*Bulletin of "Carol I" National Defence University*
10.53477/2284-9378-21-49

# MODULAR COMMAND AND CONTROL STRUCTURES AND FORCE ORGANIZATION USABLE IN OPERATIONS AT HIGH ALTITUDES

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Mountainous areas located at high altitudes, hardly accessible, are used as safe heavens and staging areas by various asymmetrical groups. Addressing these challenges in areas of operations located at high altitudes requires the existence of specific capabilities for command and control. C2 based on mission command must be adapted to the current requirements generated by conflicts with variable geometry, mosaic type conflicts, composite, multifaceted, multi-layered, multi-domain conflicts. Command and control systems should have architectural flexibility, intelligent digitised platforms and its modules should be perfectly functionall and interoperable (based on self-sufficiency – extended capability to operate over time). We believe that, at high altitudes, the architecture of a complex command and control system must be modular and designed as a coherent integrator of sensors, decision-makers, performers and support capabilities, interconnected in subsystems that ensure the planning, preparation, execution and effective evaluation of military actions. In the conditions of diversification of risks and threats in the multidimensional operational environment, the architecture of the command and control systems must be permanently adapted in order to ensure real-time, horizontal and vertical communication between forces, support structures and command-control structures.

**Keywords:** command and control system; high altitudes; mountain operations; artificial intelligence; technique; technology.

To emphasize the importance of developing complex C2 systems adapted to operational environments located at high altitudes, we have identified some representative military art historical landmarks related to conducting combat operations at high altitudes as well as some current conflicts. The limitations in exercising command-control and in conducting military operations identified by the study of current conflicts have implicitly led to the need to develop C2 systems. The specific capabilities required by a C2 to ensure success in actions/operations performed at high altitudes also emphasize the need to develop that modular system of command and control systems, starting from the combination of current concepts with state-of-the-art technology.

It is known that over 25% of the land area is covered by mountains, about 85% of the world's borders are classified as mountainous, and about 12% of the world's population lives in areas with high altitudes. On these facts, we consider that it is absolutely necessary to develop the capabilities of a force operating in the mountain environment, especially at high altitudes and implicitly of related command and control systems. Mountain forces were developed mainly in the last quarter of the nineteenth century, especially with the mission of defending the borders. In 218 B.C. Hannibal's army demonstrated an unexpected capability to cross the Alps and performed one of the most impressive maneuvers executed in a historic offensive operation. World War I confirmed the defensive attitude of the mountain troops, exceptions being the Battle of Mount Krn (1915)[1] or the conquest of Mount Matajur by Erwin Rommel[2]. Conducting military operations to high altitudes often led to changes in the situation and radically influenced the outcome of the battle[3]. In World War II, mountain troops operations were mainly conducted in cold weather (the Russian campaign) but also resulted in counter-insurgency operations in the Alps and the Balkans. For example, the Battle of Narwik in Norway, can be considered a JOINT operation involving naval, air force and mountain troops units in a synchronized operation. The battle of Mount Cassino along the German "Gustav" defensive line in Central Italy[4] represents another lesson related to the capabilities of conducting combat operations

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at high altitudes that made the difference between the participating forces[5] (forces trained for such situations and forces facing the situation of fighting at high altitudes for the first time).

At the end of the 20th century and the beginning of the 21st century, significant examples of battles fought at high altitudes were those of Central Asia (Kashmir Region, the fighting scene between India and Pakistan, for the Siachen glacier, that even generated a new concept – "oropolitical" or climbing with a political purpose). The mountains of Afghanistan (many peaks exceeding 6.000 m altitude and mountain plateaus often exceeding 3.000 m altitude) were an operating area during the Invasion of the Soviet Union in 1979 and the Enduring Freedom campaign[6]. In the Caucasus area (mountains with altitudes that constantly exceed 4.000 m altitude) the Russian army reconsidered the maneuvering ability of the mountain troops to secure their southern flank[7].

At present, there are many ongoing conflicts in the mountain environment at high altitudes that need to be seriously monitored. Afghanistan itself, recognized worldwide as a strategic area, is still unstable and represents an area of interest to many parties involved[8].

Border conflicts such as India-China[9] (at over 4.000 m altitude) and the Nagorno-Karabakh region (South Caucasus area) are also sensitive issues. The immigrants' routes from Asia and Africa to Europe pass mainly through mountainous regions, even at high altitudes. Other conflicts identified worldwide are mainly related to water sources, natural resources and critical infrastructure in the mountains (e.g. the conflict in Peru – altitudes above 5.000 m).

Consequently, many countries are in a process of adapting and improving their forces for the new scenarios[10] specific to high altitudes mountain environment fighting in state-of-the-art, variable geometry, extended multinational and based on opportunities conflicts. In this context, we believe that the development of the capabilities necessary to conduct operations in this particular and specific environment is up-to-date and NATO has taken this into account[11]. There are multiple issues arising – the survivability of the forces, their maneuverability, their support of any kind, the increase in combat capabilities and a high-performance C2 in this harsh environment. For the force, this requires specific training, adequate equipment, as well as a specific approach to the doctrine of combat in the mountain environment (especially for operations conducted at high altitudes) and the tactics (specific techniques and procedures). Some NATO member states are constantly developing the techniques, tactics and procedures specific to combat in the mountain environment, but at the alliance level efforts are limited (they are exercised on a small scale on the coast in support of naval operations in the North Sea).

**Limitations in exercising command-control and in conducting military operations/actions at high altitudes**

The mountain terrain channels the movement and limits the maneuver of forces, and high elevation terrain is often impractical for the nowadays equipment/vehicles. The movement or maneuver of dismounted forces is grueling for the human resource and time-consuming.

Climate and bad weather can negatively affect actions/operations conducted at high altitudes, but they can also offer tactical advantages.

The difficult mountain environment and high altitudes have a strong physical, physiological and psychological effect on the military personnel. Living in isolation and/or conducting military operations at high altitudes without prior training (long-term) considerably affect the human factor from a physical, physiological and mental point of view. Unfavorable environmental conditions (cold, dampness, fog, persistent rain or snow) lead to the onset of fear, depression and/or even to the decrease in the morale of the human factor involved in both the command-control act and the execution (at the force level). However, proper specific training and very good physical condition create self-confidence and optimism. Leadership must combine healthy reasoning with a thorough understanding of the characteristics of the mountain environment which will lead to achieving efficiency in the command. Leaders must demonstrate the optimal ability to command in isolated circumstances, hard-to-reach terrain and in the most difficult weather conditions to address the physical, physiological and psychological impact on units.

Due to the rugged terrain (large uncovered areas, high altitudes, narrow valleys, steep slopes), the tactical actions within a larger operation are conducted divided, mainly with decentralized

command (command by mission) and relatively small forces (section, platoon, company level) or *battle groups* constituted according to the requirements or specificity of the mission (on the principle of disintegrated forces with rapid integration capacity). We can exemplify by organizing patrols (reconnaissance, combat, or tracking[12]), by organizing patrol bases[13] or by task organizing force on the Mosaic principle (partially or totally robotic/autonomous weapons). These forces, regardless of how they were constituted, must have long-lasting and self-sustaining capabilities. In these situations, mutual support and relocation of forces is very difficult or even impossible, and the separate action (command-control-execution) of these elements is inevitable. They can be *centralized* or *decentralized led*, but most of the time *they act in a decentralized manner*. These specific procedures determine the specificity of C2 and the effective command of forces during the planning or conducting phases of military actions at high altitudes. Frequent and rapid changes in the weather lead to changes in combat and operating conditions and often require an adjustment of operations planning, command – control, as well as a change in combat techniques and tactics. For example, fog, low cloud ceiling and precipitation often lead to a sharp visibility decrease, observation and the use of conventional weapons being severely limited. The forces placed in high positions may lose the dominant role and will be forced to maneuver the opponent (close observation and close combat are to be conducted) in order to meet the set objectives. In these weather conditions, helicopters cannot be used. Other environmental factors that can significantly influence the military actions /operations in the mountain environment: heavy rainfall, snow, torrents from the melting of snow, sudden increase or decrease in temperature, hail, large or even small avalanches, etc.

High altitude, extreme weather conditions and the terrain restrict mobility, overload forces and equipment that need to be replaced more often or replaced by other forces. In the context of the acceptance and implementation at the level of the forces fighting at high altitudes of the *mosaic warfare concept*[14], these forces must be disaggregated but with the capacity of rapid aggregation according to the mission specifics, partially or totally robotic/ autonomous weapons, and the command and control systems used need to be modular, maneuverable, have high energy autonomy and be assisted by artificial intelligence (AI) by supporting the C2 architectures with smart digital platforms. The purpose of implementing AI at the command-control level is to optimize the decision-making process (increasing its efficiency through speed, creating algorithms, immeasurably higher analysis capacity, synthesis, interpretation of data and information, instant access to databases, etc.) and to have an adequate control over the force, especially over the partially or totally robotic one.

**Specific capabilities necessary to conduct actions/operations in the mountain environment**

At this moment, the emphasis is on developing and maintaining the existing capabilities, but I believe that it would be appropriate to predict and implicitly develop the capabilities necessary to face the new challenges of the modern conflict with variable geometry manifested in all environments of confrontation, implicitly in the mountain terrestrial environment at high altitudes. It is necessary for these capabilities to be generated according to a clear concept of high altitude combat that generates an appropriate doctrine and strategies for in-advance or crisis response operational planning (collaborative-extended at the level of PMESII institutions, coordinative, multi-tier- in parallel or successively, opportunity-based or combined) that fit the entire spectrum of operations, carried out simultaneously or successively[15]. These capabilities should be able to operate in a common manner (at NATO level) and combined, in environments with high altitudes, across the globe or other similar environments (arctic environment). This should be resolved at C2 level (i.e. C5I2SR) including cooperation and interoperability[16]. It is necessary that this system, in addition to the current capabilities (command and control of forces, shared common operating picture with its interpretation, intelligence, surveillance, reconnaissance, operational and tactical planning, air situation and missile defence, joint fires and management of air, naval and ground targets, effects management, maneuver and synchronization, information operations, force protection, resource coordination, medical assistance, etc.) introduce the *cooperation and interoperability* elements and

extend *the recognition and surveillance to macro-supervision elements,* at least at regional level if not globally, in all conflict environments. The creation of command and control system architectures in which digitalization and artificial intelligence (AI) are given the right role will enable them to fulfil this goal. The combination of the *mission command concept and mosaic warfare*, the use of digitized C2 platforms and artificial intelligence, as well as the use of the latest technologies in the development of autonomous weapons, partially or totally robotic, will lead to generating that disaggregated force (with rapid aggregation capacity) and its control during planning, preparation and execution phases of missions (classical, surgical or of any other nature), with maximum efficiency, with low consumption of resources, with the maximum reduction in human losses and in any conditions generated by the physical environment of confrontation (in this case located at high altitudes). Moving towards the future of the conflicts in this environment involves the development of these command and control capabilities and of fighting in an efficient and sustainable manner. At the level of *operational planning* it is necessary to precisely establish the dimensions and structure of the force (according to the mission specifics), intended for fighting at high altitudes (future forces destined to fight should have a balanced set of capabilities to successfully operate against a variety of threats and instability situations). The force generation and the task assignment must be fully integrated at the command and control level in the operational planning process, at the appropriate level (tactical, operational, strategic). It is necessary that all structures that would conduct high altitude military operations as well as related systems be trained through exercises carried out in that environment and supported by operating procedures (constantly updated or allowing optimal adaptation to the rapid changes produced in the geometry of the future conflicts).

The capabilities considered critical (to cover the full range of other tasks that could be assigned[17]) and necessary to achieve this desideratum may relate to:

- Exercise of C2 in joint/combined operations at high altitudes, in all weather conditions, within a degraded electromagnetic spectrum and in periods of limited visibility.
- Off-road movement and maneuvering at high altitudes, in compartmentalized terrain, in all weather conditions[18], including the provision of combat technical assistance for mobility, countermobility and survivability of forces.
- Direct or indirect fire support, carried out with organic units specialized in all-weather high-altitude operation.
- Following the information cycle[19] and conducting ISTAR[20] ops in high altitude, compartmentalized and difficult terrain and in variable (unstable) weather (with degraded or non-existent infrastructure), exploiting all the opportunities to meet the commander's information requirements.
- Ensuring an adequate level of force protection[21], support for the search and recovery of personnel and their rescue through the integration and use of all weather, high altitude equipment and procedures.
- Conducting logistic support in all terrain and all weather conditions.
- Conducting a wide range of electromagnetic operations in all terrain and all weather conditions.
- Force generation for a wide range of specific actions/operations (interoperable forces for multiple and long-term operations under conditions generated by high altitudes and/or arctic areas).

If we are talking only about the human factor, it is necessary to consider *the resilience and the adaptability* in order to solve the issues related to the stress and threats that force faces. Resilience itself should be a requirement at both the individual level and the unit level. The ability to adapt should become a requirement for any soldier. Exercising the command and control / leadership at all levels is essential.

*Flexibility* (the ability to disperse and concentrate forces) in a complex high altitude mountain environment is absolutely necessary, therefore modularity (C2, weapon systems and other resources) is recommended.

*The task organization of forces* must be carried out in such a way that they possess firepower and self-sustainability. Military intervention and obtaining the necessary information at the desired time and place is necessary to achieve critical superiority, subsequently rapidly dispersing to avoid counter-action by the enemy. Small, agile, powerful and resilient units can overcome the movement/

maneuvering limitation. The compartmentalized terrain requires decentralizing execution to sub-tactical units. Remotely controlled, partially or fully robotic autonomous systems/weapons, smaller modular units and variable lethality munitions will increase this capability. Forces operating at high altitudes must be composed of multi-domain trained units, capable of conducting specific missions, in different stages of aggregation or disaggregation, configured or reconfigured according to the requirements and circumstances of the missions or in continuously evolving situations. The command and control system must comply with the same requirements in order to provide the force with necessary mission planning, coordination, management and evaluation. Within the mission command concept, in order to successfully operate at the operational environment required pace and complexity, forces must be able to make quick decisions and adapt to ever-changing tasks. It is necessary to achieve an increased capability to react/respond to the often changing situations in the evolution of the conflict.

*Decisive actions* specifically require (at high altitudes) the decentralization of execution and an increase in the skills and capabilities of small units and their commanders. The mission staff must evolve (and this can be achieved by compartmentalizing, digitizing and modularizing the command-control), allowing subordinates to exercise their initiative in unforeseen situations and in a dispersive environment, while maintaining an unchanged intention.

*The agility and unpredictability of the maneuver* is another factor that leads to success in fighting at high altitudes. It is necessary for the C2 and the forces to respond efficiently to dynamic and complex operational challenges, exploiting opportunities through efficient and effective decisions and actions. By developing specific climbing skills, the human factor can overcome any challenge and achieve a surprise effect. Controlling the dominant terrain creates the tactical advantage of increasing the opponent's vulnerability and enables freedom of action. Also, a robust communication infrastructure to collect, process and disseminate information and to provide support for the exercise of command-control is absolutely required.

Requiring a high level of tactical mobility, combat units operating at high altitudes cannot rely on mutual support, while logistic support is difficult. We are therefore talking about the need to achieve *self-sufficiency*. This is achieved by building-up substantial reserve forces at all levels, engaging only the minimum necessary and self-sustaining forces (for a certain period of time), while maintaining the remaining forces and assets in a supporting role.

The operations conducted at high altitudes are characterized by the independent engagement of the units or tactical elements (disaggregated force with the capability of rapid aggregation), the symbiosis[22] of command[23] - combat - support (organization of tasks), isolated actions, vertical maneuver, the need for frequent replacement of forces, the lack of infrastructures, the control of the road / transport network, of the gorges and dominant heights, difficult supply chain (logistic support carried out with great difficulty), difficult connections or even lack of communications with isolated tactical elements, the lasting effect of terrain and weather challenges, difficult medical support.

In this context and at this time (with the current organization and the present mountain troops equipment) it is suitable to implement the concept of *mission command*. In the context of implementing capabilities specific to the concept of mosaic warfare, at the C2 level we will find digitized platforms and the presence of AI in symbiotic connection with the disaggregated force (with rapid aggregation capacity, in the composition of which we include autonomous weapons, partially or totally robotic, robots, drones, etc.). This aspect will lead to its control during the mission preparation and execution (classical, surgical or of any other nature), with maximum speed and efficiency, with low consumption of resources, with the maximum reduction of human casualties and in any conditions generated by the physical confrontation environment.

The challenge is how extensive knowledge of the characteristics and special requirements of military actions carried out at high altitudes, capabilities, performance and performance standards necessary for tactical elements for carrying out actions, techniques, tactics, procedures, methods and principles imposed by the characteristics of the environment and the specifics of the mission will be integrated with such a modular and interconnected

system, with the experience gained, the flexible, proactive and prudent way of thinking as well as with the initiative and the modeling effect.

In particular, it is necessary to solve problems such as the communication challenges due to weather and terrain conditions, the execution of the maneuver, required by the dynamics of the fight, the reduction of risks caused by the increase in the physical and mental tension of the personnel and the provision of additional equipment and adequate means of transportation.

I believe that command and control systems created on the basis of digitized architectures and which have embedded AI, should task the artificial intelligence the analysis (in the decision-making process) variables such as: correct and timely assessment of the parties to the conflict, estimation of the enemy, combat strength and operational effectiveness, the C2 structures and force mobility (especially vertical mobility), the possibilities of conducting resupply, channeling in certain directions, hard-to-reach terrain, isolated engagement areas, potential landing sites for small maneuvering elements, rapid changes in the dynamics of the fight, the need to perform observation at a distance/or of the entire area of operations (observation on the back, flanks and back), the increased time required to build positions and shelters necessary for personnel protection, the effects of weather on the technique and the human factor (including the change of visibility conditions), etc. In particular, these aspects can be translated into: materials and equipment (to be transported/supplied), mobility (including means of transport), measures to preserve combat power and the use of weapons and ammunition.

The creation and task organization of force according to the concept of mosaic warfare could be a reliable solution to these requirements.

**Modularity of command and control systems usable in operations at high altitudes and the need for their containerization**

An efficient organization of a deployable C2 system could be on functional and integrated modules. The digitized platforms that can build up the modular architecture ensure the interconnection (close or remote) of the modules in order to enable collaborative and selective[24] planning at the same time.

The main advantage of C2 systems modularization is that these modules have capabilities to solve situations independently (each on its own specifics), collaboratively selectively[25] (on Rubik[26] or mosaic model) or in an integrated manner (all interconnected modules or the entire modular system interconnected with other C2 systems).

The modular system of systems is like a *Rubik cube*. It has the possibility of changing or adapting three-dimensionally its architecture according to the *typology* or *typology of the action/operation*. Using the same components, the Rubik cube can display a considerable number of solving solutions, constantly changing its faces. In this regard, the command and control system will quickly change its structure (faces) using the same modules (components) and generating adaptation capacity and the capabilities necessary for facing the challenge. Literature offers several variants of modular organization of command and control systems. In this respect, the functional modules could result in:

- the C2 module subsystem comprising: communications and IT, information management, decision support personnel and liaison officers;
- information activities module subsystem consisting of: PSYOPS, information and public relations, intelligence, CIMIC, electronic warfare, OPSEC, INFOSEC, special operations;
- the intelligence module subsystem at the level of which the collection, analysis, production and dissemination of intelligence products, weapons research products and electronic warfare actions are conducted;
- force protection module subsystem which includes: CBRN defence, combat engineers, cyber defence, information protection, military police, occupational safety and health;
- maneuver module subsystem composed of: current operations, synchronization of operations, future operations, combat engineer, planning, evaluation of operations;
- the fire support module subsystem at the level of which planning, coordination, integration, synchronization take place: engagement of the opponent, lethal and non-lethal engagements, target management, anti-aircraft defence and air support;
- the resource module subsystem composed of: personnel, logistics, medical support, administrative support of the command post.

Regarding the *integrated modules,* we can bring into discussion the *current operations module*, *the future operations module and the plans module*.

The main combat elements at high altitudes are support by fire and maneuvering, the use of barriers and the fight for information superiority. The assessment of the tactical commander over the ground operational picture is of particular importance in the decision-making process. The integration of the data resulting from the execution of reconnaissance in the procedures of a modular and digitized C2 (assisted by AI) as well as the rapid and selective transfer of data and information within the system of C2 systems allow decision-making and enable timely execution of actions/ operations. We believe that the possession by a party to the conflict of *informational superiority* is the key to ensuring success at least at the level of the activities carried out at C2 level. The exchange or transfer of data and information actually obtained from the field can have a key impact on a moment of combat at high altitudes if the decision is made in due time. Therefore, command and control must operate in optimal conditions. One of the conditions is, as we have previously presented, modularity. From a physical and architectural point of view, we believe that these modules should be containerized so that they can operate permanently – static or on vehicles suited to the terrain, climate and high altitudes (certain components can be robotic in order to ensure accessibility in areas with very high altitude where the human body does not resist for a long time). The operation of containerized modules (built on the principle of at least energy self-sufficiency) leads to the maximum exploitation of the results obtained through strategic and operational reconnaissance (in addition to those obtained through own reconnaissance), electronic warfare reconnaissance, air and land reconnaissance. These data and information, supplemented by the results obtained through the reconnaissance conducted in the area of operations, the technical reconnaissance, the surveillance / control of the airspace, unquestionably change the situation in favor of this type of system of modular C2 systems compared to one built on the classical model.

*Fire support* is conducted (alternate and fast) both in close combat and for engaging the enemy at a distance. The fire-support module of a modular C2, digitized (assisted by AI) and functional at high altitudes (containerized and self-sufficient) ensures the planning, coordination, integration, synchronization of the opponent's engagement with the specific means (lethal and/or non-lethal). Target management, air defence and air support are tasks of this module that are solvable both independently but especially in a collaboratively integrated way both at the level of the C2 to which it belongs but also at the level of other similar modules horizontally or vertically. It is essential to achieve this integrated and collaborative way of working due to the barriers imposed by the characteristics of the terrain at high altitudes and by frequent changes in weather conditions, the systems having to be interconnected both horizontally and vertically in order to be able to substitute or support each other. Depending on the dynamics of the battle, mountain artillery, partially or totally robotic autonomous weapons, armaments on combat machines, etc. can be engaged alternately or simultaneously.

As for the *maneuver*, the high altitude terrain restricts movements and channels forces to a very large extent. The speed of movement is reduced and the axis of movement can be interrupted by natural obstacles (flooded mountain rivers, landslides and avalanches). In order to be performant, the *C2 maneuver module* specific to high altitude areas, must operate on all its components. From a technical point of view, we believe that in order to obtain the maneuvering capability of the C2 in high altitude areas, both the system as a whole and its modules should be able to operate separately and integrated, but there should be a remote connection. For example, the human personnel and the digital platforms of the maneuver module with its functional and /or integrated submodules (current operations, synchronization of operations, future operations, combat engineer and planning and evaluation operations) are to be distributed on separate containers, smaller, easier to transport by specific means of transport at high and very high altitudes. Dispersed over a certain electromagnetic range they can interconnect and work enabling both force protection and high maneuverability. The maneuverability of small elements and their high self-sufficiency is suitable at high altitudes on the same consideration for which there is a need to plan and execute combat actions by small, easily maneuverable tactical structures with high

firepower. The combat type that best suits these situations is a separate maneuver-joint action. The maneuver must be thoroughly planned with timely preparations and reconnaissance. Planning is relatively difficult and requires a lot of experience. The maneuver must be executed in such a way that the mission is accomplished and sustainability is ensured at the same time.

*The force protection* of at high altitudes and the survivability of the personnel are determined by the quality of the existing infrastructure and equipment more than in any other confrontational environment. In order to ensure operational - tactical presence in the entire mountain operations area for a prolonged period of time, command-control systems and forces must have the survivability capability in order to maintain combat capability. Passive and active protection increase the chance of survival. The C2 *force protection module* must work and act like the other modules discussed above. The principle would be *functional and actionable sub-modularity* on: CBRN defence, combat engineer, cyber defence, information protection, military police, occupational safety and health. The management of specific situations through passive protection measures[27] and active protection measures[28] as part of direct management, is manifested during reconnaissance activities, during combat or tracking patrols, during the establishment of patrol bases or the effective use of reserves. Acclimatization is very important for the human factor (as one of the major problems) and must be part of the operational plan. It also includes the preparation of reserves and replacements. Replacement of forces at high altitudes by air transport, without prior acclimatization, do not work. The personnel would be compromised from the start in terms of physical and mental health.

As for *communications* as part of the C2 module within the command and control system, they are subject to restrictive condition imposed by high altitude areas. Most of the time it is necessary to use relay/repeater stations and other connecting elements (liaison officers, combat patrols, etc.) in addition to communication and IT elements of the C2 module. Helicopters are often used for reconnaissance missions, *mobile command posts* and for the personal contact between commanders, but they cannot always be used due to weather and vulnerability against the adversary. Therefore, we support the possibility of using communication systems, on a functional submodular model, on robotic or partially robotic systems, with extensive capabilities to execute the maneuver and to support themselves for a long time in areas located at high altitudes. The measures adopted to *ensure sustainability, supply, adequate infrastructure, protection against mountain environmental factors*, as well as the C2 measures adopted *to preserve combat power* are of decisive importance in conducting military action/operations in this type of environment. At the level of the operational planning process within the resources module (personnel, logistics, medical support, administrative support of command post), logistical situation and estimates should be produced by personnel with experience in mountain operations, but also involving digitized and AI assisted platforms (if we want to implement the concept of decision-centered planning (such as mosaic warfare). A deployment of elements/ forces fighting autonomously in remote areas, combined with the risk of disrupted supply chains, requires logistical sustainability based on self-sufficiency and self-sustainability (supply cannot be guaranteed). Therefore, planning must be carried out on self-sufficiency, durability, and independent maneuvering elements must be strengthened by logistical supply forces, with mountain skills and capabilities and/or handling forces (on the ground or in the air) partially or totally robotically disaggregated (with aggregation capability and rapid action). At this moment, helicopters are the most efficient mean of transportation at high altitudes, but it is a *monolithic*[29] type (discovery-determination, decision and action) that once compromised will compromise the task/mission assigned to it. However, the use of helicopters can be restricted by bad weather, high altitude and enemy's activities. For as long as possible, the advantages of supply vehicles and all other appropriate means of transportation (such as tractors, vans, platform trucks, snow vehicles, quads, snowmobiles, cable transport, transport animals, robots, drones, etc.) should be exploited. The C2 resources module manages the reconnaissance, security of special equipment and the personnel and equipment evacuation, while risking falling on steep slopes.

*Maintenance and repairs* are not advisable to be carried out at high altitudes unless robots are conducting them. The objective is to ensure the

necessary degree of availability of the material and the operational availability of devices, weapons and equipment. From the point of view of the replacement (if necessary) of the human resource, the replacement personnel must have had the same high altitude training and have the same equipment as the forces already deployed. The conditions generated by an environment make it substantially more difficult to provide medical support.

The need for a new approach to combat at high altitudes is imperative. Today, the most significant operational challenges that forces face in such an environment, include those related to sensors and networks, and those related to autonomous high precision weapons, partially or fully robotic. For example, China is using these capabilities as part of a comprehensive system of systems, designed to attack perceived vulnerabilities in adversary's forces. Russia complements its long-range precision weapons and sensors, the proxy and paramilitary forces it uses to implement "gray zone"[30] tactics to gain territory and influence by challenging disputed territories or destabilizing neighboring countries[31].

Instead of destroying an opponent's forces until he can no longer fight or succeed, a decision-centric approach to war would impose multiple dilemmas on an enemy to prevent him from achieving his goals. War based on classical maneuvers is designed to thwart the enemy's operations by disrupting its centers of gravity, such as support or command and control (C2)[32]. This can be viewed as attacking the cohesion of an adversary's combat network[33]. The transition to the approach to combat/conflict in areas at high altitudes, through concepts centered on quick decisions, is inevitable. In contrast, network-centric warfare is based on the commanders of theatres of operations (on their awareness of the situation(s) over large areas and on the ability to communicate with all the forces under their command). However, centralized decision-making will be neither possible nor desirable during future conflicts in extreme environments such as those at high altitudes. Improving adversary's capabilities in terms of electronic warfare (EW), other counter-C2 and intelligence, surveillance and reconnaissance capabilities (C4ISR) will reduce the ability of commanders to understand newly created situations or communicate in the area of operations especially in in high altitude locations (due to natural environmental factors). These actions will restrict the commanders' ability to exercise control over elements of own forces. While network-centric warfare requires a high degree of clarity and control, decision-centric warfare (generated by opportunities) induces uncertainty in enemy's forces and improves the adaptability and survivability of own forces by harnessing the distribution of force, dynamic composition and recomposition, reductions in electronic emissions, and actions against C4ISR. These aspects lead to a substantial increase in the complexity and uncertainty that an opponent would have in its own decision-making process. Autonomous weapon systems (unmanned vehicles) and the management of communication network systems could help forces to conduct dispersed actions with devastating effects on the adversary. The use of AI-managed autonomous systems at C2 level, allows for the aggregation of force according to the specifics of the mission, on the principle of economy of forces (disaggregation of the capabilities of traditional platforms and units with more missions in larger numbers and less multi-functional and costlier). In this context, our opinion is that decision-making support needs to be achieved with the help of AI. Decision-centric warfare addresses the limitations of command through mission with a new C2 structure, that combines human command with the control of artificial intelligence. The decision based on the involvement of AI and its support tools would allow commanders to control dispersed forces, adapt to environmental conditions at high altitudes or to the adversary, and to make enemy's decision-making process more complex.

The *Mosaic Warfare concept* provides a decision-driven approach[34] to conflict, that can be successfully extended to the high altitude environment. The central idea of Mosaic warfare is to create adaptability for own forces and complexity or uncertainty for the enemy by quickly composing and recomposing a disaggregated military force using *human command and machine control.* The implementation of the *Mosaic warfare* concept or other decision-centered warfare concepts will require substantial changes in the design of C2 forces, structures, architectures, and processes. If the design of the force is carried out *without modifying the associated C2 process*, commanders and personnel of the general staff will have difficulty managing a greater number of elements

of a disaggregated force compared to a traditional force. Without automated and AI-assisted control systems, commanders would be much less able to properly manage the new force structures resulting from decision-centering (to create complexity for the adversary) or recomposing the force in response to the enemy's actions and countermeasures. The example below illustrates a model of AI assisted, human command decision-making process (participates in the development of courses of action and the mission task organization) and control exercised through artificial intelligence over the execution of the mission by the mission specific aggregated force.

The idea presented in the previous example was validated by three war games conducted by the CSBA (Center for Strategic and Budgetary Assessments) that compared, in plausible, high-powered scenarios and based on a potential future regional conflict[36], the performance achieved by the C2 systems and conventional forces of the U.S. and those of the mosaic forces (with the related C2 processes). The war games were built to test five assumptions about the feasibility and operational benefits of the Mosaic War concept[37]: commanders and planners can gain confidence in a machine-activated control system; Mosaic Warfare will increase the complexity of the force and degrade the opponent's decision making processes; Mosaic Warfare will allow commanders to engage several actions at once, creating additional complexity for opponents and overwhelming their decision-making process; mosaic force design and the C2 process will increase the reaction speed of forces and decision-making process; Mosaic warfare will allow more commanders to apply more diverse combat methods and tactics, strategies compared to those executed with a traditional force.

Another opportunity offered by the concept of Mosaic warfare is the execution of actions or operations through maneuvers. Forces could create uncertainty for the opponent and discourage aggression by using decision-centered approaches, such as successive and/or simultaneous maneuvers executed with mosaic-like forces. Two fundamental applications of maneuver warfare are deploying or preventing the enemy from achieving the desired goal at the desired time and disrupting or attacking the enemy's center of gravity. This can be viewed as attacking the cohesion of an opponent's combat network.

In conclusion, all these challenges especially arising from bringing military action to the high

EXEMPLE OF A CONTEXT-CENTRIC C3 APPROACH[35]

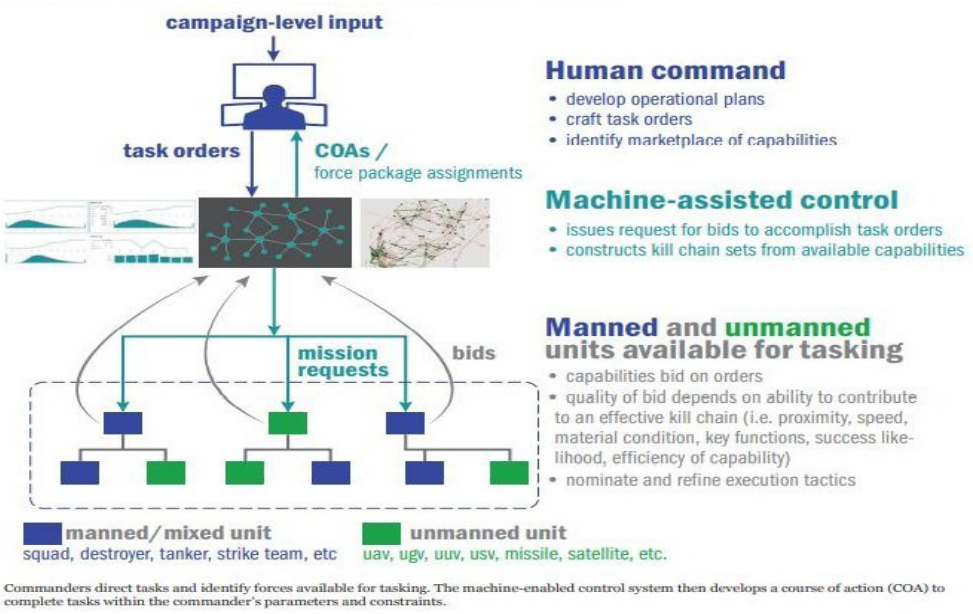


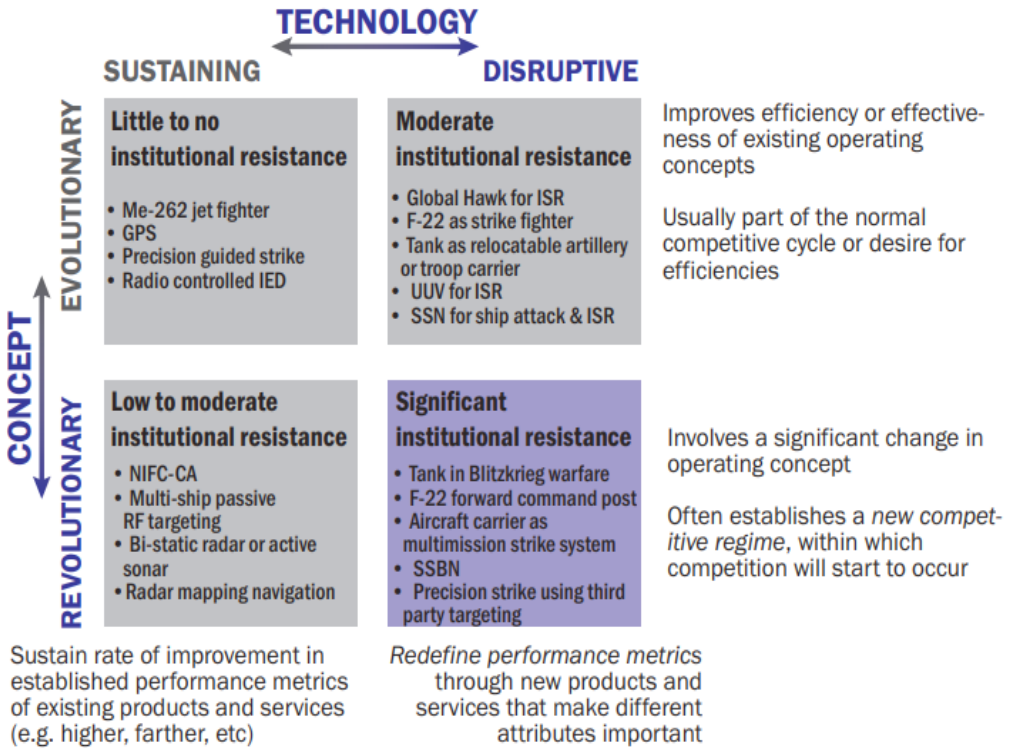

**Figure 1** *Example of a context-centric C3 approach which uses human command and artificial intelligence control over disaggregated force with mission specific aggregation capability*

altitude environment can be managed by modular, digitized and artificial intelligence assisted command and control systems, given that the fight will be approached by corroborating the latest concepts specific to state-of-the-art conflicts with the latest technological discoveries.

**Combining concepts with technology**

Supportive technologies provide progressive improvements to current systems and use similar mechanisms to achieve combat effects. Disruptive technologies use new mechanisms to provide military value using different vectors than previous technologies. For example, on a current radar, the *jammer*[38] can be rated (like its predecessors) by how well it hides or misleads the target. On the other hand, the performance of a *stealth platform*[39] is evaluated according to how well it avoids being detected or targeted by radar. New supportive or disruptive technologies can be combined with evolutionary operational concepts that introduce changes in the use or capabilities of the equipment (such as the use of radar to locate navigational means) or revolutionary, operational concepts that pursue military objectives in entirely new ways (such as using satellite for navigation). One way to visualize the relationship between technologies and operational concepts is shown in Figure 2[40]. A parallel is made between the supporting and disruptive technologies based on revolutionary and evolutionary concepts, some of the resulting effects also being portrayed.

Recent efforts to develop AI and autonomous systems have focused on improving modes of operation rather than developing new combat concepts. For example, Project Maven, an early DoD-enabled program (US's Department of Defence) uses AI to improve speed and accuracy in the interpretation of images compared to human analysts. Many of these images are gathered by autonomous satellite or UAV sensors, that perform the same functions as those with human crews, but can do so more or on wider areas. This approach does not fundamentally change the way DoD gathers or uses information. Maven and autonomous sensors combine precision weapons and sensors in




Military innovations combine a sustaining or disruptive technology with an evolutionary or revolutionary operational concept. The combination of a revolutionary concept with a disruptive technology has the potential for initiating new competitive regime but is also the most challenging innovation to implement. This figure is based on the discussion in Richard H. Van Atta et al., *Transition and Transformation: DARPA's Role in Fostering an Emerging Revolution in Military Affairs*, vol. 1, *Overall Assessment*, Paper P-3698 (Alexandria, VA: Institute for Defense Analyses, November 2003), available at https://fas.org/irp/agency/dod/idarma.pdf.

**Figure 2** *Military innovations from the combination of types of technologies with new combat concepts*

the network and manage information differently, to gain a substantial advantage in decision making[41]. The superiority of the decision adopted through the command-control architectures specific to the concept of mosaic warfare starts from the central idea of the concept, namely to create adaptability and flexibility to own forces and complexity or uncertainty for an enemy, by quickly composing and recomposing, if necessary, the disaggregated forces that use *human command and artificial intelligence control*.

The significant changes required for the design of C2 forces, architectures and processes will be difficult to implement quickly in a high altitudes environment conflict. Consequently, in order to assess efficiency and effectiveness, an experimental force can be initially set up to act in such an environment, to carry out operations specific to decision-centric operational concepts and to command by mission. This method was used during previous changes in the US military (the development of Air Land Battle by the US military and the implementation of stealth and precision strike capabilities by the US Air Force)[42]. At this time, most of the existing forces worldwide are made up of multi-mission units, with crew such as planes, ships and formations of troops that are autonomous, or monolithic, incorporating their own sensors, C2 capabilities and weapons or electronic combat systems.

In the U.S. military, power elements that are not autonomous multi-mission units must be part of a pre-designed System of Systems (SoS) in accordance with DoD requirements and procurement policies[43]. The relatively inflexible configuration of monolithic multi-mission units compared to SoS, limits the variety of courses of action for that force, reduces force adaptability, actions/operations performed are predictable, and decreases the likelihood of misleading the enemy (as part of operational concepts focused on gaining a decision-making advantage). By breaking down some of today's multi-mission monolithic units into a greater number of smaller elements with fewer tasks, one could better track decision and informational superiority and achieve the expected effect in confusing the opponent. For example, at high altitudes, a group of fighters could be replaced by a fighter acting as a C4ISR platform along with combat drones, UAVs equipped with sensors and electronic warfare (EW) equipment. A force operating in the mountains could be made up of small formations that operate using combat drones, UGVs and/or UAVs to improve their self-defence, ISR and logistics capabilities.

Figure 3 shows the difference between a monolithic unit and an aggregated force based on the mission specifics (*composable force* – is the term used in the specialized literature of the U.S. Army) in terms of the act of discovery-determination target, decision and action (sense, decide, act). Disaggregating units with multiple missions could increase the flexibility and adaptability of the force and create a complex situation for the opponent. The traditional "monolithic" fighter (left) is replaced by a bundle of forces aggregated on the mission specifics (right) in which the attacker acts as a C2 core (commanded by the human factor and controlled by AI) for one or more groups of UAVs. This aspect is illustrated in the Figure 3.

**Conclusions**

Units designed to fight at high altitudes are designated to perform specific actions/operations in an extremely hostile environment. The human factor engaged in combat must have special equipment and must be trained in the terrain and weather conditions specific to this environment. C2 at high altitudes must be able to exercise command and control in operations, in degraded electronic spectrum and in harsh weather conditions (fog, frost, blizzard, etc.). This capability requires a complex operational planning process and the assignment of specific tasks for the execution of actions/operations under any weather conditions. A common operating picture is a key component of C2, whether the forces are of monolithic type or especially for the composable forces.

We propose two scenarios of force build up and exercise of control command:

- reinforced units, especially established on the mission specifics (small, supple, mobile, with high self-sustainability, with high firepower and high maneuverability) having a modular C2 but supported by classical architectures and platforms (based on the concept of mission command);
- disaggregated forces with rapid aggregation capability (depending on the specificity of the mission) in the composition of which to also add partially or totally robotic autonomous weapons,

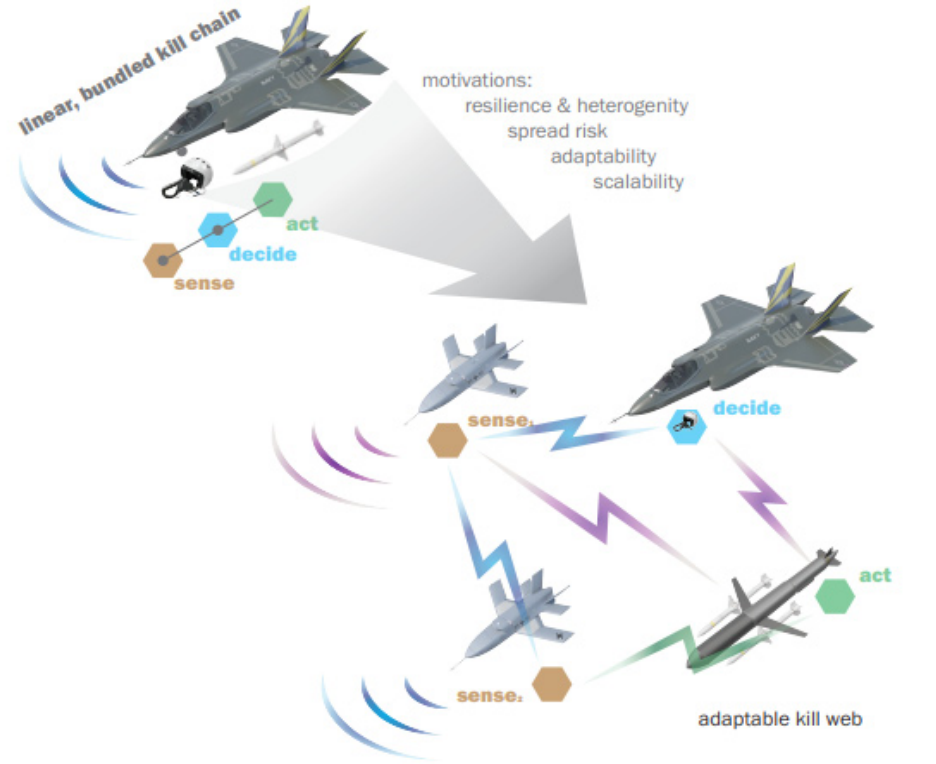



**Figure 3** *Monolithic units versus aggregate force packs on the mission specifics*[44]

over which to exercise human command and artificial intelligence control, at the level of a modular system of command and control systems, supported by digitized platforms and operational within the mosaic war concept (based on decision) specific to conflicts with variable geometry.

Harnessing disruptive technologies, artificial intelligence and autonomous systems is the new competition arena for modern armies. New operational concepts will be essential in order to fully exploit the potential of these technologies. AI and autonomous systems must not be limited at improving current operational approaches. Decision-centric operational concepts, such as the *mosaic war concept*, could harness the benefits of AI and autonomous systems while reducing the impact of their potential disadvantages. For example, by disaggregating monolithic (manned) platforms and troop formations into smaller, less multifunctional units, the design of the decision-centered force would reduce the pressure put on an individual autonomous system necessary to replace an entire multi-mission platform. Combining human command with a degree of control given to artificial intelligence, C2 will process decision-making algorithms, harness human creativity in the execution of tasks, allocate the necessary forces and easily conduct military actions as part of an operation. Moreover, using predictive scenarios in the planning process (to which AI will have a substantial contribution in both analysis and prediction) will avoid surprise and will create solutions to solve possible, probable and imminent situations.

The implementation of decision-centred operational concepts is likely to be evolving. In terms of conducting military actions to high altitudes, a *decision-centered force design* and a C2 system (*modular and digitized*) with a related process (*procedural, algorithmic but also intuitive based on experience and knowledge*) could be adopted in the first phase to implement the concept of mission command. Decision-centered concepts may not fully correspond to the requirements of new types of conflict, but they can be developed, combined or replaced by other new concepts, depending on the continuous evolution of technology and the evolution of conflicts.

Command and control systems must be based on modular architectures and digitized platforms (supported by artificial intelligence in both the operational planning process and the execution) that allow them to permanently adapt to the requirements of a conflict with variable geometry. We believe that the *modular and submodular* organization of a command and control system designed to conduct military actions/operations at high altitudes and beyond, built according to *Rubik or mosaic architectures* (allowing them to combine and recombine quickly according to the mission specifics or to the actual or predicted situation) and supported by *intelligent digital platforms* (in which AI is implemented with a clearly defined role in the decision-making process and control of the force) is the scenario that offers an optimal solution in the asymmetry and unpredictability of situations generated by modern conflicts, multifaceted and with an extremely variable geometry of actions.

**NOTES:**

1 The 3rd Italian Alpine Troops regiment executed a surprise attack at night. Using the most difficult routes they managed to conquer this strategically important peak.

2 The famous raid in which the Württemberg Mountain Battalion managed to infiltrate the Italian trenches.

3 In 1915, The High Italian Commandment did not adequately exploit the gained advantage and moved on to conquer the next positions, in accordance wit the time doctrine. Two years later, the in prompt exploitation of the difference between austro-hungarian and the german troops conducted to the fall of the entire eastern italian front.

4 The Apennine mountain range, impeccably defended by general Kesselring's forces, proved to be an insurmountable obstacle to many Allied divisions.

5 German paratroopers gained important experience in the Apennines, which allowed them to last so long. The Mountain Troops, arrived from the Russian front, were not so efficient, because, being dislocated in the steppe for a long time, they were not used to fight in impractical and compartmentalized environments.

6 In a famous interview, General Massod, the hero of Panshir, when asked how he managed to resist for so long with a few poorly armed fighters in front of the world's largest and most powerful armed forces, replied that their power lies in the nature of that place, narrow valleys and harsh mountains, "How Afghanistan defeated the Soviet Union", *Deutsche Welle*, 2021.

7 Blandy, *North Caucasus: The Advent of Mountain Brigades*, Defence Academy of the United Kingdom, 2007, pp. 1-5.

8 http://unep.ch/publications/UNEP_Afghanistan_NRM_ guidance, 2021, accessed on 09.11.2021.

9 The Ladakh area, along the line of real control (LAC), where we see the confrontation between these emerging superpowers.

10 *** Russian Exoskeleton Project, *Russia's latest combat exoskeleton to boost fire accuracy by 20%,* TASS Russian news agency, 2021.

11 *** *Brussels Summit Declaration*, 2018.

12 Reconnaissance Patrol – Provides the commander with accurate and timely information about the enemy and the terrain in order to produce a plan (they can be of two types for researching the routes of the areas); Combat patrol – it is necessary that any subunit of a suitably strengthened platoon level execute missions such as ambush and raid (absolutely necessary in mountainous terrain and materialize in tasks such as: destroying / capturing the opponent or military equipment / installations; harassing the opponent; ensuring the protection / security of the upper echelons); Tracking Patrol - the platoon or section can be assigned to track/find the opponent who has broken the contact in order to re-establish contact with him.

13 Patrol base - position organized at section / platoon level during halts or for a longer period (no more than 24h and never twice the same position) for the control of important objectives and the preparation of future decisive actions (offers the advantage of covering large areas with small subunits and maintaining control of them).

14 Bryan Clark, Dan Patt, Harrison Schramm, *Mosaic warfare exploiting artifcial intelligence and autonomus system to implement decizion – center operations*, Center for Strategic and Budgetary Assessments, 2020, pp. 8-13, 56-58.

15 Cezar Popa, *Strategii, concepte și procedee de efcientizare a procesului decizional*, Raport de cercetare științifcă nr. 2, "Carol I" National Defence University, Bucharest, 2021, p. 22.

16 Niculai-Tudorel Lehaci, *Tendințe în evoluția sistemului de comandă și control la nivel operativ*, "Carol I" National Defence University Publishing House, Bucharest, 2015, p. 65.

17 Rapid response, Arctic/subarctic or urban control operations.

18 Including arctic conditions.

19 Intelligence cycle consists of directing, collecting, processing and dissemination phases (NATO Allied Joint Doctrine for Intelligence Procedures AJP-2.1).

20 ISTAR – Intelligence, Surveillance, Target Acquisition and Reconnaissance (NATO Allied Joint Doctrine for Intelligence, Counter-Intelligence and Security AJP-2(A)).

21 This includes implementing air defence, OPSEC, INFOSEC, COMSEC, Cyber Defence, CBRN, CIED and health protection policies and standards.

22 Symbiosis is also achieved at action level (command-combat-support) and at man-artificial intelligence-machine level (C2 systems – autonomous weapons, partial or totally robotic - robots- drones- satellites, etc.).

23 In the sense of the term command, in this context, I wish to include the command and control modular systems built on complex digitalized architectures, in which is implemented artificial intelligence and which are close connected (symbiotic) with the command element of the force of execution.

24 Only the modules that are needed at a given time depending on the time available, the specifics of the mission and/or the concrete situation on the ground are involved in the operational planning process.

25 It connects those modules that are needed at some point to solve a situation.

26 Cezar Popa, *Structuri, sisteme, echipamente și tehnologii moderne în compunerea sistemelor de comandă și control*, Report for scientific research no.1, "Carol I" National Defence University, Bucharest, 2020, p. 34.

27 Preventive preparation/prevention and adaptation measures.

28 Tactically proactive measures aimed at discouraging an opponent from effectively attacking or counteracting the effect of an attack.

29 *Monolític*, adj. Regarding the monolith; of monolithic. Well-rounded, unitary, *Explanatory Dictionary of the Romanian Language*, https://dexonline.ro/definitie/monolitic, accessed on 11.11.2021.

30 The area between peace and war or erratic war. The tactics used are the information flows and the channels of influence along with the cyber, economic and psychological ones with the involvement of the public opinion, morals and legal processes, https://adevarul.ro/international/asia/china-poarta-razboi-neregulat-sua-principiile-inarmarii-zona-gri-1_609a101a5163ec4271e9ae60/index.html, accessed on 09.11.2021.

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35 Bryan Clark, Dan Patt, Harrison Schramm, *Mosaic Warfare expoiting artifcial intelligence and autonomous systems to implement decision – centric operations*, Center for Strategic and Budgetary Assessments, 2020, p. 16.

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37 Bryan Clark, Dan Patt, Harrison Schramm, *Mosaic Warfare exploiting artificial intelligence and autonomous systems to implement decision - centric operations*, Center for Strategic and Budgetary Assessments, 2020, p. 17.

38 Jamming equipment.

39 Increasingly complex smart platforms with low dependence on monolithic platforms.

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44 Bryan Clark, Dan Patt, Harrison Schramm, *op.cit*., p. 47.

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