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# COMMAND AND CONTROL SYSTEMS – MODERN STRUCTURES, EQUIPMENT AND TECHNOLOGIES

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**Abstract:**

The command and control systems are constantly adapting, resizing and developing relating to the technological evolution and to the changes which happened in the physiognomy of military operations.
In this context, the command and control systems become more complex and efficient, both through the quality of the military command personnel and command and control systems architecture, which integrates and interconnects high-performance equipment and means.

*Key words: the command and control systems; variable geometry; capabilities; technology; cognitive computing.*

## 1.Introduction

Military command and control (C2) systems are the functional structures that enable military organization to plan, conduct, evaluate and coordinate military operations. Those systems require two processes, the command process and the control process.

While the military conflict changed from its classic forms, the functioning of the C2 system evolved as well. The conflict with variable geometry, the last known evolution of the conflict, had many different forms, "peaceful revolution" and "civil war" to " war against terrorism" and "extended international conflict", with multiple state and non-state actors being involved [1]. According to some authors, this is a "Fourth generation conflict" which means there is at least one non-stat actor involved along other state actors [2].

Proxy war is another term that has been used recently. This is a conflict waged by two powers (armed forces, state actors) through middle parties (interposed) on the territory of another one[3]. Within this type of conflict, the opposing powers are not directly engaged against each other, but through interposed state or non-state actors.

Regarding this, I believe that an extension of the C2 system is required, expanding from managing military operations to managing political-social-economic and military operations using a system or a system of systems. The requirement for the C2 evolution follows three major directions: the use of new technologies, the multinational character and the expansion of the operations in all fields of a conflict. The command and control system needs to permanent adapt to the new types of conflicts, and its architecture needs to be built according to the technological evolution, using the latest generation equipment and artificial intelligence.

## 2. Control command structures

Nowadays, the conflicts are more and more complex and evolved, based on technological evolution and power of information. Acknowledging the present conflicts, the vulnerability of the command control system may come from within, while the threat, the danger, the risks are external.

The actions specific to contemporary conflicts are an argument for the multidimensional character which creates a permanent shifting geometry by adding or by consuming / disappearance of one or more reference axis.

The dimensions of the conflict are operations conducted in all environments: physical (land, air, maritime and space), cyber or virtual space, information. This fact also contributes to the multidimensional character of the modern conflict.

All in all, the command and control system needs to become an entity with a complex architecture, capable to manage all types of operations that are being conducted in all environments and dimensions.

Along its interconnected elements (C2 structures, information subsystem, communication subsystem, IT subsystem), the command and control system needs to sum up a complex of management activities related to information, procedures, equipment and auxiliary means, used by the commander to conduct operations. Conflicts with variable geometry require a command and control system organized on different modules, command, control, communications, computer, cooperation, information, interoperability, surveillance and reconnaissance – C5I2SR.

New unique infrastructure solutions are required to be developed, along with the possibility of interconnecting multiple different state operational headquarters, command and control systems, versatile and deployable, with the capability of implementing sensor and forces monitoring systems, modern location and navigation capabilities that enable the detection, surveillance, target acquisition and even more.

My opinion is that through integrating and interconnecting present systems with new ones, valuable new services and information may be acquired, adding the possibility of using artificial intelligence too.

## 3.Modern equipment and technologies enabling command and control

The environments of the modern conflict are more and more complex, more evolved, based on technological evolution and on the power of information. Planning for a common objective by multiple conflict actors requires information exchange, similar procedures and common planning, requirements that at strategic level are often met with difficulty [4]. In this situation, the strategic level needs to manage the situation. The planning process in multidimensional environment, with risks and threats specific to a conflict with variable geometry generate new challenges both to civilian and military actors. The military situation and its evolution, along with other minimum necessary information can be used in shorter time and enable a prompter reaction, adequate to ever shifting situations of a modern conflict.

The advanced command and control system (AC2S) developed by the Czech Defense University in 2017, represents a concept that uses modern technologies in order to increase military operations efficiency. This system enables a relatively new architecture of the system, communication, computer support concept and decision process. Tactical decision support system (TDDS) is a part of the AC2I. This system supports the commanders in the tactical decision process by using models/ patterns.  AC2I develops the concepts of using computer support in the decision process.

Researches in the use of the artificial intelligence analysis of information based on the technological support of the decision process enable increased efficiency of command and control. Decision support systems (DSS) represent an instrument to exchange information, to analyze and to discover other information that may enable optimal mission planning. Advanced DSS is capable to propose and to analyze possible options to fulfill the intent of the commander to asses to probability of success and to warn against the potential threats [5].

AC2IS architecture is composed from three types of elements: headquarter, armed forces and robotic systems (equipment), each one has its role and missions. The headquarter is the main control center with the following functions: assessment of the situation / situation awareness, operation planning and control, information collection, analysis and dissemination using adequate tools, command and control of the forces, unmanned vehicles and robotic equipment, communications with higher.

The forces are equipped with the tactical decision support system (TDSS). Unmanned vehicles and robotic equipment and may be included as long as they are compatible with the architecture (UAV- unmanned air vehicles, UGV- unmanned ground vehicle, AUV- aquatic unmanned vehicles). The high precision attack systems are connected on a wireless network in order to share information with the headquarters. AC2S is modular. The system may be configured in order to be compatible with any type of operation, military or nonmilitary. Any type and number of available vehicles may be included. The personnel and equipment needed for the operation can be set according to real requirements. Wireless connectivity favors all these elements. Nevertheless, only status information and control messages can be transmitted. This is one of the capabilities of the system that needs to be improved.

The Decision Support System (a subsystem of the AC2S) is fully capable of understanding the plan, if there is an adequate model of tactics to be employed. The system can create optimal solutions and options to solve the problems by analyzing the situation, the conditions and the effects. The courses of actions are displayed and the commanders decide what solution to choose, having the option to combine any of the available solutions. The personnel and the robotic equipment execute the decision. Each element knows its role, activities and tasks.

TDDS has real time, 2D, vectorial and raster geographical management capabilities of the operational area. It represents a support for multiple grid systems (geographical, WGS84/UTM, MGRS), has geographical analysis capabilities (for example the analysis of the topographic objectives, direct and 360 visibility) [6] and incorporates advanced military tactics patterns / models (five advanced tactics models: units optimal maneuver in the operation area, optimal logistics model for units, UAV optimal recce model or ground based assets optimal recce model). [7]

Having in mind the risks and the threats associated with the conflict with variable geometry, the tactical modular systems need to be expanded to operational and strategic level in order to achieve the necessary capabilities required for an efficient management of the challenges arisen by this type of extended conflict. This is why the development of such a C5I2SR type of system is required. The present confirms that advanced technologies enable information flow in multiple domains such as: force command and control, common operational picture and common operational understanding), information, surveillance, reconnaissance, tactical, operational and strategic planning, air and antiaircraft defense situation, joint fires and target management, effects management, maneuver and synchronization, information operations, force protection, resources management, medical assistance, etc. The command and control system required in a conflict with variable geometry need to expand its interoperability, macro surveillance and reconnaissance at least at regional level, if not globally or extraterrestrial, in all the environments of the conflict.

It is the moment when artificial intelligence becomes a necessity for the cyber systems. It should base on integrated analysis of all conflict situations along vast periods of time, in order to generate anticipated evolving combined conflict models to be managed before real situations become unmanageable.

Technological development does not exclude the human factor. The human factor remains the most important one in the decision making process, supported by an adequate command and control system. The personnel manning these technologies allow the information to be fed to commanders.

## 4. Artificial intelligence – future command and control systems integration element

This is the beginning of a major paradigm change, effect of remarkable scientific discoveries within the last decades; a step where information has become the main point of PMESII activities. The future command and control systems enable computers to assume active roles, not just passive ones. This new model is possible due to the artificial intelligence. The central role is no longer represented by the passive information but by the dynamic information. The C2 system's architectures and their computers are to get a new capability, the one to learn. The new challenge within the command and control paradigm becomes the „*cognitive computing*" [8]..

Nowadays, there are computers and devices that are capable of developing their own learning capability. These can be used both in planning and conducting military and non military operations specific to latest generation conflicts. Nick Bostrom, in his book „Superintelligence: Paths, Dangers, Strategies" is detailed describing the way artificial intelligence systems evolved. Alan Turing developed the concept of „child-machine" which, by learning, could in time become a computer with a high reasoning capability (specific only to human). In his book, Nick Bostrom launches the hypothesis that in order to build an artificial intelligence system, another extremely evolved and intelligent system is required, with a very high information processing capability. For example, in order to simulate and understand the evolution of the human nerve system using a computer, we would need 1031-1044 FLOPS. The most powerful computer in the world, own by China, with a processing capability of 3.39×1016 FLOPS would not be powerful enough for such a simulation.

Future cognitive systems will learn permanently using databases generated by a vast array of sensors and other systems [9]. This is „bug data", at organization level networks, statewide, region wide or global. Related to the command and control, regardless of the structure, level or domains, the cognitive systems will build scenarios based on relevant hypothesis and contextual data, offering possible courses of actions or in some circumstances even taking their own decisions directly impacting current operations. The quality of these decisions does matter. A sufficient amount of data, generated by intelligent systems and sensors and other developed instruments to understand those will leads to the emergence of collective intelligence. Collective intelligence represents the most important effect of common use and information share by both humans and computers. Engineers involved in the development of the new technologies say this present „partnership" with computers and the future one with the cognitive systems represent one of the most important steps of human adaptation to information technology evolution [10]. Is the augmentation of the computer systems or the augmentation of the human senses, or both, required? Which is the optimal solution to build complex command and control architectures? Is the symbiosis human-machine a future solution? Humans have limited senses, but technology may expand those. All sensitive and learning systems, regardless of their human or artificial nature, have a common point: starting with the stimuli/ data, information received by the sensors/ receptors, the intelligent devices have the capability to understand the world. The next step is that the systems to model the information they receive, to order it and to virtual build real life elements. This represents the point in which the cognitive systems start the progress. Along the capability of executing commands, the cognitive systems will have a sufficiently large capability of acting independently. The computers and future devices will integrate and analyses information from different sensors, and simultaneously developing their learning capability. Present computing systems have a limited information analysis capability compared to the human brain. The chip that cognitive systems will have will reproduce the functioning of a human brain. For example, IBM has built a chip named "Neurosynaptic chip", that mimic the functions of a human brain. This chip has the capability of simulating 1 million programmable neurons, 256 millions synapses and over 4000 neurosynaptic cores. This technological leap, along with nanotechnology discoveries will lead to achieving cognitive systems, with a surprising high processing capability, similar ti the human brain, capable of learning and dynamically reprogramming, while interacting with the environment. This is the level all command and control systems want to achieve in efficiently managing crisis and latest generation conflicts – those with variable geometry.

## 5. Conclusions

Technical evolution enables the building of command, control, communications, computer, cooperation, information, interoperability, surveillance and reconnaissance systems – C5I2SR, and even more.

Information technology is defining the present, but the social behavior is giving its current form we perceive. The digital evolution is based on permanently mixing current technologies, on validation and rapid implementation of new technologies, sometimes even in early stages of development. The digital evolution and transformation had a major impact on the full spectrum of military operations. In order to remain competitive, the command and control systems had to change C2 structures and architectures based on current requirements of the conflicts with variable geometry, using the effects generated by the digital revolution.

The systems based on artificial intelligence will attempt to anticipate our intentions and to offer options before we need them. An important process of information systems based on artificial intelligence is the "cognification". The cognitive process needs to be directed. Some of "enclosed" intelligent systems (mainly those used in the national/regional or global security systems) use only what they are fed from or can be connected to big data type databases and are protected against unauthorized dissemination outside own command and control systems.

What they are currently missing to the artificial intelligence systems is the consciousness. Information technology and digital evolution accelerate the rhythm of dematerialization, by facilitating the leap between goods and services.

The products are transformed by the artificial intelligence, and we start to perceive the consumption as a service because our interaction to the technology has transformed. The digital transformation led to the current army most fundamental needs – the immediate availability of services and products. The most competitive models are represented by platforms. The advantage of the platform is that they generate ecosystems which enable the use of services and products. The global economy is dematerializing step by step, and the capability to create a resources mix will influence the most PMESII environments.

Technological development does not exclude the human factor. The human factor remains the most important one in the decision process, supported by an adequate command and control system. The personnel manning these technologies allow the information to be fed to commanders.

Researchers have developed artificial intelligence based on the principles of a human brain. It has algorithm and synthetic analytic capability and can rapidly generate solutions needed in decision processes. Commanders are offered in a relatively short time already analyzed courses of actions based on existing databases. The decision will be much quicker, regardless a system generated, an intuitive or a mixed course of action is being followed. Essentially, the human factor has the most important role.

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