COMMAND AND CONTROL IN NETWORK-CENTRIC WARFARE AND INFORMATION AGE

Lieutenant-General (ret.) professor Cristea DUMITRU, PhD*

Abstract: *In the Information Age, the foreground is represented by the exploitation of information technology so as to fully benefit from the explosive potential of its rapid spreading and processing. These, in turn, are revolutionizing the way states, institutions and people interact, radically changing the traditional principles of management and organization. The military implications of the new science of organization versus hierarchical and distributed systems models are still under study. Obviously, information age technology and modern management ideas exert a great influence on armies in terms of organization, equipment, training, fighting and operation, protection and ways of participation in conflict resolution.*

Keywords: *Command and Control (C2), Command and Control Processes, Network-Centric Warfare (NCW), Information Age*

1. Introduction

The command and control term designates a multitude of activities taking place at all levels of military organizations. These activities include actions concerning the division of tasks, motivating staff, imposing and finding common goals together with coordination between members of the organization, as well as assessing the manner in which these goals are achieved both within the organization as a whole and by each of its members.

Command and control is, by its nature, an iterative decision-making process, whose stages are closely related to the feedback process established between the reality in the battle space and the measures contained in the plans and correctives devised by the order.

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* Member of the Academy of Romanian Scientists, Military Sciences Section and former Chief of Romanian J.6.

Changes generated in the field by the Information Age have brought some amendments in the approach to this line, amendments that imply a series of opportunities and some challenges that will be described hereinafter.

Military operations are or should be designed to meet a goal or solve a problem. The appropriate way to formulate problems often includes, according to the art of war, the need to recognize and distinguish between tactical and strategic level and to implement specific problems resulting in a broad perspective.

Even developing a campaign battle finally appears as a long set of issues interrelated to each other.

The current approach to developing such a plan of campaign is mainly based on understanding the set of relations established between the events of reality that have as main feature a particular need for development. Thus, the plan could be decomposed into a series of steps, each of which being constructed and resulting in a linear way from the previous ones. Our capability to conduct something as complex as a military campaign depends on the ability to separate events in time and space. From the organizational point of view, three levels are foreseen: strategic, operational and tactical. In terms of geographic scale, we operate with theaters or sectors and from the functional perspective, specific purposes may be actions, operations or maneuvers correlated in a sequential manner. This way battle space is segmented so that we can deal with small and isolated problems and leading to a better understanding of the complexity of assembly.

However, the nature of the information in the Information Age makes actions increasingly difficult because of such a reductive approach. Current technology has continuously compressed time and space, and political realities wiped clear separations between the strategic, operational and tactical levels. In all projections suggested there is a great deal of chaos and uncertainty. We are increasingly facing the situation to conduct greater actions, with higher speed and in the shortest possible time. At the same time, there is also the need to integrate within planning of own actions a multitude of information from a large variety of sensors available in such a manner that it provides an overall picture of the battle space and adapt our optimal response.

All these challenges to command and control will require changes of

the doctrine of use of forces consistent with the concept of Network-Centric Warfare.

On the other hand, in the view of NATO forces, war is characterized by the existence of the phenomenon of *fog and friction*. This concept refers to the uncertainty relative to what is really happening in the battle space and the difficulty to translate the intentions of the commanders into combat actions, as they were designed. Impediments in question are closely linked to the lack of awareness of the continuous reality in the field and the inability to build an overview due to incomplete and disparate information. These shortcomings are exacerbated by the existence in the battle space of a large number of organizations that may have some helpful information, but whose coordination is extremely difficult. Last but not least, the reduced range of sensors currently available and their inability to distinguish between the allied and enemy forces affect the ability to obtain a complete picture of the battle space.

The main requirements of command and control must lead to the completing of the following needs:

1.Avoiding major mistakes

2.Avoiding attacks on allied forces

3.Cohesion of goals and action

4.Maximizing the efficiency of use of forces

5.Achieving economy of forces

So far, these objectives were achieved through meticulous planning of each stage, by merging a large number of forces, including the use of reserves, through a rigid doctrine and restricting the flow of information to the highest levels of command based on overvaluation of the principle of unique command. In the information age, we will have to rethink these concepts and practices due to a reality that has completed its course.

The objectives of military missions have experienced obvious changes; some viable options in the past have disappeared making way for a number of alternatives that have changed the nature of the actors. There are changes in the way of decision-making, allocation of responsibilities within the organization, development and assessment of options and choosing the most favorable resolution. New implications appeared in terms of system architecture and training the own staff by creating an environment able to move from unique command to a participative management of the actions,

due to both multinational missions where NATO is involved and distribution of the awareness of battle space and need for a quick decision.

Increasing the tempo of the actions has led to the transformation of the way planning and conducting the battle are realized. This process is no longer viewed as a series of static elements and proof of greater integration between the planning and the execution must be made, leading to their fusion.

The efforts to accelerate the erasure of the time differences between planning and execution have led to the need for a new command and control concept called *Dynamic Planning*, where joining the C2 processes to the execution is justified at least for two reasons:

6.Any product of the command and control process (decisions, plans, orders, etc.) has value only after being turned into real actions in the battle space

7.Within the Network-Centric Warfare concept, command and control, and execution tend to turn into a single, integrated process due to the growing pace of operations and the need to provide answers in real time suitable to critical situations

NCW offers the possibility of improving both the C2 and execution at every level for specific missions, in the following manner:

8.Decision grids will be better informed

9.Actor grid will be better informed

10.Decision and acting grids will be better interconnected

11.Sensor grid will respond promptly to requests

Thus, better informed decision grid can identify approaches once impossible and will no longer have to give priority to the defense in the face of uncertainty. It will therefore pay more attention to long-term modeling of the battle space and be less concerned with the reaction to surprising changes.

Enhanced connectivity between acting and decision grids will provide increased ability to design appropriate responses to changing circumstances. The nature of C2 processes will change to a great extent as may be granted enhanced competences and responsibilities to lower echelons. The higher echelons of leadership will have time and resources to focus on monitoring the situation and prospecting so that issues can be identified and resolved even before the actor grids to realize their existence.

From the above, we should consider command and control on three different levels: command and control processes, command and control activities and command and control system.

2. Command and Control Processes

The first step in addressing the concepts that define command and control is the acceptance of a particular language, which contains the basic ideas for starting to understand these concepts.

There is a set of twelve concepts that are considered indispensable in understanding command and control and required for modeling the command and control processes. These concepts are:

Observation - perception is converting an external signal of any kind in cognitive representations. Two types of observations can be identified: direct and indirect.

Direct observation is when an object, event or phenomenon is discovered in physical shape through one of the senses (sight, hearing, smell and touch) and this is directly represented in the cognitive field.

Indirect observation occurs when man calls to any physical means to facilitate and streamline the observation of a phenomenon, situation or any object in the physical environment. This is the characteristic of current systems that rely heavily on technology for observation and study. For this reason, perceptions can be subject to misinterpretation because of the quality of technical means to play true reality.

Data is represented by individual facts, concepts or instructions in the appropriate manner for communication, interpretation or processing by human or automated means. Examples of data could be radar signals, sensors recordings, and observations.

In informatics, data is accepted as number, measure, relationship, etc. which serves to solve a problem or, if it is obtained from the research, it will be subject to processing. In the military field the current meaning of the term has not yet been defined and in its widest perception it could be considered as knowledge elements on one event, action, condition or environment that give the owner the possibility of eliminating a segment of ignorance without giving the possibility of an overall, full and accurate understanding about the event, condition, action or environment finite in time. In other words, data can be considered as part of a whole, which in

logical interaction with other data may generate the whole.

In the military, both the information and data are properly defined according to the purpose of the used processes. In addition, their definition should correspond to a degree of common or average understanding, so that each user can be able to distinguish and use them.

Information is the result of data processing and has a form of individual representation. By individual, we understand a person, group, organization or system. Information for each entity has a specific meaning.

Information is the main element of the information field, but it depends largely on other areas. It has the starting point in the physical (data), but the cognitive domain is the one which decides if it is information or not, where it is located and how it should be used.

Knowledge involves conclusions drawn from the model suggested by the information available. Knowing a situation results from the conclusions that can be drawn from the information that relates to the situation. Knowledge exists both in information and in the cognitive fields. Knowledge is gained in the cognitive domain as a result of learning and it is stored in the information field. Loading in the individual cognitive field can be done through several ways including: previous instruction, training or experience; direct experience in the physical interaction with other individuals; interaction with the information.

Knowledge can also be moved from the cognitive field into the information field when transferred to other individuals in the form of instructions or rules for handling or for storage in computers.

Awareness is the level of understanding of a situation in which the decision-maker is fully clear on the current status and future developments in the immediate stages. Assumptions drawn from awareness rely heavily on useful information, the correct understanding of the situation, self-confidence and confidence in collaborators and forces. This stage or process is also called in certain works as the "communion of knowledge" and it is considered to be more than measuring the degree of communion of information.

Awareness refers to a situation and the outcome of complex interactions between past knowledge (and beliefs) and current perception of reality. Every individual has a unique way of becoming aware of the situation. Professional education and training are used for providing the

military with the same updated data, information and knowledge leading to a similar warning.

Understanding involves having a sufficient level of knowledge to draw conclusions about the possible consequences of the situation and a sufficient knowledge of the situation to predict future models. Awareness is focused on what is known from past and present situations, while understanding a situation is focused on what the situation can become and how different actions will impact on the present situation.

Transmitting (pooling) is referred to in other works as "sharing" or "communication" and in essence is the interaction between entities, directly or indirectly, through which they mutually provide data, information, knowledge, understanding, etc. Evolution over time has always depended on the evolution of communications technologies, but in the last decade there was a real revolution in this respect. Thus, starting from peer-to-peer (subscriber-to-subscriber) communication, point-to-multipoint communication has been achieved, based on the existence of networks and information storage centers. For a more correct approach, it is necessary to address this subject according to the subject to be transmitted (the content of the transmission), so we can have at least three distinct segments: the transmission of data and information, the transmission of knowledge, and transmission of understanding.

Transmitting information

Sharing information is an interaction that can take place between two or more informational entities (these can be people, databases, or programs).

The ability to share information is essential in order to develop a stage of common knowledge as essential for collaboration and / or synchronization.

Many entities may be involved, and the form of transmission of information may vary significantly. When two or more people are at a short distance, information can be exchanged between them by voice, conversing with each other; other techniques involving body movements, such as hand-made gestures, other gestures can also be used. When two or more people are geographically located at a distance, several types of technology (telephone, e-mail, and teleconference) should be used. Over time, different types of technology have been developed to capture, store and transmit information.

Transmitting knowledge

To some extent, the transmission of knowledge exists in all efforts made by people, in order to work together, and is manifest in the cognitive field.

Instruction and doctrine have been committed throughout history to developing a high degree of transmission of knowledge, warnings among the troops so that they understand and react to situations as indicated. Transmitting knowledge is essential for the independent elements of a force to be able to coordinate their actions and become vital, especially when the forces are trying to coordinate their actions without communication or try to self-synchronize.

The extent to which the transfer of knowledge can be developed has a significant influence on the nature of the command and control, the nature and amount of communications needed to develop and maintain the transmission of warnings, the ease and the degree to which the forces can be synchronized.

Communicating beliefs

Communicating beliefs is an existing cognitive state when two or more entities are able to develop similar knowledge about a particular situation.

The degree of similarity (or tolerable differences) will depend on the type and degree of collaboration and timing required.

A multitude of factors influence the extent to which a stage of communion can be developed between two or more entities (similarities and differences of views, cultural, language, and interests). Common beliefs are an essential requirement for the ability to synchronize physical actions in the absence of a detailed plan.

Decision is also located in the cognitive field and represents choices, options on what to do.

The widening of the vision of the decision implies the realization of a conceptual model of the mission space regardless the level at which it manifests itself.

Although decisions are described as the outcome of the understanding, they can be clearly taken in the absence of any understanding. For this reason, the military is trying to support command and control processes through more technical means that can bring more

data and information so as to minimize the degree of ignorance and thereby reduce the risk of decisions in situations of uncertainty.

Action takes place in the physical field and is determined by cognitive decisions. The decision can directly trigger a new action or continue one already in progress by modifying its parameters. The action may be decided by a higher level following a decision followed by an order (information) or on its own initiative as a result of its own deliberations.

The individual level of knowledge influences the level of awareness, understanding degree, and decision-making process.

Collaboration is a process that takes place between two or more entities in the cognitive domain and always involves working together to achieve a goal. This feature gives distinction to the mere common data and information, knowledge or beliefs. Collaboration requires the ability to have communion of information.

Collaboration involves sharing data, information, knowledge and perceptions of certain facts and situations, assuming the work of all actors pursuing a common goal.

In order to understand precisely the meaning of the term, one must first mention what collaboration is not:

12.Sharing, from the very beginning, data, information or knowledge without aiming a specific purpose.

13.Making them public / distributing them to certain users.

14.Exchanges of information that do not contribute to a common purpose (i.e. Routine reports of a unit's situation or punctual reports of enemy activity are vaguely linked to common objectives).

These are simple sharing and transmission situations.

Collaboration requires active communication and work together. The classic military example is the collaboration (cooperation) plan, in which actors with different areas of responsibility simultaneously pursue the same objectives of the missions.

The purpose of collaboration is to allow a similar understanding and perspective on the situation, together with synchronization, in order to organize the activities optimally so as to avoid redundancies or reciprocal impediments, and to achieve a synergic effect.

Collaboration involves several facets, such as: *time required continuity, scale, density of information, domain, structure, role of the*

participants and manner of interrelating them.

In many military situations, collaboration is difficult or sometimes even impossible without specialized technology. That is why, although collaboration is omnipresent, its quality is determined by a number of factors such as: leadership (organization of collaboration according to priorities and then commander tries to impose some kind of interaction), organization, doctrine, training, experience and stability of TTP (Tactics, Techniques and Procedures) of force.

Involving those responsible for managing and supporting operations, this allows for the consideration of several unforeseen situations that can occur. Collaboration in the decision-making process can lead to better choices in complex issues and to improving the connections between planning and execution, in the conditions of an operating environment in which changes occur rapidly and under stress. Their collaboration can have maximum efficiency when:

- All important actors are involved to fulfill the mission;
- It is carried out throughout the mission at all command levels;
- There is an interconnection between all team members;
- Communication between collaborators is not restricted;
- It is participative (all actors are involved in processes);
- It is continuous;
- The activity done by each team member is synchronized with that of the others;
- The team has good information;
- The team has effective means of communicating images, information and data;
- It takes place on both information and cognitive level;
- All collaborators have a strong motivation to accomplish the goal pursued. First, collaborators need to agree on the importance and legitimacy of the goals they have to pursue. If actors do not consider this goal legitimate and important, they are not motivated to work together or to make investments (time, information, and energy resources) needed for success;
- Actors have at least a minimum of general knowledge about goals, if not expertise;
- Collaborators have competence in using technology and trust in the

technology used;

•The participants know and get on with each other; this involves similar or compatible levels of training, education, culture and experience.

If failing to meet these conditions, collaboration is impossible, and major dysfunctions may occur. Instead, with a unanimous agreement, the parties can organize effective debates. The technical and cognitive communication capacity involves, on the one hand, the related apparatus and on the other hand a common language about a certain problem.

Collaboration is different depending on the environment, so three types of collaboration can be distinguished: information, cognitive, and physical environments.

Collaboration in the information field offers the possibility to create a common perception of the battle space by sharing data and information. Collaboration in the information field is the basis for creating a common operational picture and self-synchronization.

Centralized information accessed by users in the grid of actors (fighters) can be viewed from multiple perspectives, which will allow the identification of patterns and anomalies, with beneficial results for the ability to predict the way events evolve subsequently. This will have positive effects on decision-making, reducing the risk of false alarms and misinterpretation of data and information. Finally, faster data transmission, through automatic data processing, allows faster integration of new data and knowledge of the battle space. Essentially, as it often happens in the Information Age, the speed of the command is crucial.

Information sharing cannot be carried out without some costs, most of which will be allocated for the purchase of computer technology. Obviously a highly important role will be played by information security systems, which, in addition to be costly, could become aggressive, and sometimes if they are poorly configured, they can generate delays or refuse to allow access to information resources.

Collaboration in the cognitive field may vary a lot, depending on the language of the collaborators, the level of education and culture (national or organizational), their level of involvement (motivation), trust in the collaborative environment (including their ability to use it when technical capabilities are required) and possible common work experiences from the previous period.

The potential benefits of cognitive collaboration are enormous. A better understanding of the military situation and the factors that drive it are the most obvious benefits and correspond to a common understanding of the problem. The opportunity to plan through collaboration is also essential.

Collaboration in the physical field is actually the synchronization, which is defined as a separate concept of command and control.

Synchronization takes place in the physical field and is the most important arrangement of things and effects in time and space, and is the result of detailed planning and conscious coordination or collaboration. However, synchronization may also be the result of convincing communion about a situation that provides adequate guidance for action.

Synchronization is defined as "*an arrangement of things in time and space around a goal*". In a military context, synchronization can be thought of as "*those results characteristic of command and control (C2) processes that continuously arrange and adapt the relationships between actions (including movement and missions of the force) in time and space in order to achieve the goals*". This characterization of synchronization involves at least three important properties.

First of all, synchronization occurs in the physical field, after which it is necessary to merge all fields (cognitive, informational, and physical). Because the speed of the decision-making process and the flow of information in relation to the C2 processes increases, the dynamics associated with the force elements in physical field will define the limits of synchronization in all fields.

Even when force elements are predestined for higher speed, it will be limited all the time because people cannot move at the speed of thought or information.

Secondly, achieving the required degree of synchronization will need an organizational C2 design at a level of centralization or decentralization that ensures the appropriate degree of direction and flexibility for various types of environment, missions, troops and information support capabilities which need to be reconsidered.

Thirdly, synchronization often involves both vertical and horizontal alignment. It requires vertical alignment across multiple organization echelons and aggregation / des-aggregation of activities that are of interest to these echelons in order to ensure that tactical actions are consistent with

the higher operational level and can relate to strategic goals. Horizontal alignment takes place across multiple dimensions of C2 processes, including those associated with different organizations and functional areas, with different types of forces and portions of mission space.

Synchronization is an increasingly important concept, but getting it becomes a great challenge for a number of reasons, such as increasing complexity, greater than ever heterogeneity and a rapid rhythm of events.

The traditional means of achieving synchronization are those resulting from the development and promulgation of doctrines, tactics and procedures. Extensive education and training can be used to create a culture of teamwork based on a common understanding of the mission, the means to fulfill the mission and the language for applying these means.

3. Final Considerations

In response to technological advances, especially in the field of information and communication technology, the so called revolution in military affairs and later the concept of Network-Centric Warfare emerged as a theory to further utilize technology for military command and control. The concept of Network-Centric Warfare has made claims and assumptions that future technology will improve mission effectiveness by, for example, increasing the understanding of a current situation and its development, the speed of command, and providing means to use more efficient forms of organizations.

The implementation of Network-Centric Warfare concepts in the military systems of NATO member countries will consume considerable resources over the coming decade. Consequently, being able to measure progress, or otherwise, the NCW implementation, is of significant importance for future systems engineering, testing and evaluation.

The most effective consequence of Information Age paradigms is the occurrence of deep changes in various fields including the war environment. The growing complexity and diversity of recent war missions, tasks and also methods have deeply affected the Command and Control structure. In fact, various missions in the war framework require faster and more flexible plans where the traditional central and hierarchical C2 structure is not suitable. Threat-based development instead of strength-based development is among the traditional C2 properties which results in lack of flexibility and

planning. In the trade C2, the innovation and creativity of people are restricted and therefore there is no guarantee for a smart response to the environment change. Also, there is neither agility nor fast movements and it is hard to plan complex operations in the right place and at the right time.

The Network-Centric Warfare is a good substitute the traditional C2, since NCW is a distributed warfare which is capable of overcoming the main obstacle the traditional C2 is faced with for developing a robot information infrastructure, increasing qualified information, upgrading shared awareness, cooperation and also self synchronization.

BIBLIOGRAPHY

*** - JOINT VISION 2010

*** - JOINT VISION 2020 – Chairman of the Joint Chiefs of Staff, Director for Strategic Plans and Policy, J5, Strategy Division

*** - NETWORKED ENABLED CAPABILITY – An Introduction, Ministry of Defence (United Kingdom), Verson 1.0, Aprilie 2004;

ALBERTS D., GARSTKA J.J., *Hayes Richard E., Signori David A. – Understanding Information Age Warfare,* CCRP Publications, August 2001

ALBERTS S.D., GARTSKA J.J., *Network-Centric Warfare – Developing and Leveraging Information Superiority,* Center for Advanced Concepts and Technology C4ISR, 1999

DUMITRU C., *Comanda şi Controlul în Războiul Bazat pe Reţea,* Comunicare ştiinţifică la Universitate Naţională de Apărare, Bucureşti, 2005;

DUMITRU C., *Concepţia C412SR în Armata României – proiecţii principale,* Sibiu, Revista Comunicaţiilor şi Informaticii, nr.5/2005;

DUMITRU C., ROCEANU I. – *Războiul bazat pe reţea, provocarea erei informaţionale în spaţiul de luptă,* Editura Universităţii Naţionale de Apărare "Carol I", Bucureşti – 2005;

DUMITRU C., *Sistemele de comunicaţii şi informatice ale Armatei României,* Sibiu, Revista Comunicaţiilor şi Informaticii, nr. 4/2004;

DUMITRU C., *Sistemul Informatic Integrat al MApN*, Comunicare

ştiinţifică la Centrul de Studii Strategice de Apărare şi Securitate, Bucureşti, UNAp, 2005;
ROCEANU I., ILIE A.V., *Conceptul de Război Bazat pe Reţea în cadrul acţiunilor NATO,* Bucureşti, Editura UNAp, 2004
ROCEANU I., *Războiul Bazat pe Reţea – dincolo de tehnologie,* Comunicare ştiinţifică la Centrul de Studii Strategice de Apărare şi Securitate, Bucureşti, Editura UNAp, 2005;

Web-references

http://www.c3i.osd.mil.\NCW.\
http://www.dodccrp.org
http://www.federal.hyperwave.com/solutions/
http://www.mapn.ro/strategiasecuritate
http://www.mors.org/publications
http://www.oft.osd.mil/initiatives/ncw/ncw.cfm