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CONSIDERATIONS ON THE IMPACT OF ARTIFICIAL INTELLIGENCE ON MILITARY ENGINEERING OPERATIONS

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Abstract: *Contemporary society is going through a period of deep transformations generated by the emergence and implementation of advanced technologies. Of all these, Artificial Intelligence (AI) stands out as having the greatest potential to generate profound changes in postmodern society, with strong implications in most areas of social life, especially in military competition. War, a social phenomenon of major relevance to human communities, is no exception to this reality, and artificial intelligence (AI) represents a "potential game changer" in the field of leading and executing military actions, with the possibility of introducing significant adjustments in the principles, rules, methods and procedures of preparing and conducting military actions, at all levels - strategic, operational and tactical. At the same time, the rapid growth of the global population, together with the phenomenon of increased urbanization, makes the urban environment one of the main environments in which the military operations of the future will be carried out. The complexity and high degree of difficulty of such environments (multi-layering, reduced mobility and high vulnerability of forces) bring with them various challenges for engineering support operations. For this reason, adjustments are needed at the level of operations planning, endowment with autonomous systems and equipment, as well as at the level of the selection process, recruitment and training of human resources.*

Keywords: artificial intelligence, military engineering equipment, military engineering operations

1. Introduction

The implementation of advanced technologies in the military field, the growth and trend of demographic growth at the planetary level, migration, the phenomenon of increased urbanization, terrorism as well as other security risks and threats generate direct effects on the contemporary operational environment giving it a complex, fluid character, but above all digitized.

From the analysis of the peace-war continuum, where violence registers certain variations, from the state of peace to that of war, it can be stated that the range of military operations and implicitly the extent of the requirements for military engineering operations can remain constantly high. Therefore, there is a great need for engineering operations involving the execution of the full range of engineering missions/tasks to provide a varied and sufficient palette of actions in support of military operations. In other words, it can be said that intelligence operations, as a component of any military operation, were, are and will remain indispensable both in the conduct of major military operations/campaigns and in crisis response operations.

The planning of engineering operations is based on information collected by specialized structures and not only by sensors that, in certain situations, may be

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incomplete or inaccurate. This can lead to planning errors and ultimately mission failure. Implementing a planning process supported by innovative technologies (artificial intelligence-AI) could eliminate many of these shortcomings. Also, digitizing the engineering operations process can improve operation preparation and execution times, operational performance, and possibly reduce sustainment costs.

At the same time, contemporary engineering operations incorporate varied areas of expertise, such as environmental protection (EP), military reconnaissance, as well as infrastructure management. Significant support is also provided for countering improvised explosive devices (C-IEDs), providing utilities (electricity, water, etc.), clearing routes, setting up force camping areas, as well as explosive ordnance disposal (EOD) [1]. The multitude and variety of military engineering operations must be accomplished in a complex operational environment that requires both increased protection of own forces and constant situational awareness to maintain effectiveness of pace and maneuver. Limiting the assignment of personnel to high-risk tasks (e.g.: intelligence reconnaissance of terrain and enemy, protection of bases and overcoming/removal of obstacles, etc.), will significantly increase the battlefield survivability of intelligence structures. An effective way to increase force protection is by assigning high-risk tasks to unmanned vehicles or sensors. Beyond this, to reduce personnel costs and overcome unexpected enemy reactions, a new challenge arises, to make these vehicles semi-autonomous or autonomous.

Harnessing the innovative potential of innovative technologies such as artificial intelligence-AI requires military structures to identify, recruit and train an adequate human resource with digital skills.

2. The Influence of Artificial Intelligence in the Planning of Military Engineering Operations

The innovative technologies, like as artificial intelligence, that began to be implemented, in the military field, from the beginning of the 21st century determined the triggering of a process of accentuated digitization of the contemporary operational environment. In this context, the armies of the NATO states, in general and the Romanian Army, in particular, are obliged to establish as their priority objective the winning of the information war. To support this objective, the Romanian Army will need software systems that provide a common digital image in a continuously dynamic battlespace. At the same time, digitization will provide information on the impact of the battlespace on operation planning, enable situational awareness, synchronized battle management, as well as provide advanced support for decision-making and execution of various phases of the operation.

The abundance, almost to the point of saturation, of information in the contemporary operational environment gives it a high degree of complexity due to its high level of uncertainty and redundancy. Under these conditions, "military planners must be able to plan based on incomplete and sometimes inaccurate information" [2]. At the same time, they must be able to obtain information about the status of ongoing operations and also must be able to use all this information to adjust plans according to the dynamic nature of current operations. Consequently, the operational planning process, carried out in the new context, despite the fact that it is led by highly qualified personnel, is relatively slow, cumbersome and rigid. Also, it implies frequent disagreements significantly with look to the likely actions of the adversary, anticipation of resource consumption, as well as to the final result of the operation. Many of these disagreements arise due to differences in mental models and assumptions which stay to the base participant to trial. The planning and execution of military engineering operations involve the performance of numerous independent tasks, with the involvement of heterogeneous structures and equipment, which gives the two processes a high complexity. For this reason, timing engineering operations is difficult to achieve.

Implementation of a planning process of engineering operations based on artificial intelligence (computational intelligence - numerical modeling of biological intelligence), as it can be noticed in figure no.1, may represent a viable solution to all these challenges. "In many circumstances AI systems can quickly and efficiently analyze a situation and make the best decision in a critical situation" [3].

Thus, it would fall to the military engineering planners to establish the key tasks, and the software should solve the following operations:

- the automatic analysis of courses of action and the establishment of tasks for each subunit/own military engineering unit, taking into account their assignment in other missions;
- anticipating the enemy's actions, as well as his reaction to the actions of his own structures;
- developing countermeasures to enemy actions;
- analysis of mobility lanes and provision of data on obstacles, as well as on the possibilities of bypassing/removing them;
- estimation of synchronization requirements;
- assessing the risks of military engineering operations and formulating proposals for its management;
- assessment of the consumption of material resources and the need for replenishment.

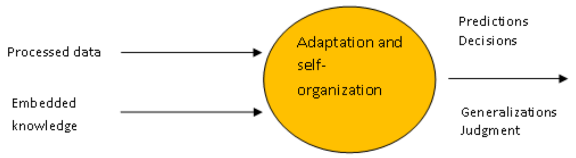

Figure 1: Computational intelligence in the decision-making process

As a result, the use in the planning process of technologies based on evolutionary algorithms such as "neural networks" and "genetic algorithms" would make it possible to collate and combine the available information, assign the planned tasks to the military engineering structures available to fulfill them in the allotted time. Thus, the planning time of engineering operations would decrease and at the same time, an increased efficiency in the use of human and material resources would be achieved, avoiding overlaps and the existence of redundant tasks.

3. Implementing Artificial Intelligence within Military Engineering Equipment

Military engineering operations, within a joint military operation, have a significant weight and at the same time represent a multiplier of the combat capacity by executing the missions of mobility, countermobility and maintaining the operational capacity of the forces. These involve the execution of a large volume of tasks that involve a high consumption of time and resources, as well as the exposure of the personnel involved to multiple and various risks. One way to reduce these difficulties is to equip engineering structures with modern (automated or autonomous) equipment that incorporates elements of artificial intelligence and is capable of performing a wide range of tasks within the scope of engineering support missions. The delegation of tasks to these types of equipment will increase generating an augmentation in the degree of mission accomplishment in a particularly complex operational environment.

An analysis made, more than a decade ago, by NATO military specialists [4], regarding the ability to fulfill missions, highlighted the fact that the existing Military engineering structures are insufficient, and those that exist are not equipped with sufficient and adequate capabilities to carry out the engineering support missions/tasks, which means a major capability deficit for them. Also, the analysis highlighted the fact that the existing equipment is mostly outdated and requires completely new solutions, adapted to the threats and challenges manifested in the current operational environment [4].

The establishment of military engineering capabilities and more, able to respond to the challenges related to the fulfillment of specific missions/tasks, in the context of the current security environment, represented one of the main directions of action to reduce the identified deficiencies. Aware of the seriousness of the problems facing the transatlantic world, the heads of state and government, at the NATO Summit on June 14, 2021, which took place in Brussels, adopted the NATO Agenda 2023 and also agreed to launch the Innovation Accelerator in the Defense for the North Atlantic domain (DIANA) [5]. The purpose of DIANA is to encourage transatlantic cooperation in the field of critical technologies, to promote interoperability between allied forces and to leverage civilian innovation through collaboration with academia and the private sector. Thus, there is a favorable premise that, at the level of the Alliance, new engineering capabilities will be created that will be able to execute, in the most demanding scenario, the entire range of missions, for the implementation of a large-scale military campaign, which involves the defense operation collective.

Research efforts regarding the development of military equipment are mainly oriented towards meeting the requirements of replacing human personnel, for the execution of missions with an increased degree of risk in environments difficult to control, increasing the yield for the fulfillment of military engineering missions/tasks. Thus, the realization of semi-autonomous or autonomous equipment, which incorporates advanced technologies, capable of fulfilling missions/tasks such as: execution of passages through explosive and non-explosive dams, execution of destruction works; zone/route refusal; military reconnaissance; release of routes; execution of campaign fortification works; military engineering reconnaissance; explosive threat management; extinguishing fires; CBRN support; search and rescue (S&R) support is a basic requirement for the provision of allied engineering structures [6].

It should be noted that, currently, engineering structures in the armies of NATO countries have equipment capable of executing, by remote command, reconnaissance missions, research, neutralization of ammunition and improvised explosive devices, fortification works, etc. They have technical characteristics that allow the transportation of heavy loads, the execution of force protection works, visibility in hard-to-reach areas, as well as to operate in all conditions of time, season and weather. The most representative of these are:

"SEARCHER - equipment used for: Demining, Reconnaissance in hostile/difficult environment, EOD support to C-IED, Search and rescue in consequence management, MILENG support to Environmental Protection" [4].

"DONKEY - equipment used for: Safe transportation of CLASS V (mines and explosives), transportation of heavy equipment for general support engineers, continuous supply during logistic bridge building operations. Earth moving works (use of autonomous convoys)" [4].

"WINGMAN - equipment used for: Earth moving works, support to C-IED (route clearance), engineer recce tasks, support to Force protection as sensors for protecting an area, MILENG support to Environmental Protection" [4].

"HUNTING-KILLER - equipment used for: Engineer recce tasks in non permissive environment, protection of infrastructure (MILENG support to Force Protection" [4].

The challenge will be to transform these semi-autonomous vehicles into autonomous ones in order to reduce the number of soldiers assigned to perform missions/tasks, as well as to find suitable solutions to combat enemy actions.

Autonomous systems are systems that perform probabilistic reasoning based on a set of inputs, i.e., unlike automated systems, if given the same input, an autonomous system will not necessarily produce the exact same behavior every time. Instead, such a system would produce a range of behaviors.

Human intelligence generally follows the sequence of "the perception-cognition-action-information processing loop" [7]. It involves an individual noticing something in the world around them, thinking about what to do, and then making a decision after weighing the options. Artificial intelligence is programmed to perceive the world around it through computers and then process the incoming information to perform actions similar to humans by optimizing and validating algorithms to make action choices.

An NC-AGV Network-Centric Autonomous Vehicle [4], in order to perform engineering tasks, will have to perform some basic functions, namely:

- to move autonomously;
- to perform engineering tasks and missions;
- to interact within a network-centric model, with other equipment or command centers;
- to be able to solve conflict situations.

From the analysis of the general and specific functions that must be performed by an automatic/autonomous military engineering equipment, its general structure can be determined (figure 2), composed of the following main systems:

- sensory system (provides information about the external and internal environments of the equipment)
- the command and control system (consisting of a computer that collects information from sensors, processes it with the help of optimization and verification algorithms, and finally determines the type of action to be executed)
- action system (includes the locomotion subsystem and the manipulation subsystem) [7].

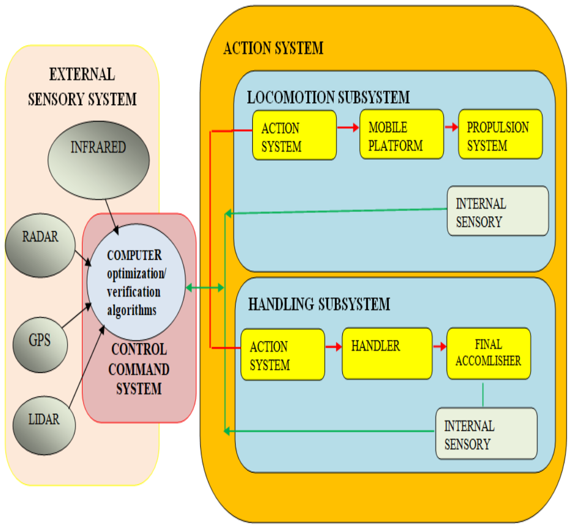

Figure 2: The general structure of an autonomus engineering equipment

4. Particularities regarding the Recruitment and Training of the Future Human Resource in Military Engineering Structures

Digital transformation in the military in general and within engineering structures in particular is not just about simply having the latest technology, the military needs skilled personnel with the right digital skills to optimize, fully adapt and apply innovative technologies. As Dr. Raj Iyer, CIO, US Army said "Going digital is a mindset, it's a culture change. It's about how we can fundamentally change the way we operate as a military through

transformative digital technologies, empowering workforce and redesigning our rigid institutional processes to be more agile" [8].
The success of the process of implementing innovative technologies in the military field is closely related to the possession of advanced digital skills by the military personnel. This involves redesigning the recruitment and selection system so that highly qualified personnel in the field of innovative technologies can be attracted. At the same time, the human resource recruitment system must be directed towards the discovery of top talents in the digital field. In addition, strategies for training, career development opportunities as well as retention of the workforce with digital skills must be created. At the same time, today's military personnel must acquire the skill sets necessary to embrace and effectively apply digital technology through the development and implementation of new concepts and prototypes for the acquisition, development, certification and deployment of critical skills in AI, science data, cybernetics and emerging technology fields.
A number of initiatives must be considered/conducted across the military to address how the institution will hire, retain, train and deploy the digital workforce of the future. The digitization of the human resource in the army cannot be achieved outside of a solid partnership with the academic environment, allies in the NATO states, as well as with the defense industry. These partnerships will enable the Army to develop a highly capable human resource that can execute its digital priorities. At the same time, training programs for both civilians and military must be established, designed and implemented at the military level, beyond traditional IT, to include how digital technologies can be adopted, implemented and adapted throughout the institution.

5. Conclusions

The execution of multi-domain operations has become a reality of an increasingly digitized operational environment, as the contemporary one can be characterized. The success of these operations largely depends on the success of military engineering operations, which were, are and will remain indispensable in the conduct of any type of military action.
The ever-increasing trends of implementing emerging technologies in the current confrontation space require conceptual, structural and operational updates and adaptations at all levels of the military body, therefore also at the level of military engineer structures.
Therefore, the digitization of the engineering operations process has direct and positive influences on operation preparation and execution times, operational performance, as well as on sustainment costs.
The implementation of a planning process supported by innovative technologies such as AI can represent a viable solution to the challenges present in the contemporary operational environment. Thus, artificial intelligence can constitute a real support for the planning process of engineering operations with direct contributions in the collation and combination of available information or the allocation of planned tasks to military engineer structures.
Technological evolution will enable the creation of weapon systems and military equipment that use artificial intelligence (AI). In general, the newly created equipment will have as its main purpose the reduction of the number of soldiers engaged in the fulfillment of missions/tasks, as well as to find suitable solutions for combating the actions of the enemy.
The creation of a robust recruitment and selection system, the design of training programs based on digital career models, as well as partnerships with academia and industry are prerequisites for building an army whose personnel are digitally ready,

adaptable, with an innovative spirit and possessing the full range of digital skills required. At the same time, the Army must identify and cultivate the necessary skills by encouraging innovation and continuous learning so that the human resource can keep pace with the ever-changing technology.

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