Network Centric Operations:
Implications for Allied and Coalition Operations

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1.   Abstract

Network Centric Warfare (NCW) or perhaps a better term would be Network Centric Operations (NCO) is rapidly becoming one of the areas where the most likely progress in efficiency and effectiveness of military operations will take place. The benefits of information technology and specifically network technology in the civil business area is starting to make itself feel in the military domain too.
In the US a lot of attention is given to NCW to start adapting US forces to the ideas of NCO. However, little is still known about how to achieve coalition-based NCO. This paper will go into some detail in discussing issues involved in Coalition-based NCO or CNCO as we will call it. After a short summary of the main issues of NCO we will try to identify some of the most important key factors involved in CNCO and discuss some of these items. Special attention will be given to concepts of interoperability. A migration path based upon the here proposed methodological approach is suggested as a means to achieve CNCO.

2.   Introduction

The three basic elements of Network Centric Operations (NCO) are Information, Communications and Operations. NCO is the optimal use of information, made available by sufficient secure communications to plan and execute fast, timely and decisive operations against opposing forces or in non warfare situations (like humanitarian actions). For a discussion on some of the terminology on NCW see [Alberts et al, 1999].
NCO is the synthesised combination of these three basic elements and not just an addition of them. The combination of these factors leads to some specific areas where network centric operations have their main impact:

A. Shared situation awareness and understanding.
B. Enhanced capability for co-operative and co-ordinated planning and engagement.
C. Vertical and horizontal consultation and information capabilities.
D. Enhanced means of rapid intelligence gathering.

List 1 Main Areas of NCO improvements

The developments we expect to take place in the military domain are the same we see already occurring for some time in the civil and commercial domain. There we encounter a rapid adoption of open standards, systems and components, information becomes vastly available by means of the internet, complete company processes become net-oriented, and the rapid availability of information is speeding up business processes significantly. Completely new services come into being because of the existence of network or web technology.

In the military domain equivalent developments are likely to take place. Much effort is already put into the realisation of concepts like advanced sensor netting above, at and under water, in the optimisation of the sensor-to-shooter pipeline, in VTC facilities (video teleconferencing), and in speeding up the C2 cycle with unfortunately still poorly defined concepts like self-synchronisation. The evolution towards NCO is not a simple and evident process. There exist some real problem areas which need to be studied carefully before being able to solve some of the major difficulties involved with NCO.

Some of these problem areas are:
- the very dependence on systems integration levels and levels of interoperability;
- the consequences of the secure aspects of information;
- the dangers of information overload situations;
- backseat driving (military as well as political) because of the ease to skip several levels of command;
- the need to develop appropriate concepts of operations and doctrines;
- the fact that many of the frequently used concepts are still merely words and still poorly understood.

Another major issue is that NCO is currently a predominant US matter. Other nations lag behind or do not (yet) have the means to invest as heavily in the network centric concept. Because of this threatening unbalance the implications of making NCO sufficiently achievable for a coalition are big and challenging to say the least. Typical characteristics of a coalition are that they can be coincidental of nature, especially when we look further then only NATO. A coalition of one day may exist of adversaries of a another. The question of trust and information sharing is a major issue here.

Also when dealing with non-US forces and with some of the non European forces as well the unbalance in technology will pose serious problems for achieving a sufficiently high level of integration needed for network centric operations. NCO just takes more than adding the individual forces of participating nations together. Much will depend on the ability to achieve or having achieved already a sufficient level of interoperability. Starting from a level too low may result in an increased time required to bring a coalition-based network centric operation up to speed or even that we never achieve it.
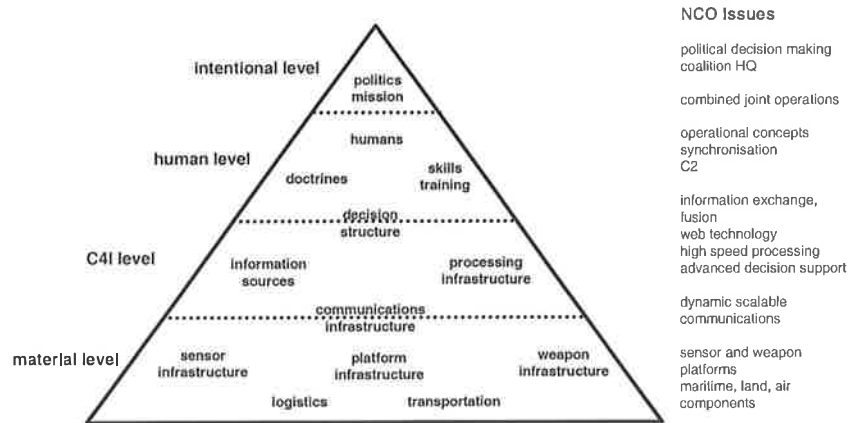
3.   Elements of Coalition-based NCO

Many developments and advanced concept and technology demonstrations on NCO are taking place in the US forces, in single service as well as in joint operations. Through these experiments a lot of knowledge and understanding is currently obtained about single nation NCO. To investigate some of the major implications involved with CNCO we will first try to identify the key areas of attention for NCO and then focus on those topics in these areas which have the most impact on the coalition aspect of NCO.

In Figure 1 the most important elements of NCO are shown. We can distinguish 4 levels which should be considered when dealing with NCO:

1. The Intentional Level, where the goals to be achieved are formulated.
2. The Human Level, with the command structure working to achieve the mission goals.
3. The C4I Level, which is the supporting layer for the human level to carry out command.
4. The Material Level, which consist of the assets needed for the mission.

The pyramid of NCO elements gives a good overview of all involved areas on which the impact, the consequences and the actual implementation of NCO should be considered. It gives a framework of what should be studied and where issues must be resolved with respect to NCO.

Figure 1 Elements of Network Centric Operations

The framework of Figure 1 is valid for both the one nation type of NCO as well as for coalition-based NCO. In the following sections we will look at some of the problem areas which exist when dealing with coalition-based NCO. The coalitions we will focus on are not only NATO-based, where we have US forces working together with European and PfP nations, but also coalitions which may come into being without the US or NATO.

In this paper we do not discuss every single element of the NCO pyramid. Instead we will take an approach in which we focus on three different perspectives of the pyramid:
- Political.
- Operational and Conceptual.
- Technological.

Many of the issues which needs to be considered with respect to CNCO belong to one of these three perspectives.

3.1 Political Perspective

On the level of politics a coalition can be created and it can be terminated. The political level can decide on the level of information exchange, which is so essential to NC operations, on the use of national information, given to the coalition to be used. We already have problems of information availability in our current multi-nation operations but in NCO it is even more pronounced since information sharing is a key enabler of NCO. Past *and* current operations still show us the difficulties for allies to obtain and get access to US-only information, of which SIPRNET is only an example. In other words, the principle and the amount of 'US-only information' can become a real showstopper for coalition-based NCO where the US is included. But not only the sharing of information is an issue, also the authentication of it is: how much is national information trusted in coalition networks when nothing is known about the origin?

Another key conceptual area of NCO (see *List 1 Main Areas of NCO improvements*) is co-operative planning and co-ordinated engagement. Especially in an advanced state of network centric operations and warfare we need to be able to deal with transfer of command even more and faster then we are already doing now in our current coalition operations. Especially in lethal engagement situations we have to be sure that fast and decisive decision making using multi-nation resources is ensured by the political level. The possibilities for backseat driving on the political level can be a big impediment for this.

3.2   Technological Perspective

Of a complete different nature than politics are the technological problems involved in achieving a true NCO for a coalition. The key factor here is the possible technological unbalance which can exist between different partners of a coalition. For the US the implications and implementation of advanced information communication technology and especially the focus on NCO poses already an enormous challenge. It is even more so in a coalition context. The technological gap which already exists between US and non US forces, even high ranking European ones threatens only to get wider.

One of the major improvement areas of NCO is shared situation awareness and understanding. This requires a high level of sharing of information, compatibility of information processing capabilities, both with respect to data and information fusion as well as using the same IDCRIT for instance. In the past we have seen deadly examples when this requirement is not fulfilled. For high quality common operational and tactical pictures advanced sensor netting and an interoperable information distribution and processing infrastructure is required. When we wish to assure that identical pictures and interpretations on different places exists *and* will be used to base decisions upon, the ability to fuse different sources and types of information must be sufficiently available throughout a coalition force (it should be noted that in the US this technology is currently still subject to strict export regulations).

The key technology here is Information Management (IM) of which fusion is only a part. IM involves the ability to gather, analyse, process, distribute and interpret data and information to the level of acquiring sufficient knowledge and understanding.

From a technological and also an organisational perspective solving the problems associated with the unbalance in technology will become a big challenge. One of the solutions might well be not to try to establish a balance but to solve it through other means, like using NCO capability levels as discussed in sections 3.3 and 4.

In this context it is important that we realise that not only the availability of NCO technology is sufficient but also the ability to use it, to interpret the fast growing amount of data and to make the right decisions based upon the mutual understanding. For CNCO Compatible concepts of operations (CONOPS) and especially personnel skills and training play an equal important role as the technology itself. It will simply not be enough to make some of the technology available, because the human skills to handle it will still be lacking.

Even when coalition partners have sufficiently high technology levels the underlying systems still need to be interoperable with each other. This poses another problem at the technology level. We will look into that in more detail in *section 4 Interoperability.*

3.3   Conceptual and Operational Perspective

As we have stated before it does simple not suffice to bring forces together to achieve a network centric operation. We need to carefully create the synergy between the elements listed in *Figure 1 Elements of Network Centric Operations.* This synergy can only be obtained when the principle concepts of NCO are sufficiently understood. Many information and knowledge about NCO is still on the terminology level and not on the methodological level, supported by a well defined infrastructure, information exchange requirements, information and data schemes, interfaces, etc. (see *section 4 Interoperability).*

In the coalition context of NCO we will frequently deal with unbalanced technological levels as discussed in the previous section. To be able to handle this may call for an approach in which we distinguish levels of NCO capability which will be dependent on the state of advancement the contributing nations. The coalition NCO capability level which may be achieved will be a result of the technological C4I infrastructures, but also on the human skills and training, on the different doctrines and operational concepts of the participating nations. Interoperability is the keyword here.

In all the areas and the elements of NCO the concept of interoperability plays a central role. It is sufficiently important to be discussed separately.

4.   Interoperability

Interoperability is a key factor to achieve integration with respect to systems, procedures,
doctrines and even organisations and humans. Many interoperability considerations in the past were
concentrated on a system level but other levels are at least as important in NCO. In Figure 2 we have given a
full overview of all the areas for which interoperability must be considered and defined in the context of NCO
and CNCO.

The areas which are distinguished are:
1. The action level.
2. The procedural level.
3. The hybrid system level of both human and machine.
4. The services level.
5. The world level.
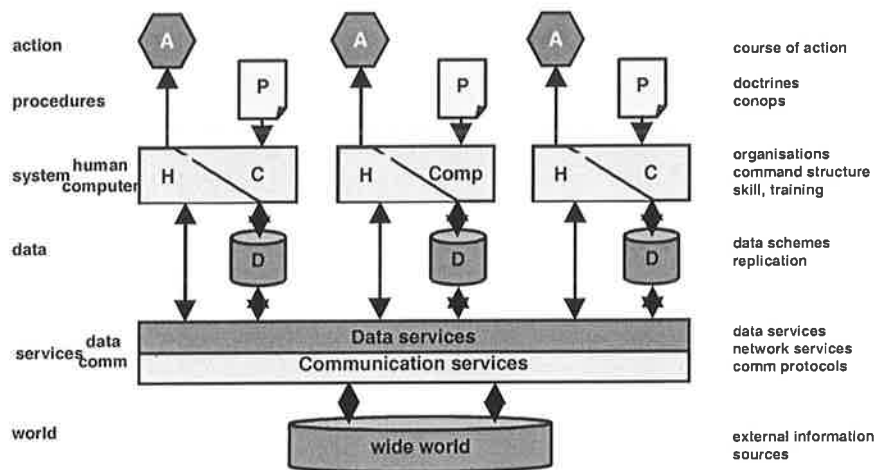
Figure 2 The Interoperability Areas

Because of the central role in NCO of information interoperability on the services and data layer is important.
Because of the goals we wish to achieve with network centric operations (see *List 1 Main Areas of NCO
improvements*) we need to have synchronisation and compatibility on the action and procedural levels, and on
human decision making as well. This includes static aspects like interface descriptions between system
components and data schemes, but it also involves dynamic aspects of the command & control process.
A structure of levels of interoperability and degrees of compatibility is needed with respect to 'Understanding
the Situation' and 'Deciding on Action', the two main C2 processes. This is interoperability on the procedural
and action levels of *Figure 2 The Interoperability Areas*.

In a coalition-based network centric operation the networked force infrastructure needs to be composed from
its individual components into a synergetic whole. Because of the earlier mentioned unbalances which may
exist not always the highest NC level of operation can be achieved. We need to be able to decide from the
individual force characteristics the maximum attainable degree of NCO on the strategic, operational and
tactical level. This leads to an interoperability matrix as shown in Figure 3. Here we see the various
interoperability areas combined with the three operational levels. For each cell a series of standards,
interfaces, compatibility levels or degrees should be defined. The most important ones are the Measures of
Merit, with which we can start to develop a more methodological approach to NCO and CNCO than we have
at the moment.

According to [COBP, 1999] four hierarchical levels of Measures of Merit (MoMe) can be distinguished:
1. Measures of Force Effectiveness (MoFE).
2. Measures of C2 Effectiveness (MoE).

3. Measures of C2 System Performance (MoP).
4. Dimensional Parameters (DP).

List 2 Four Hierarchical Levels of Measures of Merit

The Measures of Force Effectiveness (MoFE) focus on how a force performs its mission or the degree to which it meets its objectives. Examples include territory gained or lost, rate of advance, combat loss ratios, and casualty ratios.

The Measures of C2 Effectiveness (MoE) focus on the impact of C2 systems within the operational context. Examples include the ability to formulate plans that work to achieve objectives, the capability to create a common operating picture of the battlespace, and reaction time.

The Measures of C2 System Performance (MoP) focus on internal system structure, characteristics, and behaviour. Performance measures of a system's behaviour may be reduced to measures based on time, accuracy, capacity or a combination that may be interdependent.

The Dimensional Parameters (DP) the properties or characteristics inherent in the physical C2 systems. Examples include bandwidth of communication linkages, signal to noise ratios, component size, number and variety of wavebands, and luminosity of display screens in command centres.

Op levels / Areas	Strategic	Operational	Tactical
action			
procedures			
humans			
systems			
data			
data services			
communications			
world			

Each cell addressing issues like:

- standards

- level of :
  interoperability
  compatibility
  connectivity

Needed are MOP, MOE and/or MOM for each cell

Defined in joint, coalition and OOTW context

Figure 3 Interoperability Matrix

The current MoMe hierarchy as described in [COBP, 1999] is not yet tailored to NCO and the specific coalition aspects of NCO. The concept of the MoMe hierarchy should be further studied and developed in order to achieve a better understanding of CNCO, to be able to identify capability levels and to reach a state in which we can start to design the different elements of NCO as given in Figure 1.
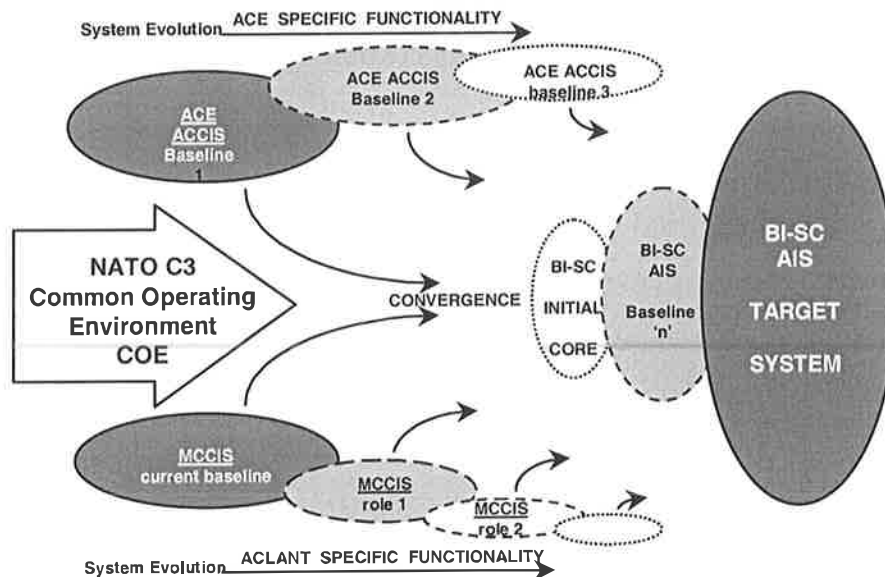
5. Recommendations

As can be derived from the previous sections it is not likely that CNCO will spontaneously come into being. In the first place the concepts underlying NCO are still poorly understood and not yet based on sound scientific methodologies. In the second place it will take a lot of effort to achieve the required amount of integration as discussed in section 4.

It is an illusion to think that from completely separately defined and developed national systems and system components a C4I architecture can be put together with NCO capabilities. The interoperability requirements to achieve the synergy required for NCO are too severe.

Therefore we shall always require a certain core capability, both in the one nation situation (read the US) as well as in the coalition situation (NATO, Europe or otherwise). Because of the requirements to be fulfilled and the technology required it is questionable whether a coalition-based NCO can ever be achieved without US or NATO elements and system components involved. To investigate the requirements of a core CNCO system

and the interfaces and interface levels we might consider using a series of JWID (Joint Warrior Interoperability Demonstrations) exercises which should be designed to contain an increasing amount of NC character.

It may very well be that for instance the NATO BI SC AIS can become the core component for achieving CNCO. The path followed in the development of this NATO BI SC AIS is given in Figure 4, where the ACE and the ACLANT specific functionality is meant to be merged into one single BI SC AIS.

Figure 4 The Migration Path towards a NATO Bi SC AIS

Consequently we recommend a stepwise (but not strict sequential) approach to achieve desired capability levels of NCO and CNCO.

Step 1. The potential and the unavoidable evolution towards NCO must be recognised within coalition nations. Without this the initiation and synchronisation needed to develop NCO capability will not take place.

Step 2. We need to have a sound scientific fundament underlying NCO. A model and methodology with which NCO functionality can be described and with which parameters, metrics, the different hierarchical levels of the MoMe and the various capability levels of NCO can be defined. Based on this methodological approach concepts like speed of command and self-synchronisation can be better defined and be made quantifiable.

Step 3. Based on the NCO model and on the interoperability concepts discussed in section 4 we need to establish performance or capability levels of NCO. These levels will serve as the guidelines for national and coalition-based R&D plans to achieve the chosen level of NCO capability. This needs also to include strategies to cope with unbalanced technological levels of coalition partners and with restrictions to information exchange requirements.

Step 4. The core system and system components of NCO need to be identified and developed. Like we said the NATO BI SC AIS may serve as such a core system or component.

6.   Conclusions

We have discussed in this paper some of the implications of coalition-based network centric operations. We are still in the process of slowly discovering what NCO is all about, what the critical factors are and how to

tackle and solve the many political, conceptual and technological issues. The differences between a one nation NCO (read the US) and coalition-based NCO are significant and will require dedicated attention to be solved.

Badly needed is a good methodological approach to NCO and CNCO. This will take a lot of effort. But we need this in order to guide the various investments of nations in the path to achieve CNCO capability. As one of the most promising and revolutionary concepts CNCO must be given a dominant place in the C4I Vision and Policy documents of many nations. By its very nature NCO in a multi-nation context can be nothing else than a synchronised and joint effort. Co-ordination of R&D efforts on NCO and CNCO within NATO and within the European Defence Force is therefore of the utmost importance.

7.   References

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Communications networks	Natural language
COTS (Commercial Off The Shelf)	Ontologies
Criteria development	Peacekeeping
Data fusion	Secure communication
Information management	Situational awareness

14. Abstract

This volume contains the Technical Evaluation Report and 25 unclassified papers, presented at the Information Systems Technology Panel Symposium held in Quebec, Canada from 28th to 30th May 2001.

The papers were presented under the following headings:
- Architectures and Standards: Fundamental Issues
- Information Management
- Mobile Software Technologies
- Interoperability Procedures and Practices
- Information Centric Warfare
- Coalition Common Operating Picture