



SPECIFIC PROCEDURES TO INCREASE EFFICIENCY OF THE DECISION-MAKING PROCESS IN THE CONTEXT OF THE VARIABLE GEOMETRY CONFLICT

Col. Cezar POPA, PhD Candidate*

The risks and threats specific to the permanent geometry change of an action/operation in the context of the current multidimensional operational environment conflict are extremely diversified and undergo permanent mutations. This situation implicitly requires that the command-and-control systems architecture must allow rapid adaptation to the requirements imposed by the frequent situation changes, in the conflict specific analysis domains, namely PMESII (political, military, economic, social, information and infrastructure). The digitization and algorithmizing of the decision-making process carried out simultaneously with the structural and functional implementation of artificial intelligence is the current way of streamlining the decision-making process by exponentially increasing the capabilities of the command and control systems regarding the volume and speed of data and information processing, the interpretation, of the capabilities of structural and functional organization of both the C2 modules and the operating force, of the capabilities to control and evaluate the execution of the action/operation, etc. Algorithmizing and the digitization of the decision-making process combined with the experience, knowledge based intuition and talent/art (specific to the human factor) inevitably leads to making adequate decision aiming to be quickly integrated into operational plans and orders

Keywords: algorithmizing; digitalization; artificial intelligence; intelligent decision support system; expert system; artificial neural networks.

The new emerging and disruptive technologies based on networks, artificial intelligence, quantum technology, big data, etc. are the ones that considerably influence the architectures of new command and control systems. Integrated and interconnected within the command-and-control systems, these new technologies will considerably influence (make more efficient) the planning, the preparation, the execution and the evaluation of the entire spectrum of military operations at any level (tactical, operational, strategic/global – if in the near or distant future such action capabilities are to be reached).

For this reason, I will discuss the specific procedures to increase the efficiency of the artificial intelligence assisted decision-making process, and I will present a model of forecasting the specific and often changing situations generated by the variable geometry conflict.

In designing the new operational models of command and control (C2) through integrated systemic approach, I considered it necessary to provide an answer to the question: "How should

the command-and-control systems architecture be designed to increase the efficiency of the decision-making process and to ensure the successful conduct of conflict-specific actions with variable geometry?"

The current control and command systems have managed these challenges in three ways: reactive (application of a response and reaction plan – through an offensive attitude, which is conditioned by the need for rapid implementation of the plan) (Roman 2017), proactive (the action plan is pre-prepared and timely applied to minimize the effects and consequences) and in a combined manner. I believe that proactivity is main vector in managing the situations and challenges generated by conflict with variable geometry. The challenge lies in anticipation and early forecasting or quick adaptation of plans to changing situations in conflict geometry. I believe that the combined approach is the optimal solution for an efficient management of often changing situations specific to conflict with variable geometry and that this approach becomes effective through AI (artificial intelligence) implementation in the decision-making process, process that takes place at the level of command and control and is built on an entirely digitized architecture.

**Mountain Warfare Training Center
"Bucegi"*
e-mail: cesarp07@gmail.com

The military decision-making process is a *model of analytical planning*, applicable to the entire spectrum of military operations, which establishes the procedures for mission analysis, courses of action development, analysis and comparison, optimal course of action selection, developing and issuing operations plans or orders. The current trend is for this analytical process to have a solid mathematically, algorithmically digitized base and to be supported by artificial intelligence, therefore to become *analytic – mathematically digitized*. The tools and techniques used in the current decision-making process are brainstorming (exchange of ideas), the estimation process, the intelligence preparation of the battle environment, briefings, etc. These tools are constantly diversifying and expanding due to the evolution of technology. In state-of-the-art command and control systems architectures, advanced technology, digitization and artificial intelligence play an extremely important role in the decision-making process. The processing capacity (data and information analysis and synthesis), the ability to analyze and present information in a synthetic form, the ability to provide courses of action based on mathematical - algorithmic analysis, lead to the optimization / efficiency of the decision-making process. The technical and technological expansion at the execution level, allow the high-performance C2 systems to rapidly communicate the decision to the response/execution cells, these cells being technologized and partially or totally robotic.

The predictive scenario regarded as a process of streamlining the decision-making act

Proactive action and combined approach need the predictive scenario to be a result of a process that integrates a large part of the capabilities offered by artificial intelligence, digitization and algorithmization but which is based on expertise (experience, intuition based on scientific knowledge) and the decision of the human factor. The predictive scenario conducted on an algorithmic basis is an optimal way of implementing the decision-making process within the operational planning tailored to the requirements and challenges of the variable geometry conflict.

Completing the steps of the predictive scenario

Achieving a predictive scenario involves the existence/completion of several steps. A first step

is *choosing/naming the analyst*, and requires the build-up of the working group consisting of PMESII (political, military, economic, social, information, infrastructure) expert level personnel and AI (artificial intelligence) - a combined, symbiotic and integrated working group. The choice must be at least predefined (depending on the type of situation that may occur) if not even already set according to a certain timeframe existing expectation (near or further away) depending on the operating level of C2 (command - control) (strategic, operational or/and tactical). The expert level provides the human factor with the necessary solid knowledge of the represented field, the experience and the creative intuition necessary in the analysis and synthesis of important data and information on the anticipated type of situation. AI provides fast access to BIG DATA databases and immeasurably larger capabilities compared to the human brain in analyzing, synthesizing, concretizing and/or abstracting accessed data and information, based on logico-mathematical algorithms. At this point in the creation of the predictive scenario, the experience and creative intuition of the human factor is combined with the analysis, synthesis, concretization and/or abstraction of the data and information generated by AI. The result is the variables that will be subject to *modelling and simulation*.

Step number two is represented by the *cause-and-effect relationship* in the analysis of each situation. A decisive role at this level is occupied by all aspects, similar situations from the past or related to current ones. The databases built and furnished for this purpose are quickly navigated through AI, processed, identified the necessary situations and analyzed comparatively in terms of the cause-and-effect variable. The results are automatically generated based on the working algorithms established and implemented at the AI level. The results can be materialized on landmarks such as situations, actors, actions, space, time, etc. The methods of presenting the results can be mathematical, graphic, analytical, etc. depending on the analyzed situation. The purpose of these analyses is to identify the generating sources of situations and actions, their evolution in order to obtain a prediction about possible and probable subsequent changes. Templates can be set up if the actions/situations have a degree of repetitiveness.



This does not present the guarantee of a templated, repetitive future, but it can be a starting point for the next step of the predictive scenario (determining the unknowns). At this point in the scenario, all the elements that can influence the forecast are integrated in order to discover the determinants of the operational environment and to form the complete situational images (PMESII level).

Step number three is the *determination of the unknowns*. AI has an important role, again. Current IT systems (continuously improved) have substantial modeling and simulation capabilities. Experts and AI interpret the results of the simulations and modelling, using the variables determined in the first step and already introduced into the system. Analysts (the panel of experts and AI) are currently estimating data with high uncertainty. The estimate is conducted in a dynamic context, generated by high-stakes situations that need to be anticipated, forecasted. The conditions for an efficient and timely management of these situations must be created at the time of their occurrence. Estimates are made by mathematically and logically algorithmic objective analysis and synthesis, by systemically interconnected artificial intelligence, and by rational and intuitive-logical analysis and synthesis of the human factor (combination of knowledge, experience, creativity, intelligence and innovation).

Step number four is the *determination of variants*. These also take into account previous cases reflected in the binomial possible causes – related effects. The procedure to be used in these situations is the implementation of the system analysis methodology, "the rationalization of record-keeping problems, for an orientation based on the approach and solution of complex information-decisional problems" (Roman 2017, 52). Following the interpretation of the results obtained during the activities specific to the second step, AI and experts will generate possible future situations¹ and scenarios for the given situation based also on the known historical situations. The algorithms used by AI are *logical - mathematical* and those used by experts are *logical-intuitive* based on experience.

¹ For possible future situations, the cycle of achieving another predictive scenario for each situation will be resumed. In this way the work of creating predictive scenarios is continuous. There is a possibility that most of them will not be implemented if they are generated horizontally (as variants of the same situation).

For each generated variant/scenario, courses of action will be generated in the same working system (logical-mathematical and experimentally logical-intuitive). These courses of action are to be analyzed in the decision-making process, in full swing at the moment, in hybrid system (human experts and AI). I have encountered in the specialized bibliography a series of possibilities of determining and using the variables reflected in the binomial possible causes – related effects. Some of them use methods that are based on principles of operational research (Scipanov 2014), are transposed today into analysis programs, specific to AI, but I have encountered in common practice, and I can confirm from personal experience, also decisions based on the heuristic capabilities of the commander, most often based on previous experiences. In such cases, biases may occur in the analysis of variables. That is why I recommend the use of both AI specialized programs and human expertise.

Step number five consists in *presenting the results*, materialized in approved concepts of operations and plans for the implementation/execution of military/non-military response options. At the strategic level, generic planning situations will result, each one with its own assumptions and strategic scenarios, the main criterion being the identified circumstances probability of occurrence. The results may modify the behavior and the way of action of both decision-makers and force and therefore reduces the uncertainty closer to "0". With sufficient time (forecasting being the activity) and based on AI capabilities, decisions can be made to achieve the related concept of operations and plans for each identified course of action. At this point, the projection of the necessary force to conduct the related missions resulting from the decision-making is also carried out. On the principle of operation of the mosaic warfare concept² (Bryan, Patt și Harrison 2020, 18-13, 56-58) based on the strategy of the decision maker, the machine-activated control system (AI) is directed through a computer interface that: will assign tasks to be executed; will upload estimates on opponents, the size of the force, the desired effect; will identify the forces (human or of a robotic/human nature, classical or autonomous,

² The central idea of the concept, namely to create adaptability and flexibility to forces and complexity or uncertainty for an enemy by quickly composing and recomposing when needed disaggregated forces, using human command and machine control (AI).

technological and weaponry) that could perform the tasks. However, humans maintain control, at a manageable dimension. The commander then decides the forces to perform the tasks. This approach supports the idea that a disaggregated force, partially or totally robotic, which also has in its composition autonomous weapon systems, capable of quickly composing and recomposing, could offer several advantages (Popa 2021, 31) in obtaining operational success. After the projection and the force build-up, preparations will be made for the execution of the missions resulted from the concepts of operations. In this way the forces will be ready for action by the time the forecasted situation is expected to occur.

The predictive scenario can stop there or continue with predictive execution evaluations (previously introduced in the planning process at the time of mission analysis and decision making).

Situations in which predictive scenarios can develop

We have identified three situations/cases in which predictive scenarios for determining the future can be developed.

The first situation is when *the future is sufficiently clearly determined* (the forecast elements are considered real). This level can be achieved under conditions of maximum certainty given by a clear, complex and comprehensive analysis. The predictive scenario is transposed into the plan through the planning process following the preparation of the force and its deployment until the appropriate time for action.

The next case is *to determine several possible situations* to take place in the future (a determined number of alternative situations). At this level, the clarity, the complexity of the analysis carried out and the degree of coverage are also high. The resulting scenarios can be relatively easily capitalized through operational planning / alternative plans and on the mosaic force principle, specific actions can be planned for each predictive scenario in order to avoid surprise. The situation in which multiple possible future situations are generated raises difficulties in determining multiple solutions (it is the situation in which the analyst must substantially reduce the number of possibilities using criteria / variables). At this level the analysis is extremely complex. It is the most common situation in the context of a

future conflict, in which the geometry of situations and actions is constantly and rapidly changing. The need for an exponentially expanded capability of data and information processing is acutely felt. I believe that at this level, the presence of AI in the analyst's supporting group is paramount, AI being the only one able to process huge volumes of data and information and to quickly offer predictable alternatives for the scenario construction. The presence of AI in this integrated systemic process is beneficial in all identified situations as long as it is not given full control. The human factor must always have the final decision, that will also be based on intuition (based on experience), on creative thinking, on emotional intelligence, elements that artificial intelligence does not have.

One last situation identified is the one in which practically *a predictive scenario cannot be generated* (the reasons can be multiple and it is necessary to resume the process using other data, variables, criteria, etc.).

Predictive scenarios can be generated for all levels of armed conflict (strategic, operative, tactical). I think that predictive scenarios must be carried out at the strategic level – PMESII and not only on the military field. Complex situations can be predicted (and it is necessary to achieve this) at the political, economic and social level because disagreements in these areas usually lead to armed conflict, involving the military domain. Once these disagreements are predicted, one can intervene in order to avoid an armed conflict as much as possible.

In the Figure 1 I have presented the areas of applicability of predictive scenarios with related options detailing the military response option.

Figure 2 shows a variant of predictive scenario of the command and control of a tactical command center on the maneuver module – future operations.

The operational planning process evolves from the results obtained/generated by the predictive scenario, takes place at all levels (strategic, operational and tactical) and is carried out within the command-and-control structures, with digitized architectures in which artificial intelligence is integrated, modular with high interconnection capabilities at any requested level. Within the operational planning process, its principles will be respected: defining objectives, unity of effort/

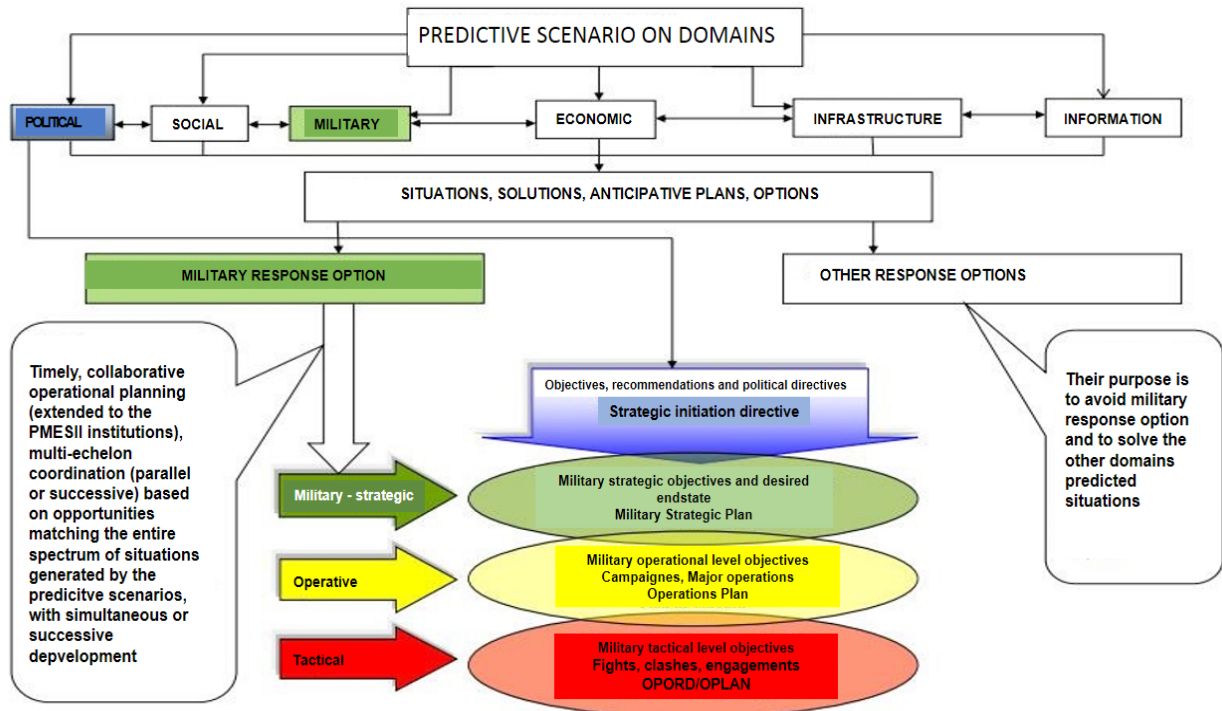


Figure 1 Areas of applicability of predictive scenarios (own design)

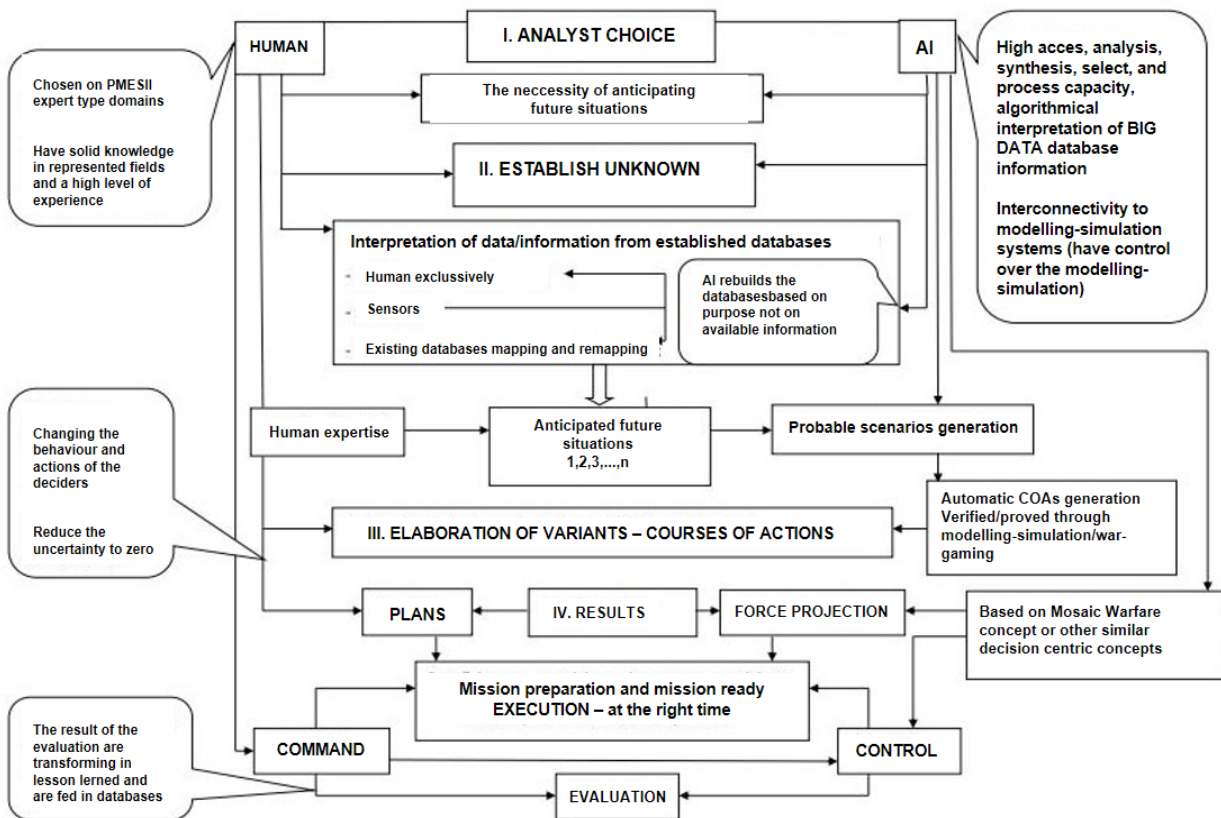


Figure 2 Predictive scenario (own design)

purpose, support, concentration of effort, effort saving (saving of forces and equipment involves engaging resources in a manner that allows achievement of the objectives), flexibility, initiative, maintaining morale, surprising the opponent, avoiding the surprise of own forces, simplicity and the multinational environment.

The execution is not a step in the predictive scenario, but it is closely related to it. A ready stand-by force required by building a predictive scenario act according to the mission and the objectives resulting from it. In this situation, artificial intelligence may be given partial control over the robotic force and autonomous weapons, as well as over the sensor integration part, but the final decision of action remains within the realm of the human factor. In the sense of decision-centered concepts, force control must be delegated to the artificial intelligence. In this respect, I consider that it is necessary to establish an overwatch on the AI's control of the weapons systems, so as to eliminate the risk of the opposing forces taking "control" over the AI or the total control of the AI itself over the force that it could use for specified purposes for its benefit.

Algorithmization, digitization and artificial intelligence assistance in the decision-making process

The question we want to answer is: What are the possible mathematical, algorithmic processes implemented at the level of the digitized architectures of the command-and-control systems and processed by the AI, to optimize and make the operational decision-making process more efficient, in the conditions of conflict with variable geometry?

Due to the complexity of the operational environment, the variable geometry of conflicts and military/non-military operations, as well as due to the complexity of the command-and-control systems used in state-of-the-art conflicts, the decision-making process was no longer carried out only intuitively, based on experience and knowledge. On this consideration, decision procedures were developed and their evolution was achieved with the help of specific methods. The existing methods of achieving a decision are built on modeling the real processes, on imitating the behavior of the studied system. Experimenting/

checking a variant of a decision within the real process is not the most appropriate way and is not always achievable. The tools and models for achieving a decision are based on the of *theoretical methods, physics, mathematics and simulation*. In order to achieve a decision, it is also necessary to assess its strength and capabilities. The theoretical method is based on theoretical behavioral models and requires the synthesis and concretization of the existing/accumulated knowledge (held at a certain time) about the existing reality (action-system) without always having the possibility of practically verifying the scientific and practical content. This method is used in conjunction with the physical and mathematical methods. The evaluation of the physical environment is the process that underlies the physical method of achieving a decision. Its applicability in the military field is frequent and is materialized by the study/ analysis of military action with the help of physical means, such as the layout of the terrain (for rehearsals), the different physical means intended for the conduct of the war game, etc. The variables played are variables characteristic of the physical environment. Therefore, this method is not sufficiently effective in achieving a valid decision if not corroborated with other methods for the purpose of completing the number of variables and with those specific to other conflict environments (informational, cognitive, etc.).

Mathematical and analytical methods and procedures

The mathematical method uses instruments that differ in nature from the studied phenomenon/action/system but which can be described by the same mathematical relationships (usually quantitative) as those of the instrument used. Mathematical modeling (Lehaci 2016, 45) is materialized in isomorphism (description in a common form of different phenomena in nature). In the military field, this isomorphism is transposed into the common form description of the different actions variables, operations and/or systems, and their numerical, quantitative expression (e.g. matrix system for comparing the courses of action). However, the realistic quantification of variables remains the biggest challenge of this method/model of achieving a decision. A wrong quantification inevitably leads to a decision-making error, not being based on the reality of the operational environment.



The simulation method (e.g. the war game) involves an interaction between the human factors responsible for the planning process, simultaneously or successively introducing the variables (defining in military operations) in different simulation systems (with capabilities of reproducing real situations in the virtual environment) in order to verify the decision and to establish the military operations synchronization matrix. The simulation method implies the existence of an adequate information system (architecture and software) as well as properly trained personnel, but this method has clear advantages over the other methods, represented by the possibility of accurate programming and introduction into the system of forces with their capabilities and by the fact that it runs independently and produces results that can be analyzed mathematically and statistically and interpreted analytically.

Mathematical modelling is an alternative to the experiment process or method, that most of the time cannot be actually applied in the PMESII fields. Mathematics (the mathematical apparatus) is the instrument of scientifically based decision (mathematical models lead to optimal or almost optimal decisions). Operational research (scientific preparation of decisions) appeared during the World War II and consists in the process of building mathematical models for optimizing the decision-making process. Several sciences have been combined to create decision-making models that significantly contribute to the decision-making process, based on less intuitive or empirical reasoning, thus resulting in the mathematical models. Choosing between several possible variants/taking the decision is a fundamental axiological option (the result of an information, analysis and deliberation process). The status of decisional process in which the decision-maker knows beforehand the specific result for each decision-making variant and the related risk is called certainty (the decision-maker has full information on the decision-making environment and the consequences of the decision-making variants). At the opposite pole lies uncertainty (that state in which one or more decision-making alternatives have results whose probability of occurrence is unknown or impossible to objectively assess).

Uncertainty is often caused by the rapid changes in the particularly complex conflict operational environment. Predictive scenarios are designed to substantially reduce uncertainty.

Game theory is a branch of applied mathematics that addresses the problem of optimal behavior and has also been adopted in the military field and resulted in wargaming (in a framework described by a set of precise rules that establish the possibilities of action for each player, as well as how they are ultimately awarded victory). Game theory is an abstract decision-making model (based on procedures, processes, tactics and strategies) in risk situations, conflict, uncertainty and information impact. Currently, the military approach to game theory extends the interdisciplinary study of human behavior to an integral approach to the behavior of integrated and interoperable systems of systems, involved in the management of a conflicts, crises, etc. Within the game theory, a series of mathematical and algorithmic processes are folded on conflict scenarios. These procedures allow the description and analysis of real or anticipated conflictual phenomena/situations, as well as the establishment of balances, i.e. the status in which no actor wants to change his behavior, regardless of other actors' behavior. As a result, the conflicting state disappears or would disappear on this balance consideration. There are many situations of balance in a game, but the most important are those that are based on correctly modelled credible situations, according to the unfolding or predicted reality. The equilibrium point is mathematically justified. A system of n strategies forms a balance point if no actor has a reasonable motive to change his strategy, assuming that everyone else keeps his strategy³ accordingly. A game is characterized by the quantity and quality of information available to the actors. Thus, we distinguish games with complete or incomplete information, as well as games with accurate or imprecise information. Games can also be built for 2 or more actors/participants or potential participants in the conflict. Depending on the existing scenario, the mathematical procedures specific to the theory of games are adopted on the criterion from simple

³ An achievable (possible) action that the player can choose within the game. An optimal strategy is that strategy maximizing a player's win, regardless of the strategies chosen by other players.

to complex. We can exemplify by a process such as playing with n actors in extended form⁴, matrix processes, static and dynamic processes in complete information (determination of equilibrium by the algorithm of maximizing relative gains, the algorithm of determining equilibrium in mixed strategies, determining equilibrium through the recursive induction algorithm, etc.). The procedures used in conditions with a degree of uncertainty are the processes called games against nature (Hurwicz's criterion – the criterion of the optimist, the Bayes-Laplace criterion, Savage's criterion – the criterion of regrets, the criterion of Wald). There are situations in which the decisions risks cannot be fully known due to the lack of assumed or not assumed reason by some actors. Such an actor can be considered generically the nature, therefore the name – games against nature⁵. The analysis of such situations is handled by decision theory. These mathematical decision-making processes are closely related to decision-centered military concepts (like Mosaic Warfare).

The information analysis grids (as mathematical and algorithmic processes) managing the uploads of decision supporting necessary information, can be transferred to the control of artificial intelligence using a digitized infrastructure. The advantages will be the increase of processing speed, mathematical accuracy and limited control of AI in the decision-making process. For example, the TAG method (Time Automated Grid) developed by IBM is an automation of a specific part of the system analysis process through which mini-data bases are built for the analyzed system. Expanding to the military field and adapting accordingly, the information analysis grids could manage the necessary information

uploads and the set-up of mini-databases for the generated or possibly to be generated situation within the conflict. TAG is not a decision-making method but it can be an algorithm of managing the inputs in the command-and-control system and has the advantage of initiating the information support operationalization, assisted by artificial intelligence through assigned computers. Therefore, by assigning control to AI, through a digitized C2 infrastructure, over the information analysis grids within the decision-making process (regardless of their nature or structure or the method used), a timely management will be achieved (almost instantaneous interpretation of the data and information necessary to initiate and conduct the decision-making process).

Analysis methods based on the design of the information systems represent redesigns of the information flows, of the processes of processing and disseminating all possible sources (closed, open, field sensors, etc.) data. In this way, the installed programs (integrating computer's work) and AI are used both for joining in the data and information analysis and processing and in the adaptation of the system of systems to the latest challenges generated by changing the geometry of the operation / executed actions or changing the geometry of the conflict. Decision-making aspects cannot be reduced to knowing simple rules for the use of AI-assisted computers in order to benefit quickly and efficiently from the possibility of decision-making by circumventing the complexity of the informational decision-making mechanism. In this regard, we can exemplify through the ISDOS system (Information Systems Design and Optimization System) made by the University of Michigan. This system has the possibility to integrate several methods/algorithms for processing the informational requirements and for correlating them in order to design the file of the information system, in order to build the necessary information requirements similar to some trees described with the help of ADC type graphs (methods of analyzing the critical path on which the ordering theory is based). An activity is distinctly determined as part of a project or as a precisely defined sub-process, for which specified time and resources are allocated.

⁴ The n -player game is a sequence of random decisions and events, simultaneous or not, that comply with a certain winning structure, given by certain operating rules (the rules of the game). The random event involves a probability distribution over an event field. The rules of the game will indicate how decisions are made by the players and their order. A player is rational if he seeks to maximize satisfaction with his own decisions, but taking into account the decisions of the other players.

⁵ The attitude towards the game is different from one actor to another, leading to no universally valid criteria within the theory of decisions. The application of the criteria may lead to different results. The choice of strategy could be given by the result of the application of several criteria, p. 24.



The GANTT diagram⁶, used in the military decision-making process (practical application through the Microsoft Office Project) is a tool to streamline the decision-making process that could be aligned on the functionality of the ISDOS system or similar systems. The diagram offers the possibility of planning the human resources and of controlling the activities but can be extended according to the needs of the command-and-control system (comparing the initial planning with an updated one, taking timely and measurable corrective measures to achieve the goals of the operation, evaluation tool, etc.). The process can be digitized and assisted by AI (in the diagram you can enter the data, the tasks, the subtask, the start time of the process and their duration - all the steps of the planning process and their sub-stages, the day and time of receiving the mission and the duration of each step, depending on the time available – until "ready to fight").

The critical path analysis methods as a logical algorithm, involves the division of a project/plan, built on a multitude of complex actions, from several component parts, at a minimum level (activities that follow), allowing the analyst to logically and technologically correlate them, making possible the interaction between the component parts (the minimal units of complex action). The challenge is that all the minimal activities must be determined and here it is necessary for the AI to intervene/assist the entire process. Decomposition criteria can be established by the human factor, by AI or combined. AI and/or the human brain will identify the activities, starting from the questions: "are there other necessarily activities that follow or precede the activities identified so far?" and "what is the duration of the newly identified activity, when exactly does it begin and when does it end?" (Roman 2017, 55). I believe that this model, in conjunction with the GANTT diagram, can be a starting point in generating an algorithm necessary to make the decision-making process more efficient, digitized and assisted by AI, resulting in a matrix analysis system based on determinants.

⁶ The GANTT diagram used in the military decision-making process (a practical application through the Microsoft Office Project) can be another tool to streamline the decision-making process. The diagram offers the possibility of planning human resources and that of controlling the activities. Through it, a comparison of the initial planning with an updated one can be achieved. It also allows timely and measurable corrective measures to be taken to achieve the purposes of the operation and can be used as an evaluation tool.

Human factor in decision making – analysis criteria

The criteria for the analysis of the human factor in the decision-making process are related to personality, preferences, values and information held, all these being closely correlated with the level of training, intelligence, creativity, intuition, etc. Human values prevail in the human behavior / way of action.

The criteria for the analysis of artificial intelligence involved in the decision-making process (if it will be given this possibility) compared to the human factor are based, in principle on (Walsh 2018, 25-26):

- much larger and faster data and information storage / storage capacity, with no risk of losing information (does not forget anything);
- the ability of computers to process data and information with immeasurably superior capabilities than humans and the exponentially greater capability of AI to 'learn';
- connected to an energy source, the AI is not limited in operation (unlike the human factor that needs rest/sleep);
- cannot be influenced by emotions (they do not exist at the level of AI);
- it is not limited in sharing its knowledge, skills, etc. (it can permanently constitute unlimited databases, on different criteria or execute mappings and resizing according to set criteria, etc.);
- there is no intuition in the decisions (algorithms, logical-mathematical);
- the AI has no consciousness (a form of norm consciousness could be built, based on the programmed observance of the norms in all fields, but this will also be of the procedural-algorithmic type). However, the enumeration could continue, what is considered relevant and what may constitute a risk in the implementation of AI in the operational decision-making process is that later this aspect would mean the end of consciousness, of human action and of human values, etc.

The role of artificial intelligence, decision support systems and intelligent decision support systems in the decision-making process

In order to eliminate or reduce the related risks, we consider it opportune that the AI mathematical and algorithmic processes of digitization and assistance of the decision-making process be

validated through a thorough system analysis, with adequate methodology. The testing system must be of closed type, but it needs to be able to simulate/model the real PMESII domains.

The decision-making process involves responsibility and risk-taking. This risk can be reduced by formalizing the decision-making process by using mathematical methods and models. These have the ability to rigorously condense the essentials, and offer the possibility of being programmed, managed and processed with the help of computers and artificial intelligence.

It is necessary that all these mathematical, algorithmic digitization and assistance processes conducted by the artificial intelligence of the decision-making process, be introduced and managed at the level of some decision support systems (SSD) (Ivanciu 2018, 23). SSD must be flexible, adaptive, interactive, iterative, model-based and graphical interface-based. Currently, command and control systems are based on another type of system, namely *electronic data processing* (EDP). SSDs are designed for communication, shared tasks, accessing and processing of internal/external data, management and processing of unstructured interfaces (electronic formats), expertise in solving current and future situations, accessing digitized mathematical models, computer science, etc. (optimization, modeling and simulation carried out for the purpose of analysis in the decision-making process. The SSD works effectively both at the modular (intelligent subsystem) level, but also at the system or systems level of interconnected and interoperable systems. By implementing AI at the SSD level, they have transformed (at least at the conceptual level) into SISD – *intelligent decision support systems* based on SE – *expert systems*⁷ and AI – artificial intelligence (Ivanciu 2018, 4-17). Human experts and SE contribute substantially to documenting and improving knowledge bases, training new personnel on different functions, disseminating the results and products of the decision-making process and to the rapid and minimal cost transfer of knowledge, data, information, decisions, etc. The competences/capabilities of the two types of experts complement each other and the results

are real. Expert systems can act for assistance and consultancy and/or development (from processes to architectures) on three main components such as databases (information, knowledge), inference mechanism and interface with the client. From an actionable point of view, SE focuses on the knowledge acquisition system, workspace, argumentation system (additional explanations) and total knowledge processing (refining) system. These aspects lead to increased efficiency and effectiveness and a reduced decision time, superior product and process quality, flexibility, operation with complex equipment, disposal of expensive monitoring equipment and quick access to databases or organizational knowledge. SE are mainly used in the specific fields of social life, for problems that can be solved by interpretation (surveillance, image analysis, signal interpretation), prediction (weather, traffic, demographic), diagnosis (medical, electronics, mechanics, software), design (circuit layout, building design), planning (project management, financial planning), monitoring (air traffic), troubleshooting (mechanics, software), training (identification of weaknesses), control (life support, artificial environments) etc. and I believe that they can be successful in the process of digitization of command and control systems and their subsequent operation thus covering the military field. In the table, there are comparatively presented some attributes of the two types of experts.

SISD (SSD that performs selected cognitive decision-making functions and which are based on artificial intelligence or technologies with intelligent agents) have developed from the need to remove the cognitive, economic, time and competitive limitations of humans in the processing of knowledge, data, information and in the decision-making process. In order to be perfectly functional and compatible with the human factor, a SISD must develop a behavior similar to that of a human consultant, access and process data relevant to the decision-making process, forecast or identify and subsequently prioritize the problems to be solved, generate different courses of action and correctly and timely evaluate both the courses generated and the action itself after its execution. We believe that using AI/IC (computational intelligence) techniques, SISD will achieve these aspects, emulating human behavior as real as possible through the use (at the AI

⁷ SE – a program that processes a set of data, information, knowledge in order to reach results that are difficult to obtain, in the same way as human experts, but with much superior speed and clarity.



Table No. 1
COMPARISON BETWEEN HUMAN WIZARD
VS. EXPERT SYSTEM ATTRIBUTES

Expert Type/ Compared Attributes	Human Expert	Expert System
Mortality	yes	no
Learning/processing/ knowledge transfer	difficult, long time	easy, rapidly
Creativity, intuition	high	low/zero
Adaptability	high	low

level) of RNA – *artificial neural networks* (Ivanciu 2015, 5-15). RNA is completely determined by the type of functional units (processing elements called neurons), architecture (location of functional units), algorithm of operation (evolution of input signal to output signal), learning algorithm and self-learning (as acquires new knowledge based on examples). RNA architecture (Ivanciu 2015, 16-34) single layered and multilayer.

Comparatively, the differences between the two types of systems are as follows:

What will clearly revolutionize the construction and implementation of AI in the PMESII domains, in addition to the aspects presented above are the *genetic algorithms* (AG) made on the basis of *evolutionary calculation* (CE). Genetic algorithms

are search and optimization techniques, having as a starting point the biological metaphor of genetic inheritance and natural evolution (selection, crossbreeding, mutation). CE principles are materialized in the search of solutions (based on the principle of natural evolution – survival of the best), for finding the final solution we work with a lot of potential solutions that evolve (for humanity the individuals of the new generation are more adapted to the environment than the individuals from which they were created) and the targeting of the search is made through specific transformations on the solutions (similar to natural processes: selection, recombination, mutation). The fields of action of the EC are genetic algorithms, evolutionary programming, evolutionary strategies, genetic programming and optimization.

Table No. 2
SYSTEM DIFFERENCES

System type; comparative variables	SSD/SISD - RNA	EDP
How to use	Active; Reactive; Predictive	Passive
Beneficiary	commander/ command functional mode	Staff personnel
Result	efficiency, efficacy, innovation	mechanical efficiency
Time frame to refer to	past, present, future	past
Physical characteristics	flexibility	consistency



At this moment, I believe that digitization provides the foundation to ensure the resilience of the networks of the command-and-control systems and to achieve the desired results after carrying out the operational planning process. Preparing and training for drastic scenarios in PMESII domains is nothing new for utilities and network operators, but the need to optimize the decision-making process is imperative. The current COVID-19 pandemic has presented us with a completely new reality, unexpected and extremely difficult to manage. Extrapolating the situation in the military field, we find that such a challenge manifested in a conflicting environment would raise issues such as those already existing at the operators involved in the management of the situation at the political, social, economic level, etc. put in a position to manage increasingly complex networks without being prepared in advance for such situations. On one hand, experience has shown that emergency planning has worked and networks have remained stable. On the other hand, the need for the incorporation/implementation of AI and automation in command-and-control systems has been demonstrated, which can undoubtedly help to balance situations at least by speeding up the decision-making process. The current challenge lies in ensuring the resilience of command-and-control networks, in difficult and demanding situations for humanity.

Conclusions

We expect that current systems, which are getting closer and closer to their operational limits, will still be able to respond to an increasing number of new requirements. However, the update and expansion of command-and-control infrastructures have not been able to fully keep up with the current challenges generated by the latest international situations. At the moment, the infrastructure and architectures of command-and-control systems, decision-making processes, and the network operators face difficulties in which they have to balance a dynamic environment of threats with the increasing constraints of daily operational reality. At least, under these circumstances, it is necessary to implement modern architectures, digitized and assisted by artificial intelligence and efficient decision support procedures.

The approach could start with the total digitization and implementation of artificial intelligence within

the networks. We believe that digitalization is the way to harmonize these conflicting requirements and to unlock a whole new space of opportunities in the process. However, digitalization is more of a facilitator than an end in itself. Based on artificial intelligence, automation technologies can support and optimize all key tasks assigned to the response force. The data collected is transformed into useful information and the information acquired supports all decisions.

Mathematical, AI-enabled computer algorithms, with an infusion of experience and specialized human knowledge, can fully or partially manage conflict situations (depending on the need). Combinations of automation software can autonomously or not control information or decision-making flows by managing decentralized, modular devices and disintegrated force with rapid integration capability (intelligent systems and subsystems, networks, autonomous weapons, robots, drones, etc.).

We believe that solutions such as intelligent digital systems and subsystems (with extensive capabilities in the virtual and real environment) and programs, response algorithms to any type of requirements (supported by smart platforms) are a real and timely alternative to the challenges faced by current systems. Building the current systems digital twins becomes a practical, multifunctional tool until they are completely replaced. By merging real data from specific closed networks with external data sources (obviously with specific data protection measures), a trial-and-error approach can be avoided in the process of digitizing command and control systems. Predictive scenarios can anticipate and prevent possible incidents (events, conflict situations, etc.) and intelligent digital systems allow for much faster decision-making and rapid implementation of the right corrective action. We consider that the use of predictive scenarios (the realization of which artificial intelligence is implemented to a strictly determined and properly controlled extent) for anticipating future situations and building related scenarios will achieve, on the one hand, a correct and coherent decision and on the other hand, will decrease the degree of uncertainty leading to the avoidance of surprise.

The behavior of the decision-makers is constructively influenced by the products of the predictive scenario/forecasted situations and the



decision is early taken with a high degree of certainty or probability. Predictive scenarios considerably reduce uncertainty, offer the possibility of preparing (in advance) for possible situations, from multiple/all points of view, remove surprise and negative effects, give confidence in solving situations and meeting anticipated objectives. In this way, the command-and-control systems are ready to act promptly, timely and with maximum effectiveness in the changing situational geometry specific to the conduct of state-of-the-art and future conflicts. A certain force, constituted on the concept "Mosaic Warfare" or similar concepts, centered on decision, offers an impeccable execution of the predicted operations and planned by such a system of command-and-control systems.

Artificial intelligence-based solutions such as those related to digital monitoring, analysis, synthesis and control are an effective way to achieve the desired performance in command-and-control systems, at all levels, where they exist or will exist in the near or more distant future. During crisis, swift decision-making and the right/optimal course of action are essential. Digitization, automation and deployment of AI at C2 level is the current solution to the challenges posed by modern conflicts, with variable geometry or future ones, regardless of environments and forms.

There are many challenges when it comes to implementing AI at the command-control and force level, automation, robotizations and digitization of networks, and these are related to a different kind of risks and threats.

Finally, I appreciate that the efficient solution to complex problems involved in the variable geometry conflict requires the development of modular, integrated and interoperable command and control systems, assisted by artificial intelligence, which will ensure the conduct of a coherent decision-making process, based on opportunities, oriented towards achieving success and achieving the desired final state.

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