or circumstances, are that put demands on the different agility components. He does not come as far as to fully operationalizing them, however.

The requisite agility, i.e., the required responsiveness, versatility, flexibility, resilience, innovativeness, and adaptability, has to be defined and assigned measurable values. If not, it will not be possible to assess whether a C2 system meets the requirements. Nor will it be possible to test Alberts's model. By giving a concept an operational definition, i.e., defining how to measure it, a researcher clarifies what the concept means to him or her.

If we wish to be able to improve the performance of C2 systems, we have to be able to trace where in the system these performance values, or products, are produced. If not, we will not know where, or what, changes are needed.

Brehmer (2009) has discussed the need to incorporate the demands of the situation into a theoretical model of C2, and what factors ought to be included, but has yet to fully integrate this in his theoretical model. I am adding this aspect here, and I thereby introduce the top level of Rasmussen's (1985) hierarchy. Rasmussen calls this level "goals and constraints" (Rasmussen, Pejtersen, & Goodstein, 1994; Table 1). The goals correspond to Brehmer's (2009) purpose(s), direction and coordination (or focus and convergence). In a specific

situation there will be a mission or task (a goal) to be achieved by a specified force (a constraint), in some context (another constraint), within a limited amount of time (a third constraint), perhaps together with other actors (a possible fourth constraint). I call them factors that put *demands* on the system (Table 1; Fig. 3.)

The Functions to be Achieved by a C2 System

What does a C2 system need to achieve direction and coordination, or focus and convergence, in order to make a force accomplish a mission or task in some context, maybe together with some others? Brehmer (2007) suggests that there are three functions that a C2 system has to fulfill in order achieve its purpose. A C2 system must be able to collect the data needed (data collection), identify what needs to be done (sensemaking), and translate it into how this could be achieved with the available resources (planning). Other C2 theorists may suggest a different set of functions, but I will use Brehmer's set of functions because they serve my present purpose well.

As mentioned above, the functions are defined by their products, what they are supposed to deliver. Data collection produces data, sensemaking produces the required effect, the effects that are needed to accomplish the task in the context in question, and the output from planning is requests for action to those who are supposed to make it happen. The products, or values produced by the functions, is the second level in Rasmussen's hierarchy, and the functions the third (Table 1; Fig. 3) (Naikar, Hopcroft, & Moylan, 2005; Rasmussen, Pejtersen, & Goodstein, 1994). T.

I will now go on to describe how this relates to the components of agility suggested by Alberts (2011).

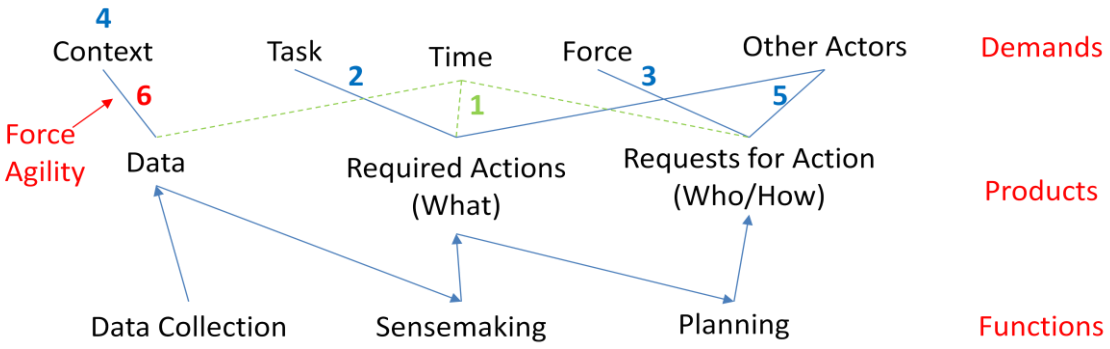

Figure 3. The functions of a C2 system, their products, and the factors that put demands on these products. The numbers refer to the components of C2 agility discussed below.

The Components of C2 Agility

1. *Responsiveness*

Responsiveness is the ability to meet the demands of time. The urgency to act differs from case to case. The so-called window of opportunity may be narrow, and a very fast response needed. In other situations it can be more important to do the right thing than to do it quickly. In every situation there is a time limit, implicit or explicit, more or less clearly defined, beyond which actions will be considered too late. Hence, there is a time budget. This time budget has to cover the time spent to collect data, to figure out what to do, to plan how to do it, and, very important, to perform the actions. The C2 system cannot allow itself to spend the time needed by the action system. The requisite responsiveness for a given C2 system is the time left for C2 when the force has been assigned their required share of the total time budget. This demand for C2 responsiveness can be divided further into time limits for data collection, sensemaking and planning (No 1 and the green broken line in Fig. 3).

2. *Versatility*

Versatility is the ability to deal with significant changes in the nature of the mission or task. I understand versatility in a C2 system as the ability to come up with solutions to the tasks it might be set (No 2 in Fig. 3). The requisite C2 versatility is defined by the range of tasks a C2 system is expected to be able to take on. It defines the expected products of the sensemaking function.

3. *Flexibility*

Flexibility is the ability to adapt the response to the situation if necessary. If versatility is the ability to think of possible solutions, I view flexibility as the ability to actually implement them. The ability to be flexible therefore depends on the force. What the C2 can ask of the force depends on what the force is able to do. C2 flexibility is the ability to think of different ways to use the available force (No 3 in Fig. 3). The requisite C2 flexibility is the range of uses of the force the C2 system needs to be able to think of (which is limited by the Force flexibility, see next paper section below). It defines the expected products of the planning function.

4. *Resilience*

Resilience is the ability to withstand threats of destruction, interruption, or degradation. What is required of a C2 system to be resilient depends on the context (No 4 in Fig. 3). Where is the C2 system supposed to function? What are the expected threats to communication, security, and the running and maintenance of equipment? This will determine the requisite C2 resilience. C2 resilience is a precondition for all the functions. If

the C2 fulfills all the functions satisfactory, in the situation, it is resilient enough. The request for resilience is, in a way, a duplication of requirements.

5. *Coordination (suggested addition)*

By now we have covered the circumstances that have to do with the time, the task, the force, but we have yet to address the other actors that might be involved. (The context will be addressed shortly.) The ability to coordinate activities with other actors is not one of the components of agility suggested by Alberts (2011), but I think it needs to be added to fully cover what is required to be agile. It is not that Alberts neglects this aspect, but he has not made it an explicit component of agility. Other actors may ask the military to do something that they deem necessary but cannot do themselves, or that would facilitate their own work. This would then add to the required actions, and add to the demands on the products of the sensemaking function. It could also be the case that the C2 system identifies required actions that are not military actions, or that the considered military actions would be facilitated if some other actor behaved in a certain way. The C2 system may then send a request for action to another actor. This would add to the demands on the planning function. The exchanges that are needed will determine the requisite C2 coordination (No 5 in Fig. 4).

6. *Information (suggested addition)*

The C2 system needs data that allows it to enable the force to perform as agile as possible. The data collection function therefore needs to collect data on contextual factors that affect the force's agility (discussed below in the next paper section) (No. 6 in Fig. 3). This includes both the collection of new raw data and the mining of already available data for the required information. For a complete assessment of the agility of a C2 system, the ability to collect the requisite information has to be one of the agility components. It defines the expected products of the data collection function. What information is required will be discussed in the following sections.

The two remaining agility components, innovativeness and adaptability, do not fit into to the picture just yet. I will return to them later. First we will look at the agility of the force.

The Functions to be Achieved by a Force

A force is supposed to bring about some effects in some environment. These effects are the force's main product, and in order to produce effects the force has to be able to move, perform some military activity and, perhaps, coordinate with others (its major functions). To be able to continue producing effects, the force has to ascertain its survival (a kind of secondary product). It has to be able to protect and sustain itself (the force´s secondary functions) (Fig. 4).

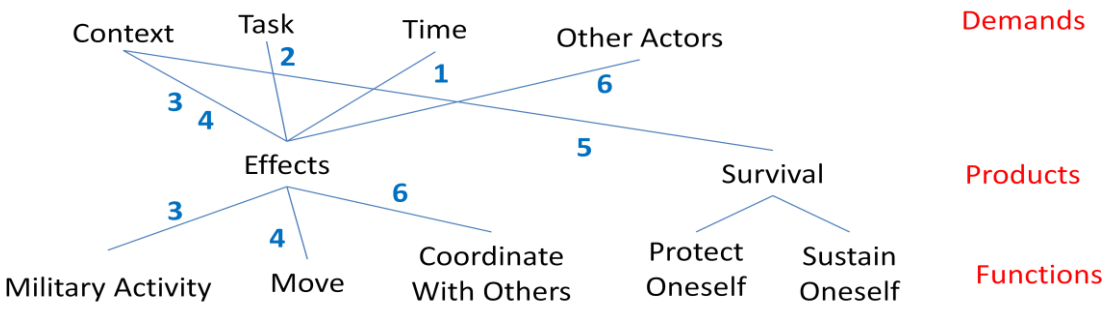

Figure 4. The functions of a force, their products, and the factors that put demands on these products. The numbers refer to the components of force agility discussed below.

The task for the sensemaking function is to figure out what effects are needed to accomplish the task in the context in question. The task for the planning function is to figure out how this is best achieved with the available force. As mentioned above, this is akin to enabling the force to be as agile as possible. The task for the data collection function is to provide the data required by the sensemaking and planning functions. The data collection function of the C2 system therefore has to collect information on all the factors in the context that affects the force's agility.

The Components of Force Agility

1. *Responsiveness*

Responsiveness is the ability to meet the demands of time. When it comes to the force, it does not have to consider anybody else's time budget. The requisite force responsiveness is how fast the force has to be able to deliver military action (No 1 in Fig. 4). The task for C2 is, as mentioned earlier, to estimate how much time the force will need and see to that they are given at least that much time. How much time this will be depends on the other factors.

2. *Versatility*

Versatility is the ability to deal with significant changes in the nature of the mission or task. I interpret versatility in the force as the range of military activities the force is able to carry out, and as the force's ability to think for themselves (No 2 in Fig. 4). It is a task for C2 to be aware of the versatility of the force and avoid assigning the force tasks that require more versatility than that. What activity is called for? Is it possible to leave to the force to decide on what actions to perform, or is the situation so sensitive the force needs to follow detailed instructions to the letter? The latter would necessitate a restriction on the permitted versatility in the force.

3. *Flexibility*

Flexibility is the ability to adapt the response to the situation if necessary. If versatility is the ability to think of possible solutions, flexibility is the ability to actually implement them. I interpret force flexibility as the force's ability to perform its actions in a wide range of contexts (No 3 in Fig. 4). The requisite force flexibility will be determined by the range of contexts that the force is expected to act in. C2 has to consider if the force is adequately equipped, and trained, to perform their tasks in the contexts they are put.

4. *Mobility (suggested addition)*

The force does not only have to take action, however. It also has to do it at the appropriate location, at the proper time, to bring about the desired effects. Mobility is, hence, of some importance to the force. The requisite mobility of the force is determined by the territory they have to traverse, and place themselves in, to be able to effectively perform their actions (No 4 Fig. 4). C2 has to consider if the force has the mobility required to perform their tasks.

5. *Resilience*

Resilience is the ability to withstand threats of destruction, interruption, or degradation. For the force, to be resilient is to survive. The equipment has to keep on working, and the soldiers have to remain healthy and unhurt. The requisite force resilience depends on what kinds of threats the force is expected to be able to endure (No 5 in Fig. 4). The requisite force resilience is determined by the context in which the force is put. C2 has to consider how the force can be sheltered, kept healthy, fed and rested, and provided with equipment, fuel and ammunition. C2 also has to consider how well these requirements are met, and can be met in the future, when it assigns tasks to the force.

6. *Coordination*

Coordination with other actors is not a C2 issue alone. The force itself might need to be able to sort out how things are best done in-place with other participating actors. The requisite force coordination is the extent to which such exchanges are needed (No 6 in Fig. 4). C2 has to consider what these requirements are and if, and how, the force will be able to meet them.

Requisite C2 information is thus what the C2 system has to know to be able to ensure the agility of the force. What data the data collection function needs to gather about the context depends on what the C2 system already knows, and what data, or information, it requires to be able to draw appropriate conclusions.

Requisite Agility, Potential Agility and Manifest Agility

So far I have only discussed requisite agility, what requirement to define in order to enable assessment of C2 systems, and forces. I have also described how I believe they relate to the functions a C2 system, and a force, need to fulfill to create the necessary products.

The *requisite agility* is a system requirements specification. It says nothing of any existing system, it only defines what the minimum requirements are if a system is to function properly in the envisioned situation. These are the criteria the existing or proposed systems are to be assessed against. Do the systems meet these demands?

Actual C2 systems, existing or envisioned, are made of people, technology (support systems), and work procedures (Brehmer, 2006). Brehmer (2006) calls this the system's form (Table 1). The people hold different roles when they collectively perform the work processes, the work processes are organized. The people acting in their roles, with the support systems, perform various processes to fulfill the functions. Rasmussen separates material resources, including people (the fifth level of the hierarchy), and the processes performed with and by these objects (the fourth level of the hierarchy) (Table 1; Fig. 5) (Naikar, Hopcroft, & Moylan, 2005; Rasmussen, Pejtersen, & Goodstein, 1994). I call the roles and support systems objects for lack of a better word (Table 1; Figure 5) In Figure 5, I have lumped together processes that perform the data collection, sensemaking and planning functions because this is how it mostly is. C2 guidelines (e.g., NATO, 2010; U.S. Army, 2003, 2010) generally cover the entire C2 process, and do not address the individual functions separately. Whether that is good, or if would be better to keep the processes that fulfill the different functions separate, I cannot tell. I do not know that it has ever been investigated.

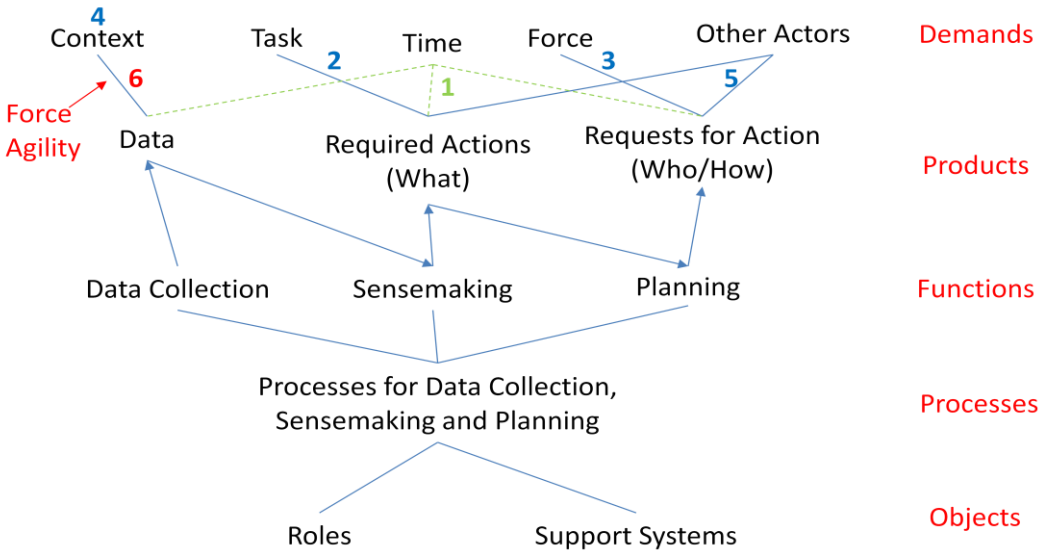

Figure 5. People act in roles performing C2 processes assisted by support systems to fulfill the C2 functions. Do the manifest products meet the requirements?

Manifest C2 agility is the capability demonstrated by an existing C2 system. *Manifest C2 responsiveness* (No 1 in Fig. 5) is the time elapsed, from when something happens that calls for a behavior change, until a new course of action has been selected and transformed into requests for actions (missions or tasks for the subordinates). *Manifest C2 versatility* (No 2 in Fig. 5) is the range of missions or tasks that the C2 system has successfully dealt with. *Manifest C2 flexibility* (No 3 in Fig. 5) is the range of different uses the C2 system has made of the force. *Manifest C2 resilience* (No 4 in Fig. 5) corresponds to the destructions, interruptions, and degradations that the C2 system has been able to withstand. *Manifest C2 coordination* (No 5 in Fig. 5) is the communication, with other actors that has taken place in order to ask for, and offer each other, assistance, that has actually resulted in coordinated activities. *Manifest C2 information* (No 6 in Fig. 5) is the knowledge present in the C2 system about all the factors that affect the agility of the force.

So, manifest C2 agility is the agility actually demonstrated by a C2 system. If a C2 system's manifest agility meets or surpasses the requisite agility, it should be considered successful. If, on the other hand, it does not have requisite agility, any success will be somewhat a question of luck. Whatever the performance of a C2 system, it gives only a hint of its true potential.

Potential C2 agility can be assessed by studying the requirements for the role holders, the support systems and the manuals contributions to them, and the prescribed processes, such as planning directives. What C2 agility (responsiveness, versatility, flexibility, resilience, coordination and information) could be expected from such a C2 system, when commanding a specified force? If the potential C2 agility fails to meet the requisite C2 agility, there is little hope that the manifest C2 agility will ever meet the requirements.

I have excluded two of Alberts's (2011) components of agility: innovativeness and adaptability. Innovativeness is the ability to invent a course of action in a situation where there is no known adequate response. Only people have the capacity for original thought as compared to routine application of rules and principles. In the system, it is the role holders who can be innovative or creative. If the role holders are creative, they will be able to think of solutions to the missions or tasks they will be given, and to think of different ways to use the available force. These requirements are, however, already covered by the demands for versatility and flexibility.

Adaptability is the ability to perform tasks for which the established organization and processes are unfeasible. I interpret adaptability as the ability to do things the system was not designed for (covered by versatility and flexibility). This appears to be another request for creativity in the personnel.

Conclusions

The analysis presented in this paper has resulted in a slightly different set of components of C2 agility than those suggested by Alberts (2011). I have proposed a model of C2 agility, where C2 agility consists of C2 responsiveness, C2 versatility, C2 flexibility, C2 resilience, C2 coordination and C2 information. I have described what factors make demands on the different aspects of C2 agility, and what is required to assess these demands, i.e., the requisite agility.

The information requirements of the C2 systems are determined by what is required of the commanded force for it to be agile in the present circumstances. My analysis has revealed that force agility consists of force responsiveness, force versatility, force flexibility, force mobility, force resilience, and force coordination. When circumstances are uncertain, it put demands on all the aspects of agility. When you do not know what will happen, you have better be prepared for anything.

Rasmussen's framework (Rasmussen, 1985; Rasmussen, Pejtersen, & Goodstein, 1994) enables us to make models that are ideal for tracing the path from the demands put on a system to the parts of the system that are supposed to meet them. To achieve this, I have expanded on Brehmer's (2007) theoretical model of C2 to cover all the five levels of Rasmussen's abstraction hierarchy (Table 1; Fig. 5). This kind of model makes possible the assessment of the manifest, and potential, agility of a C2 system, although such assessments would probably require more fine-grained models. Even so, the model presented here suggests what principles to adhere to when operationalizing agility.

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