Assessing and Recommending C2 structures Based on a Network Centric Component Model

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Abstract

The complexity of command and control (C2) and C2 as a prerequisite for effective operations requires that C2 assessments must receive considerable attention. In this paper a candidate methodology for assessing C2 structures is proposed.

The proposed methodology utilizes a Network Centric Component Model (NCCM) where components of a military structure are linked together by a common information infrastructure. This gives the opportunity for addressing analysis of C2 and analysis of force structures by use of the same methodological framework.

In the methodology there should be much emphasis on establishing a profile for the factors characterizing the structure which are to be used in a possibly wide variety of operations. By applying C2 components (decision components and information infrastructure) in different structural alternatives (command structures), it is possible to evaluate and compare these alternatives by the use of the procedure described in this paper.

It is emphasized that the assessments will have to be based on an extensive interaction between analysts and military expertise. The methodology is described in terms of an iterative process where refinement and derivations are made continuously, but with different focus areas, as a function of time.

Introduction

Force planning and planning for C2 structures have traditionally been addressed by developing requirements which the structure shall fulfill. The methodology presented in this paper is not focused towards the development of requirements in a traditional sense, it is first of all a methodology that is focused towards comparing alternatives (solutions) against a set of factors. The development of these alternatives and factors, such as speed, robustness and interoperability, involves military expertise. The comparison implies finding the best match between alternatives and factors. An important aspect of the methodology is the continuous refinement of alternatives in an iterative process, involving both analysts and military expertise, until a satisfactory structure is obtained[1].

[1] It is recognized that the methodology does not pretend to develop the best possible solution (ideal solution), but focus is on developing a solution that is satisfactory considering the different alternatives. This is a more realistic ambition than trying to develop the optimal solution, which fails to be optimal with the first small changes in internal and external conditions (e.g. technology, systems and scenarios).

The methodology presented in this paper draws on earlier work carried out at the Norwegian Defence Research Establishment (FFI) in the project "Battlespace Digitisation" (SLADI)[2]. In this project, FFI and Teleplan worked together and developed the foundation for the methodology presented in this paper.

Network Centric Component Model and C2 factors

Central in the methodology is the use of a Network Centric Component Model (NCCM) which has been applied by the Norwegian defense in a recent study[3]. NCCM does not view the force structure in terms of traditional units, but is based on components that contribute to different parts of the military "value chain". This makes it possible to address the tasks of a military structure in a holistic way. The NCCM consists of the sensor component, the decision component and the effector component, which corresponds to observe, orient and decide, and act, respectively (OODA-cycle). An essential part is also the information infrastructure (INI), which delivers connectivity and distribution capacity. The NCCM is schematically shown in Figure 1, while Figure 2 shows the NCCM in relation to the OODA-loop.

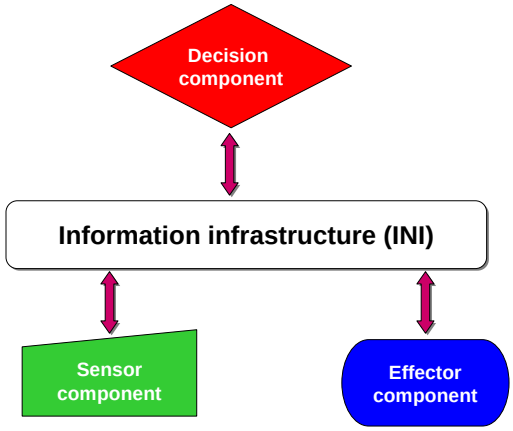


Figure 1 - Network Centric Component Model (NCCM)

The NCCM makes it possible to look at military structures independent of hierarchy, levels, services and ownership of resources.

The Sensor Component (SC) represents the resources supporting the initial O (observe) in the OODA-loop. The SC includes all resources capable of providing the organization with information, ranging from basic intelligence to target acquisition. This comprises every possible source from dedicated sensor systems to individual elements (systems and personnel) that does not have observation as their primary role.

The Decision Component (DC) represents the will of the commander and the ability to plan, analyze situations and make decisions. It is possible to divide the decision component further,

[2] Enemo Geir, Final Report FFI-Project 807 Battlespace Digitisation (2004) (In Norwegian)

[3] Defence Staff Norway, Norwegian Network Enabled Warfare Concept (2002) (In Norwegian)

for instance so that it consists of a decision support component and a liaison component in addition to a (redefined) decision component.

The role of the Effector Component (EC) will typically be covered by the major part of the military structure and is represented by resources whose primarily role is to carry out combat operations, combat service support and logistics.

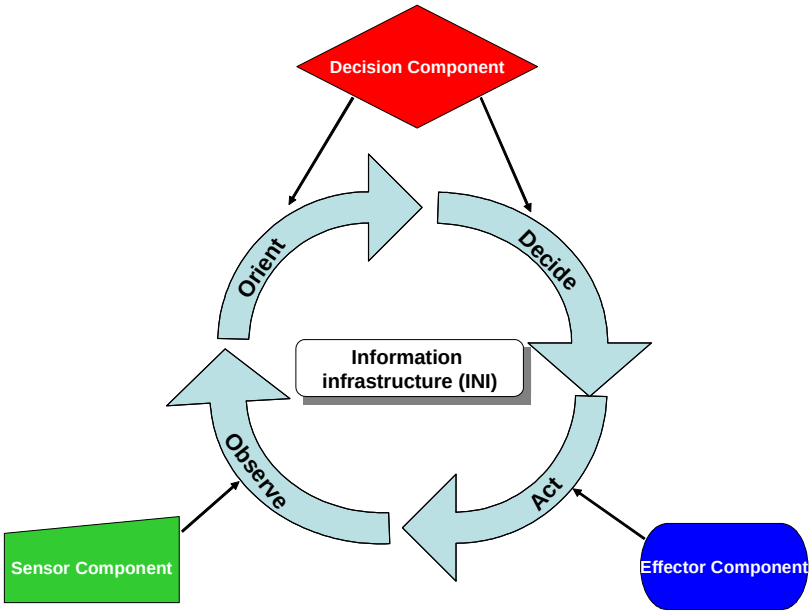


Figure 2 - Network Component Model in relation to OODA-loop

The Information Infrastructure (INI) delivers connectivity and distribution capacity for the exchange of data and information. The INI consists first of all of equipment (communications equipment, computers, physical networks, etc.), network standards and transmission codes (that allow linking of networks, secure information exchange and network security and reliability) and personnel that build and facilitate the INI and train others to utilize the potential of the INI.

The NCCM might be applied at all levels of a force structure and its application is recursive. This means that looking down the hierarchy into a given component one can apply the model to describe the internal decomposed logic within that component. Applied to a hierarchical organization this will cause a resulting tree structure. The tree structure describes primarily responsibility and authority relationships, i.e. the aspects of a command structure. For instance, a unit or platform primarily utilized in the role as effector on the operational level, will at a tactical level usually consist of all four basic elements (decision-, sensor-, effector-component, and its part of the common information infrastructure) from the NCCM. Such decomposition will continue until it reaches the bottom level as single systems or individual. In this way the organization will appear as a network with cross connections (INI) between all components, but with an overlaid tree structure of some sort (as today a traditional hierarchical structure).

Now, having a generic description of the different components in the force structure, and in the context of analyzing C2, our next step is to characterize the decision component, because our

goal is to analyze different structures and make the choice of which is the best suited. Our experience is that this characterization is best done by the use of properties or, as we call it, C2 factors. The set of factors is not given a priori, but must be based on military expertise and experience. They have to be relevant and *linked* to prioritized capabilities of the force structure as such. Political guidance and overarching prioritizations form the basis for the development of factors. Examples of such factors are robustness, interoperability, speed and strategic deployability.

These factors should be common for all components in the structure, but there may be a need for developing additional component specific factors, such as for instance *Decision effectiveness* for the decision component, determined by the ability to effective decision making. Decision effectiveness should be determined by the ability to establish a relevant situation picture (including dedicated tools supporting presentation, analysis and simulations), the knowledge, experience and culture for decision makers and staff personnel (sub factors).

The development of a representative set of factors (including specific C2 factors) has to be process oriented. It is important to create ownership to the factors among those involved in the various assessments. The goal of such a process is to achieve a common understanding of the factors and ensure that the set of factors is relevant. Experience gained from such work for the Norwegian Armed Forces is that knowledge of command and control in general and familiarity with the terminology within the C2 area, are prerequisites for a successful process.

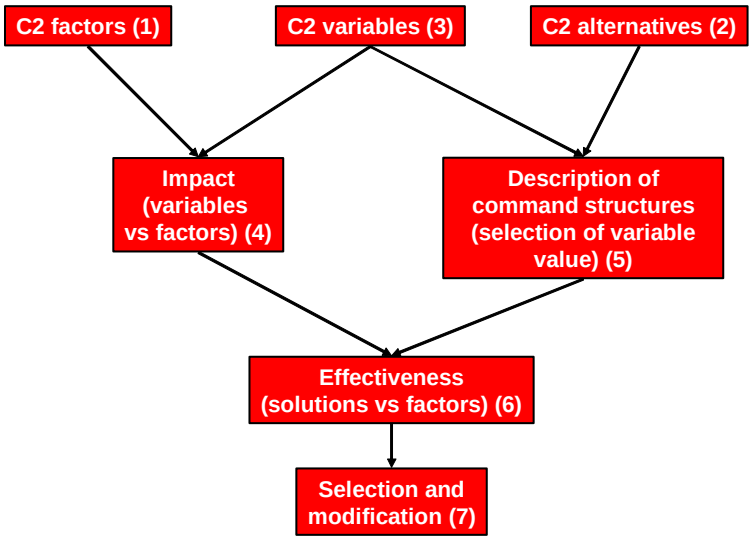
Having determined the factors, there is a need for establishing a profile for the factors. This may be done by assessing one specific scenario, but may also be done assessing a set of scenarios by weighting importance and prioritizations.

The term *factor* might in some cases be compared to and used in the same context as the more common military term capability. Still, our understanding is that use of the term *factor* represents a more generic term which in principles could be used to characterize an organization independent of time. While capability might be related to what a component or an organization can do, the *factors* define characteristics of the organization that must be met in order to obtain such a capability. Examples of *factors* in this context are *Speed* and *Interoperability*. In some cases and for some factors there will be a one-to-one correspondence between factors and capabilities, in other cases and for other factors there is not. Our experience is that the use of factors as outlined above brings a considerable degree of flexibility into the analytical process, especially with regards to what characterizes organizations and force structures.

A set of factors (as used in this context) would be valid independent of time. What is changing is the factor profile in terms of which factors are more important than others. Today, one might say that interoperability is more important than others. The reason is a stronger demand of cooperation between services (jointness), nations and military and civilian organizations.

Overview over the methodology

The basic principle of the methodology is to design alternative C2 structures followed by an analysis of the alternatives to find the best (most effective) with respect to a set of factors. Further development of the alternatives is done by conducting new iterations. The activities presented in Figure 3, might be executed in several iterations depending on complexity and the need for accuracy.



Design and Analysis Process.
Repeat as many times as appropriate

Figure 3 – A graphic presentation of the methodology.

The first activity in the methodology is to identify a set of *C2 factors (1)*. The alternative C2 structures will be evaluated on the basis of these factors. To generate a representative set of factors this activity has to be done in close cooperation with military C2 competence and experience. Examples of C2 factors are speed, robustness and interoperability.

The activity *Generate C2 Alternatives (2)* is executed together with military expertise. This activity is to sketch two or three alternatives one wish to analyze. One default alternative is usually the existing C2 structure. The activity should focus on relevant guidance and constraints.

The *Variables (3)* are used as a framework to express the alternative C2 structures. Examples of variables could be the technological level of the information infrastructure, the level of training for commanders and staff, the number of levels in the chain of command, protective measures (e.g. armour) etc. These variables reflect how HQs, command posts and command structures are expressed in more traditional military terms. The variables must be described and their possible values must be made specific.

Impact (4) is to be assessed for all different variables against the factors, e.g. it is reason to believe that a high technology information infrastructure impact the C2 factor speed more positively than a low technology information infrastructure. In some cases these assessments has to be done based on assumptions. In other cases the analysis could be supplemented by R&D or Concept Development and Experimentation (CD&E) activities (experiments, simulations etc.) to verify the hypothesis on which the assessment is done.

The *Description of command structures (5)* expresses the alternatives in terms of for instance technology levels (high/medium/low), number of command levels etc.

Effectiveness (6) for one alternative is obtained by assessing the variables describing this alternative and its impact on the factors. Different alternatives can then be compared with respect to how well they fit into the set of factors.

It is important that the methodology is iterative and the tasks described above should be repeated at least one time. Another approach is to go through several cycles, where each cycle focuses on just one specific task, the other tasks only covered briefly.

Thus, the importance of the methodology is to continuously review the set of factors, the variables and the alternatives, to see whether adjustments should be made. A refinement of one or more alternatives is usually the result of such a step, and these alternatives should then be assessed in the next revision (cycle).

An example of how the assessment of a variable's value is scored up against a sample of C2 factors is presented in Table 1.

Variables		***Factors***			
	Value of variables	***Speed***	***Interoperability***	***Flexibility***	***More C2 factors***
Status of SOP in HQ					
	Incomplete	**L**	**NA**	**NA**	Assessments
	Worked through but only partly followed	**M**	**NA**	**NA**	Assessments
	Suitable and implemented	**H**	**NA**	**NA**	Assessments
Degree of standardized processes					
	SOP based on national procedures unlike NATO standards	**NA**	**L**	**NA**	Assessments
	SOP partly based on NATO standard	**NA**	**M**	**NA**	Assessments
	SOP according to NATO standard	**NA**	**H**	**NA**	Assessments
Staff organisation					
	Organised in a national specific way not conform with J/G/S structure	**NA**	**L**	**NA**	Assessments
	Organised as J/G/S structure	**NA**	**H**	**NA**	Assessments
Training standard, staff					
	Medium	**M**	**NA**	**M**	Assessments
	High (conducted several excersises)	**H**	**NA**	**H**	Assessments
Strategic manoeuvre of HQs					
	Can be transported by plane (e.g C 130)	**NA**	**NA**	**H**	Assessments
	Must be transported by sea or land	**NA**	**NA**	**L**	Assessments
Decision support SW applications					
	Simple applications to produce situation picture, no simulation/decision support	**L**	**H**	**L**	Assessments
	Advanced applications both for producing situation picture and simulations/decision support	**H**	**L**	**H**	Assessments
Communications					
	Mainly based on voice, not able to receive and send data formats, old technology with limited bandwidth used for connection to tactical network, no SATCOM terminal	**L**	**H**	**L**	Assessments
	Modern technology communications, sufficient bandwidth, mainly based on data exchange, several SATCOM terminals	**H**	**L**	**H**	Assessments
Information exchange standards					
	The Command facilities have information systems delivering information on formats according to NATO standard	**M**	**H**	**NA**	Assessments
	The Command facilities have information systems delivering information on formats not according to NATO standard	**L**	**L**	**NA**	Assessments
More variables					
	More values	Assessments	Assessments	Assessments	Assessments
	More values	Assessments	Assessments	Assessments	Assessments

Table 1 – An example of a framework where values of a variable is scored versus a sample of C2 factors

The variable's value, e.g. staff organization according to a J/G/S structure, is assessed against the C2 factor *Interoperability* and given a score H which stands for high positive impact. The L and the M stand for low and medium impact, respectively, and the NA stands for Not Applicable and is considered in cases where one could argue that the impact of the variable can be neglected.

The next step will be to convert the impact score into numbers. The choice of scale has to be considered dependent of the complexity of the established framework. In Table 2 it is indicated a scale using 2 (low), 5 (medium) and 8 (high).

Variables		Factors		
	Value of variables	Speed	Interoperability	Flexibility
Status of SOP in HQ				
	Worked through but only partly follow ed	5	NA	NA
Degree of standardized processes				
	SOP according to NATO standard	NA	8	NA
Staff organisation				
	Organised as J/G/S structure	NA	8	NA
Training standard, staff				
	Medium	5	NA	5
Strategic manoeuvre of HQs				
	Can be transported by plane (e.g C 130)	NA	NA	8
Decision support SW applications				
	Advanced applications both for producing situation picture and simulations/decision support	8	2	8
Communications				
	Modern technology communications, sufficient bandw idth, mainly based on data exchange, several SAT COM terminals	8	2	8
Information exchange standards				
	The Command facilities have information systems delivering information on formats not according to NATO standard	2	2	NA
Command structure solution # 1 - C2 factor profile		**5,6**	**4,4**	**7,25**

Table 2 – Converting the scores into numbers, taking the average of the scores of each C2 factor and generating the C2 factor profile of the alternative Command structure

In Table 2 it is also indicated how a C2 factor profile of an alternative solution is generated. The scores of the profile are the average of the scores of the chosen variables for the specific alternative (solution) against the C2 factors.

The C2 factor profile might be presented as shown in Figure 4.

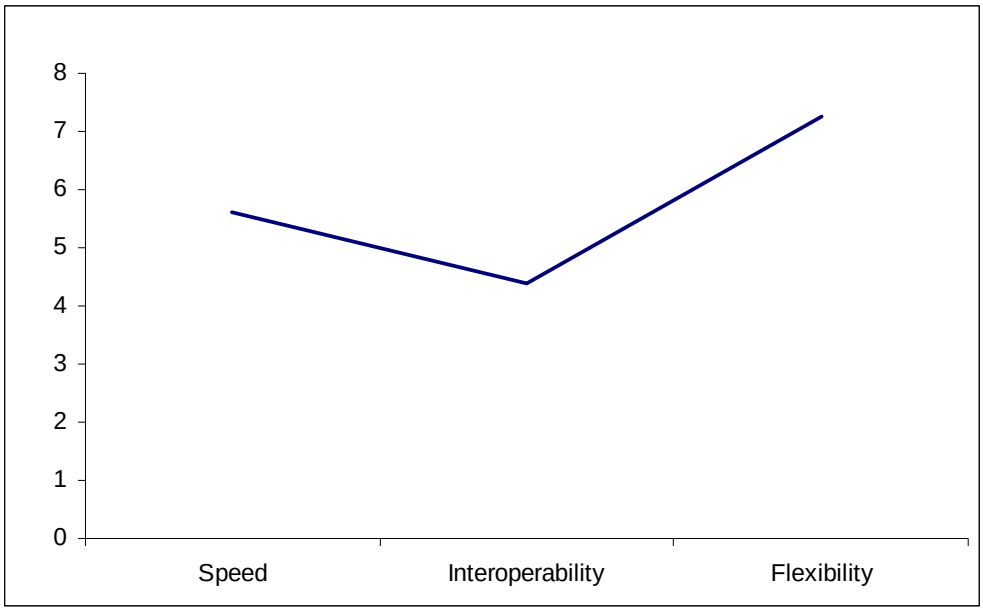


Figure 4 – C2 factor profile for an actual command structure

Discussion

The core of our approach to the analysis is based on the use of factors and characteristics, not necessary related to threats as such. The expansion of types of missions which military forces must be able to carry out makes it difficult to identify precise design criteria. Thus, this will increase the necessity to find more generic ways to measure military effectiveness on a higher

level. This argument might be seen similar to the discussion about maneuver warfare versus attrition warfare. The change in focus from quantity to quality in the development of military forces emphasizes this aspect. Qualitative assessments based on military judgment and experience together with statistics from real operations and exercises should play an important and explicit role in such complex analytical challenges.

A critical success factor for using the methodology is thus the involvement from senior military personnel and that the framework in the form of the component model and C2 factors is discussed and accepted in the relevant military and analytical communities.

A challenge in the proposed methodology is the choice of variables and their degree of detail. As presented here, all the variables will be given the same importance with respect to each other. However, this can be handled by weighting the different variables.

Choosing the value of a variable (for examples, see Table 1) is based on the initial sketching of the alternative command structures. Using this basis to choose values of the variables enforce the need to look at the values in relation to each other, e.g. it is difficult to believe that a flat command structure is consistent with a culture that emphasize detailed control measures.

The importance of the C2 factors will vary with respect to the scenario a force will operate in, e.g. multinational interoperability will not be very important in national operations. This means that a command structure fit for one type of operations, not necessarily is relevant for another. To deal with this, each mission type or scenario has to be analyzed with respect to the importance of the C2 factors. Most nations will have to use their command structure in several situations. Thus, the overarching results of an analysis will have to be a compromise between the demands of the variations in scenarios or types of missions. Different applications supporting analytical hierarchic processes could be useful in this respect.

The use of the NCCM is first of all justified in cases where it is necessary to highlight the interaction between the actors in a force structure. Looking at C2 as a phenomenon it could be easy to accept the importance of this aspect. However, the NCCM could also be used to describe a force structure as a whole. Our experience in this area is that the NCCM extend the views of officers in assessing how a specific task is to be executed across traditional organizational borders such as, for instance, services or levels of command.