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THE STATE OF THE ART AND THE STATE OF THE PRACTICE

C2 EXPERIMENTATION, NETWORK-CENTRIC METRICS

UNCLASSIFIED

NETWORK BASED EFFECTIVENESS

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ABSTRACT

Western military organizations are increasingly paying attention to the concepts of Network Centric Warfare(NCW), Network Centric Operations (NCO) Network Enabler Capabilities (NEC), and Network Based Defense (NBD) in order to increase competitive advantage, innovation, and mission effectiveness. Network based effectiveness occurs due to the influence of various factors such as people, procedures, technology and organizations (extended from Leavitt, 1965). This text identifies aspects of network based effectiveness that can benefit from a better understanding of leadership and management development of people, procedures, technology and organizations. A brief discussion is presented on how leadership and management development can support network based effectiveness. Aspects of network based effectiveness that involves further research by scientists are identified.

CONTENTS

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Explore the Network Based Effectiveness

In order to discuss Network Based Effectiveness we first need to define what we mean with the concept. My approach is a military perspective that sets military forces in focus from the operational standpoint. For better understanding the military system, let me just clarify that a military system is a highly politically driven, difficult to regulate, high risk, and media attractive system that handles situations that most people not even could dream about.

Most military networks are based on civilian networks – such as transportation, energy, and communication networks – which all follow the same flow of logic of operations as the civilian applications. Classically they are described as physical nets with nodes and links that flow in different directions and sizes. But still, I will argue that it is hard to describe the military system in terms of the business world. For example, when is the military system productive, or what effect does a military system create? This might in some cases be possible to do at a tactical level for well defined military systems, but on the operational level with system of systems there are technologies and human interactions which make it much harder. But, still military systems need to be effective!

It might even be so that the frustrations the military systems have had in the past when they tried traditional economic principles is similar to the frustrations the Information Age businesses have today with the same traditional economic principles. Military systems might be much similar to Information Age businesses than we earlier had documented.

From this standpoint I would like to address the following issues (1) a shift "philosophy" behind military activities, (2) the methodology development, and (3) the knowledge edge in this area, in order to identify the aspects of network-based effectiveness.

Peter F. Drucker stated that *efficiency is doing things right, and effectiveness is doing the right things*. I will in this short briefing maintain the question about network-based effectiveness or "Doing the right things – network-based!"

Effectiveness is commonly described as a function of output. That means that in order to observe output or results we need to define the system and have the ability to measure the output. In network environments the systems are, in reality, hard to formally describe since they change over time in structure and functionality. Also, the result is hard to concretely describe. So, to decide what the right things are, we need to develop other principles for measurements other than those that are used in the Industrial Age, which are passed on as primary-product metaphors rather then intangible "things" such as information and knowledge.

Effectiveness should therefore be considered as a relative term that gives the ability to achieve stated goals or objectives, judged in terms of both output and impact under certain conditions. In the military, those certain conditions are commonly related to missions which means that military effectiveness are generally equal with mission effectiveness.

My own interest is what facilitates effectiveness in the Information Age and, if it is possible, to find common units of measurements. The first findings in this direction are measurements that describe results related to information qualities and communications (Friman and Horne, 2005).

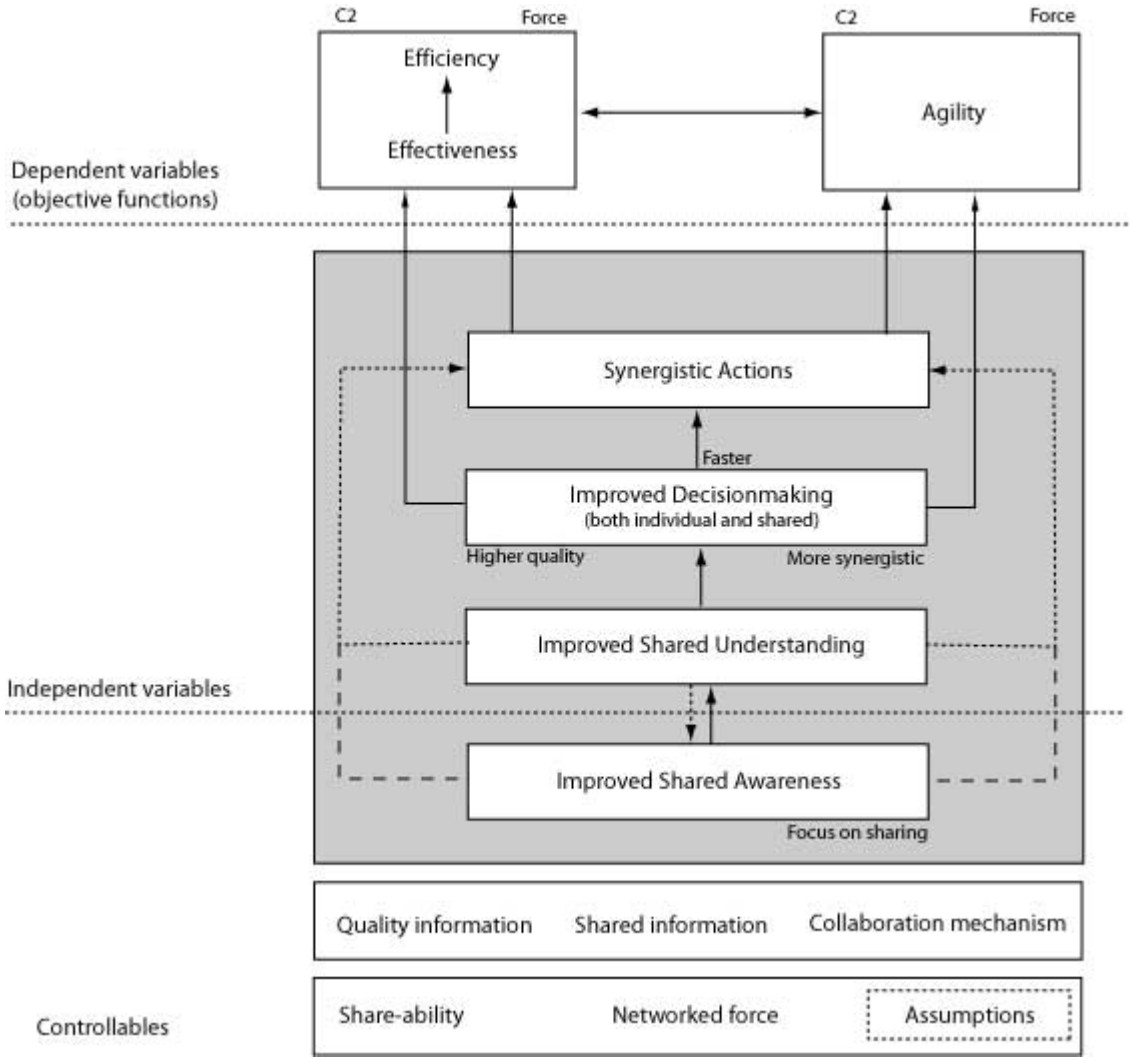

Illustration 1 - Independent and dependent variables of networked forces

The NATO SAS-50 research panel presented in a working session a model (here redrawn) that stated the control and independent and dependent variables of networked forces.[1] The dependent variables were presented to be effectiveness that led to efficiency, and agility. The core elements to be created were argued to be Command and Control systems (C2) and force, the independent variables were; synergistic actions, decision making, and shared understanding. Here, we could see that the variables that related more toward human factors rather than technical factors but could be leveraged by networks. In the model the controllables were; awareness, information, collaboration mechanisms, shared ability, and network force. The model is based on the assumption that the right thing to do is to *share high qualitative information that we could understand and together conduct joint operations*, which is nothing really new! What's new is that we could, by facilitating networks, conduct these operations globally in near real time!
I will argue that it is the globalization and the time constrains that are the real development challenges for the new Information Age's effectiveness!

[1] For the SAS-50 finial report see: http://www.dodccrp.org/SAS/SAS-050%20Final%20Report.pdf

From the military prospective, this leads to whole new ways to conduct war in the future. In what I will call *Distributed Operations* (OFT, named Distributed Adaptive Operations), small, geographically dispersed, networked, autonomous and semi-autonomous assets are led to fulfill the commanders' intent! (e.g. Glaros, 2005). And, what commanders will have to think about in this new environment are the questions of force, space, and time (Friman, 2005).

The shift in philosophy of military activities

In literature we could record a relatively stable prediction of what the new Information Age is and will develop into. In the more specific military literature those insights are transformed more specifically for military issues. So, we could conclude that *we have a shift in what war is*, and *we have general concepts of how to fight war in the future*. In order words a foundation for a new philosophy of war.

In the new world of digitalization and globalization, the world should be considered as: a world of dynamic changing rates and complex demands on knowledge and information. In this new world bureaucracies and entrepreneurial organizations show not to work properly (Friman, 2005, p 23). There is a demand for Networked organizations, and today we have the technology to support such organizations. New systems such as geographical position, high precision weapons, unmanned vehicles, and new sensor systems have changed the way war is conducted. But at the same time, military forces are given new systems, and the threats against democratic societies have changed. Conflicts have turned to be more within countries rather then between. And, the enemy has started to become invisible! Today, we have a war against terrorism! The new asymmetric warfare challenges all traditional military systems that traditionally are designed to fight other military forces not single attacks.

The search for new military structures are a continuous process, and in the networked world, new forms such as the Edge Organization and others have been discussed and considered, but still there are very few facts whether those more loosely-coupled organization structures are suitable for military activities. This means that military commanders are facing a new environment, but are still using the "old" system principles.

From an effectiveness perspective this seems to be improper, but so far few facts have been presented that could be used for decision data for major revolutionary changes.

The commander's ability to create mission effectiveness is critical. Military effectiveness could be described as a function of three factors: time, space, and force. Time, space, and force create a *golden triangle* for all military thinkers.

Depending on time, different space and forces are available, and in a specific area (space), certain forces are available at certain time, and force could be created with a certain time and space. By thinking of time, space, and force at the same time we could experiment with different scenarios, and this simple model gives us the ability to structure the key elements of any operation. In this example, the model is simplified to single entities but in real situations each element has multiple options. For example, with multi-force resources under different time spaces, the commander sets the tempo for sustaining continuous pressure against an opponent for as little or as long time as it takes to fulfill military aims.

Putting the structure of the golden triangle in the frame of all assets of Military Operations, highly complex systems, possible operational structures, are created and could be visualized[2]. At the first glance the visualization of the system seems too complex to perceive, but with the

[2] What Gregory Glaros named *the complex art of war*

technical support of new analytical instruments we now find operational syntheses[3] in operational landscapes that we probably never had thought about before. Here, commanders are supported to think out of the box and have new options for upcoming adaptive planning. The competitive advantage of having more options visualized and shared within the organizations increases the ability to adapt and create new procedures for military effectiveness.

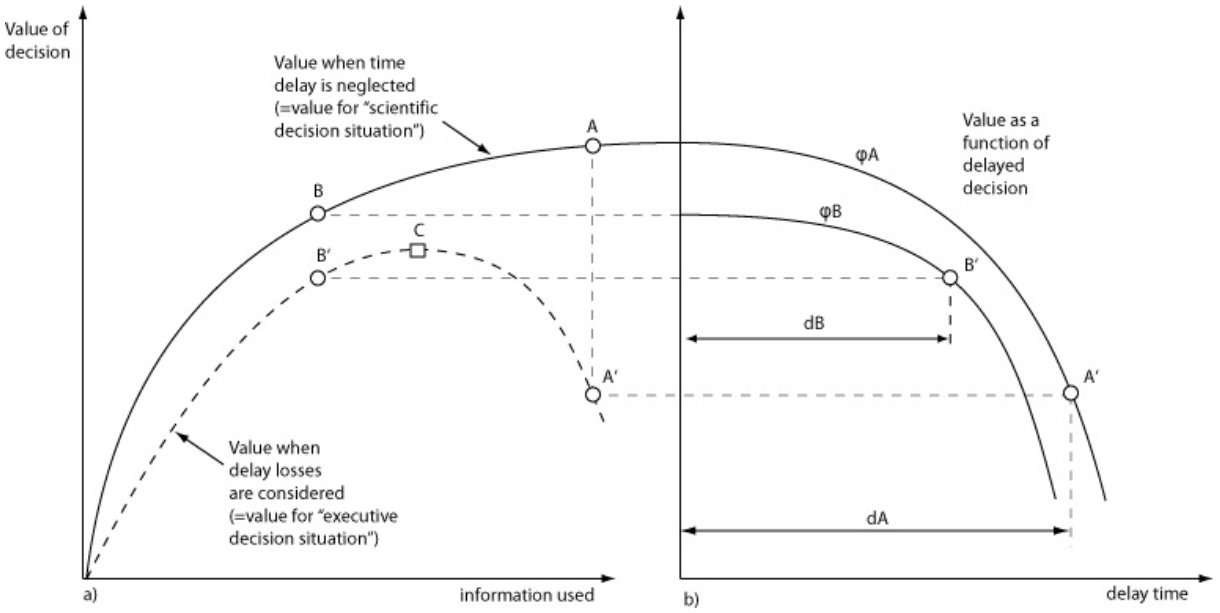

Illustration 2- Value of decision based on information used and delay time

(Langefors, 1973, p 209)

Langefors (1973) illustrated the relations between used information, delay time, and the value of decisions in two graphs. First, graph a, shows the decreasing value of used information A and B. Second, graph b, illustrates a decreasing value for information A and B and that depending on the value of the delay (dA and dB), the information differs. Taking the delay into account and going back to graph a, we will see that the value of decision B' is higher than the A'. What we learn from Langefors is that even though we use more information, we don't necessarily get a higher value for our decisions. This is obviously a simplified example, but it gives valuable insights about the key elements of Military Operation characteristics.

The expressed goals of Military Effectiveness are to network the force so that the common goals (commander's intent) and constantly updated situation-awareness can be shared throughout the organization. This awareness, in turn, allows units to support each other and the master plan without resorting to the traditional military hierarchy (e.g. Adkins and Kruse, 2003).

With the illustrative example of Langefors' model we found that for a commander's use of information in military system, the implication of time delay is important. To find instruments to handle time in a more relevant way for aware time impact so that he can use time as an active component in his operation is therefore essential.

[3] The term Operational Syntheses was first formulated by Brandstein, Alfred (1999)

Different strategies to achieve effects

Output in a general sense could be formulated in terms of *optimizations of performance* or *balancing of performance*. Output in classically described systems are often described as optimizations of performance, which is a trade off between quality, quantity and cost aspects. The classic network problems - from 1940s and 1950s - address questions about model flows and qualities in the search for maximal flow, capacities, and cost issues. Through operational research we have learned to optimize processes based on quantitative data and statistical analyses; the baseline for achieving such data is with systems that are well defined, and which components have recurrent functions (e.g. Albert and Hayes 2003:p 44f arguments on optimization).

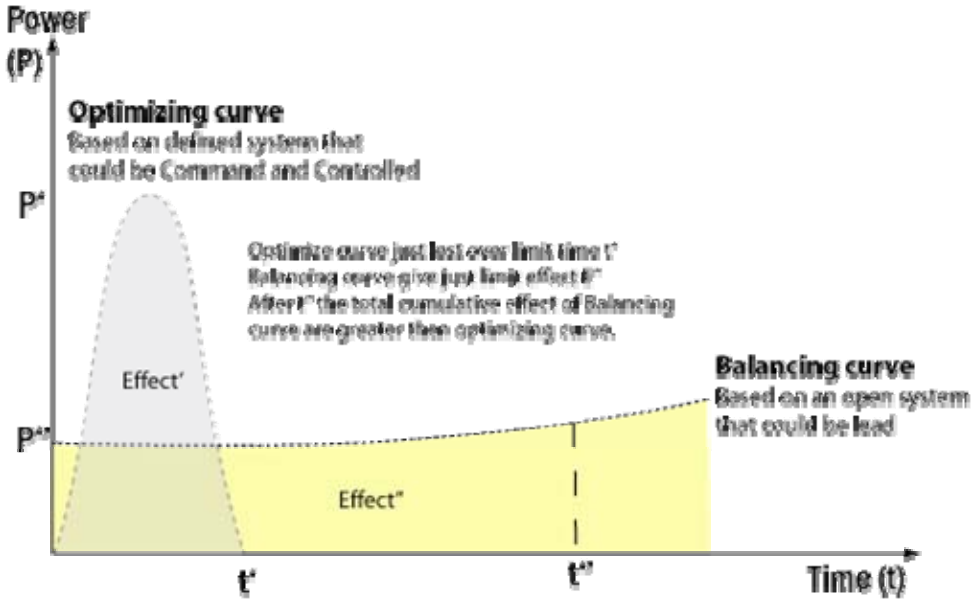

Illustration 3 - Different strategies for achieve effects

Effects of human systems in military contexts are more often described in terms of survival which is concerned about what could be called the balancing of performance rather than the optimization of performance. The dots and interrelations between individuals within and between groups are normally described in terms of qualitative data and analyses. Outputs from measurements of socially oriented systems at group levels can, under certain circumstances, be generalized and treated by statistics in order to find general human patterns. Studies of individuals are normally treated as specific case studies and the results are unique to the situation but are difficult to convert to other situations. New Age network problems have to add to the classical problem of the importance of visualization and the ability to find real options. Real options are created by greater understanding for links and conjunctions, and the way individuals and groups behave in the system.

The use of optimizing measurements on human systems will, in most cases, fail since survival is of higher value than just finding the highest optimized effects. Individuals and groups could show willingness to self sacrifice in order to create survival for there families, but they will not do that just to be “cost” effective. It is hazardous to argue for balanced solutions based on optimized measurements. Optimization does not reflect a balanced approach to military outputs because it

does not include such intangible factors as human emotions, feelings, and mindsets – such as fear and morale – which are central for humans and are not possible to optimize.

Depending upon if we define the problem in terms of an optimization issue rather than a balancing issue, we can employ a different approach and results as output! In this sense the measurement of effectiveness will get different meaning depending on applied strategy.

The shift of development

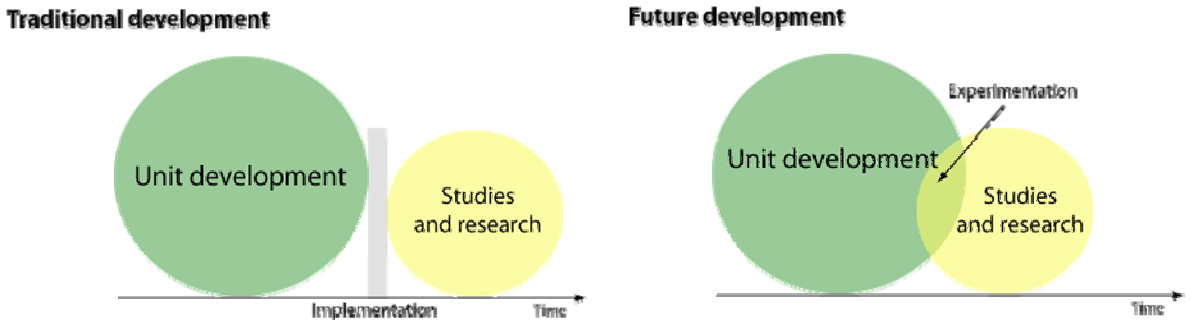

Illustration 4 – The shift of development by experiments

(Friman, 2005)

We, as researchers, have a great challenge. Today, we have research communities that are used to taking the time they need to discover and study specific issues. They are trained to be allowed to fail as long as they do that in an interesting way. On the other hand the military demands to get faster results from their research investments which demand time pressures on results. The researches are not allowed to fail, and because of that their results are much more quickly implemented in real world settings.
Traditional development had clearer borders between unit developments, studies, and research with an implementation phase. Future development is more a merge between unit development, studies and research by experimentations.
From a methodology stand point we can now see requisites for how we conduct research work, and the next step should be an investigation experimentation role as an instrument in the merging of unit development, and studies and research. To be effective in future unit development commanders needs to be able to lead and manage experiments.

The Methodology Challenge

Alberts and Hayes (2005) chapter 1 describes some of the problems with the nature of experimentation. What I think they missed is the importance of the study of an object's "future" capability that add on magnitudes of complexity at the methodology challenge.
Innovative studies of the future issues are scientifically based on "poor" data sets, that in most cases are empirically incomplete. Traditional scientific ideals are not fully applicable, and more pragmatic approaches are requested to search insights and test ideas.

The type of experimentation we assume to be accomplished is rather pseudo-experiment than laboratorial experiment, with a much higher practical focus than theoretical. But still as Einstein said, “There is nothing more practical than a good theory!”
One of the greater challenges in this approach is the military tradition of the continuing shift of personal. Some argue that this is great because of the broader number of individuals that get to be involved, while others argue that the experiments loose the ability to get deep since there’s an endless need to educate new participants. From an effectiveness perspective both arguments could be argued as positive or negative depending on what goals the activities are given.

Development processes

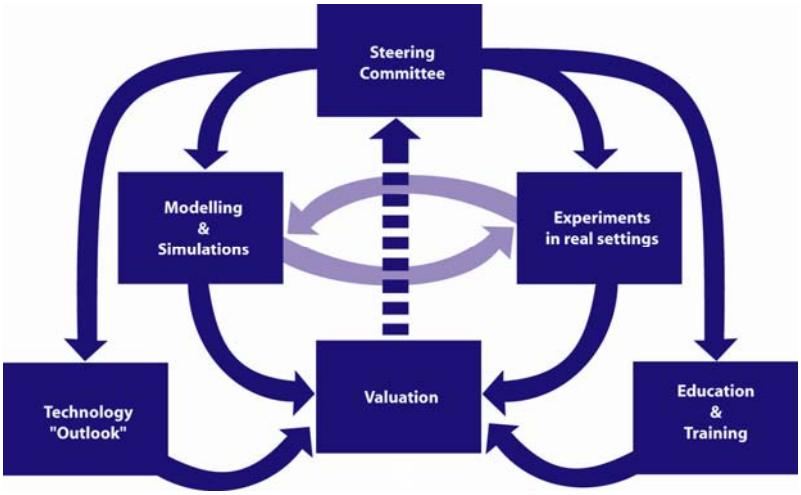

Illustration 5 – development processes

Today's development is a number of parallel activities that need to be lead in a collaborative way. The development has been described as a Campaign of Experimentation (Alberts and Heyes, 2005). The assumption is that future military effectiveness will be a direct result of how well each unit could continue to develop itself. There are four major activities – technology outlooks, modeling, and simulation, experimentation in real settings, and education and training that need to be co-ordinate in order to develop the future military system. By using technology outlooks for monitoring development trends with impact, modeling and simulating the test beds create creativity and insights, experimental settings to create facts, and education and training to feed back results to the organization. The major activity in this model is the interactions between modeling and simulation and the experiments in real settings, which is the link that drives the development. To coordinate the process, a steering committee is established which is supported by an evaluation function.
In the process we assume that three different processes will occur. First, there is the normal process to create changes by leveraging already existing systems to meet a new request. Second, there is the innovation process that takes new creative thoughts to new systems. Third, the experimental process that facilities the willingness to create and try something new that not always will directly lead to something new. It is just the first process that could be well described and planned before the event, which makes the other two hard to really command and control. It

is impossible to know before exactly what will be the results. This leads to the conclusion that future leaders need to develop their skills and knowledge about how to lead changes, innovations and experimentations. There is no longer a border between daily business and research and development!
To lead and manage development processes commanders needs be able to execute changes, innovations and experiments. The execution should content education and training initiatives to make sure that obtainable experiences are share and learned to the community of interest.

The basic conceptual model

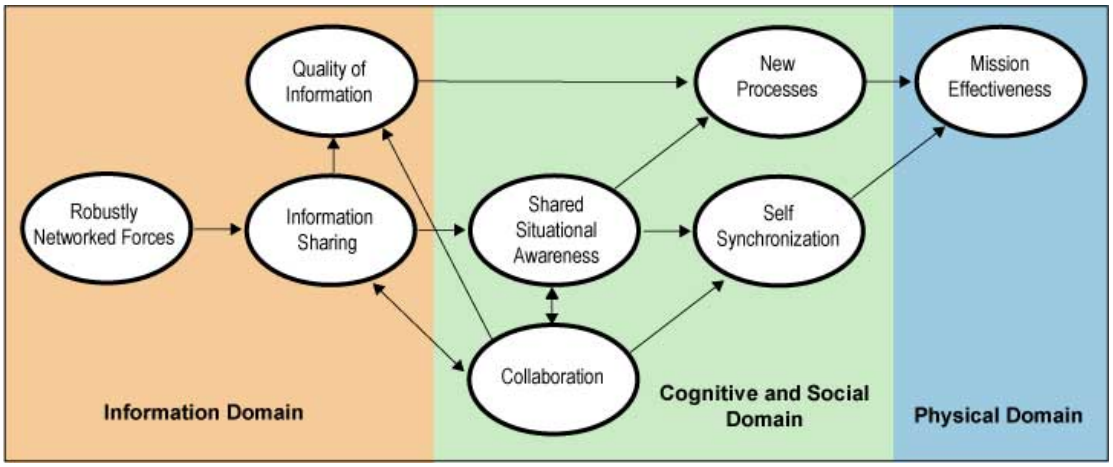

Illustration 6 – Tenets of Network Centric Operations (US Office of Force Transformation, 2005)

To make sense of the new process of military activities, a group within the US DoD/OSD have developed a general conceptual model for the logic behind future military affairs. Without going into any details, the model is based on the use of shared information that creates collaboration and self synchronized activates and new processes that led to mission effectiveness. The model is based on an organizational behavior perspective rather than the technical approach of networking that sets the cognitive and social domain in focus. This is an important signal since most arguments for the transformation comes from a technical standpoint, the new technologies facilitate a new way to act. By saying that, we could note that the model is lacking one of the vital issues of social science – learning – which takes place in all components and is primarily the source for developing new processes.
Collaboration and shared situational awareness are both driving forces behind learning. By creating a learning environment, a system can adapt to uncertainty, and by redesigning or creating new processes it can handle upcoming situations.
The foundation for creating new processes is a learning system, based on leadership, knowledge, skills, and training. The term *self organization* leads to thoughts to adapt between goals/missions and actions, which assumes that an organization is established with leaders and followers that act. Logically this assumption addresses questions about groups and organizations, leadership and effectiveness. The instrument to create effectiveness is with *new processes*. Demands for new processes stimulate self organization, and self organization will, in most cases, lead to the development of new processes. This means that it is reasonable to argue that the ability to adapt is a result of self organization and new processes, and the driving force behind adaptivness is the

ability to learn. The greater the uncertainties (complex and dynamic environment), the greater the need for learning! Learning is also shown to increase information sharing, communication, understanding, and the quality of actions (e.g. Nevis et al, 1995) of all key elements in this model.

By using the same model for a number of studies and experiments we will create comparable data sets that open for cross linked data sharing between studies.

Primarily findings for key factors

For the further development of Effectiveness we need to formulate key factors that are assumed to create or improve mission effectiveness. To operationalize today's results into observable units, we created a cross link table between the tenets of NCO and the key system components within Leavitt's model. By establishing such a link table and adding on the key driving factors from a systems perspective on to the tenets, we created a map of factors (sub units) to consider and observe at coming experiments. The factors were developed with the help of a group of experts that carry through a scrap exercise to find relevant factors.

Tenets	Technology	Processes	People	Organization
1. Robustly Networked Forces	Redundancy, security	Adaptive	Willingness, leadership	Parallel planning
2. Information sharing	Communication, architecture	Time issue	Understanding, trust	Administrative procedure
3. Quality of information	Security	Procedure	Knowledge, trust	Administrative procedure
4. Shared situation awareness	Communication	Procedure	Knowledge	Willingness
5. Collaboration	Design issue, architecture	Procedure	Knowledge, leadership	Participation
6. New processes	Design issue, architecture	Rule	Knowledge, leadership	Participation
7. Self synchronization	Design issue, architecture	Adaptive	Trust, leadership	Participation
8. Mission effectiveness	Design issue	Optimizing/ balancing	Survival, leadership	Survival, commitment

Table 1 – Hypotheses for key factors behind the tenets structure (Friman, 2005, p 29)

What came obvious by this work is that in this general overview of drivers behind different systems of different tenets are factors that we could not simply use engineering principles to design future systems. People and social groups (organizations) tend to drive more intangible factors than technology systems. The central concern for further development will be related to

the commanders and their ability to lead changes, innovations, and experiments that create (mission) effectiveness.
We could also see in this inventory that the experimental design for reaching and measuring the factors could not be done by just quantitative methods. Therefore, we needed more qualitative designs, especially in the beginning of the experimental campaign to find trends and insights that would lead us to greater understanding which later could be tested as proofs of concepts.

Conclusions

In order to get a better understanding for the aspects of network based effectiveness, I like to offer this list. It is based on the discussion above and primarily results, so it is still under development.

1. Network Based Forces Mission effectiveness is Network Based Effectiveness, where Network Based Effectiveness is doing right things network based
2. Mission effectiveness is based on self-synchronisation and new processes, which can not be achieved with out active learning process
3. Network Based Effectiveness is primarily a results of the ability to learn
4. Major concerns for networked commanders is power, space and time, which is the primarily tools for creating effectiveness.
5. In Network Based Operations is time a key military operation variable, without time consideration effectiveness can not be measured
6. It is a paradox between rational optimization and balancing strategies, which gives a different meaning to effectiveness
7. Military networks operations are loose couple systems (open systems) rather then a close systems, and loose couple systems are difficult to command and control, which increases the demand on leadership rather then management skill.
8. Future development will use experiment more frequent in the transformation between studies and research and unit development.
9. Development processes have to include education and training sections to insure the needs of learning.
10. Commanders needs to have the ability to lead and manage changes, innovations and experiments

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