Technology, Stress and Decision Making in Military Space Operations. Humans at the heart of change.

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Abstract - Space is an environment characterized by complex conditions and high levels of fluidity, in which the presence of public and private actors, as well as the convergence of national interests, can lead to the escalation of political and economic tensions. These tensions can ultimately culminate in armed conflicts to confront opponents and change/defend the current international balance of power. During a military space operation, the decision-making ability may be limited by stress and affected by the use of artificial intelligence (AI). A fair balance in the relationship between human beings and the machine, along with an effective training policy, are necessary measures to make the current digital revolution sustainable and keep humans at the heart of change.

Keywords: Stress, Decision Making, War, Military Space Operations, Technology, Artificial Intelligence.

Key messages:

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Introduction

Outer space is a highly congested, competitive and sought-after environment (1,2) where public and private actors compete to increase their geopolitical influence and benefit from the advantages provided by the space economy. The test with which Russia hit a Cosmos satellite (3) a few months before invading Ukraine reinforced the idea that space will soon turn into an arena for military confrontation. The outbreak of the conflict between Kiev and Moscow and the escalation of the crisis between Israel and Hamas have shown that the ability to operate in space is an important factor for success during multi-domain operations. Moreover, Russia recently vetoed the resolution, proposed by Japan and the United States of America to the United Nations Security Council, that would strengthen the nuclear-nonproliferation regime in space. This veto makes the risk of military escalation in Earth orbit (4) a plausible one. In such a scenario, a country's space assets can become a strategic target for competitors. For this reason, many countries have undertaken military space programs. New technologies, most notably AI, have increased the possibilities of operating in space to protect national security.

However, additional effort is needed to prepare the human component for deployment in an operational environment characterized by complexity, fluidity and, increasing digital innovation. Therefore, we need to find solutions to increase the military personnel's resilience and their ability to make effec-

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tive and timely decisions in the Big Data era.

This article aims at demonstrating that governments must make intensive efforts to prepare military personnel for deployment in an operational environment characterized by complexity, fluidity and increasing digital innovation. In addition, it is their duty to establish the right balance in the relationship between humans and machines, in order to enable the former to maintain control of processes.

This article is divided into five main sections. The first section explains what makes conducting a military operation in space very complex and analyzes the advantages of implementing AI in this type of operation. The second section describes the psycho-physical conditions that can make human decision-making more complicated, affecting the quality/accuracy of decisions and the ability to control AI outputs or the tasks assigned to AI. The third section analyzes some case studies supporting the claims presented in the second section. The fourth section explores the dark side of AI, particularly the risks associated with its implementation in military decision making and suggests some measures that can help mitigate such risk. Finally, the fifth section concludes the dissertation with a reflection on how to explore this topic further and proposes practical solutions to keep humans "in the decision-making cycle" and at the heart of change.

The Complexity of Military Space Operations

Conducting military space operations is very complex. They consist of a set of technical and scientific activities the effects of which can be observed thousands of kilometers away from the operator (e.g., altering the positioning of a satellite). These activities are affected by multiple variables (environment, timing, physical laws, etc.), and need reliable data, precision of action as well as continuous monitoring to avoid unforeseen contingencies. Furthermore, some regulatory gaps and the dual-use nature of space operations make it difficult to distinguish its military or civilian nature. Moreover, the space domain is characterized by threats of both unintentional (e.g., gravitational and solar radiation effects) and intentional nature (kinetic and non-kinetic, cyber and electronic, etc.) that require high operational readiness and decision responsiveness to be prevented and, if necessary, managed. In such situations, which are very often critical, finding creative solutions can be crucial (5).

During an interview, the CO of the Italian Space Operations Command pointed out that the difficulties that arise in a satellite re-orbiting operation can stem from several malfunctions: the failure of on-board systems, the unavailability of intercontinental-scale networks, and the lack of highly specialized personnel devolved to managing the operation. In such a circumstance, unpredictable events, such as the temporary inefficiency of a remote control antenna or an unexpected reaction of the on-board attitude control system, may result in a failure.

An additional critical problem is the lack of sensors to enable the commander and his staff to acquire a reliable picture of the operational situation. Uncertainty is, by its very nature, a stress factor and can lead to making poor decisions. Thus, considering the vital importance placed on space services today and their strategic impact on states, any errors e.g., a failed maneuvering of a satellite or its placement in an unplanned orbit may be interpreted by a competing state as a threat and cause reactions/retaliation. This may, therefore, affect the stability of international relations as well as the quality or continuity of the services provided by space systems, on which state articulations and citizens are highly dependent.

Some examples that can help demonstrate the current importance of space services are satellite communications, Internet access, browsing and geolocation, Earth observation (a field that studies weather, climate, and emergency response), financial and banking flow management, and information and diplomatic relations.

The introduction of AI has made it possible to improve the engineering and development of satellites capable of providing high operability standards throughout their entire life cycle. The future implementation of AI in the military decision-making process will enable the integration of the organizational structure of the staff, facilitating certain activities. In the military domain, commanders' decisions are the result of a systematic process: the commander's staff analyzes the mission received and develops/evaluates multiple courses of action (COAs); among these, the commander selects the one deemed most suitable to best accomplish the assigned mission and issues the necessary orders to the dependent units (6-7). The management and coordination of the mentioned activities, especially during war or fighting operations, are very complex and require short execution times and, in any case, consistency with the operational tempo.

AI is also improving big data analysis, enhancing the predictive capability of command and control systems and

reducing the risk of false alarms, making operational decision making and problem solving faster and more effective. In this regard, Meerveld et al (9) and Kase et al (10) pointed out that including AI in the decision-making process would facilitate targeting activities and the production of a sufficiently documented information output. In addition, it would allow the simulation of the preferred Course of Action by displaying its risks and chances of success. It would also improve situational awareness through the integration of all intelligence from across military domains (air, land, naval, space, and cyber), thus enabling commanders to make informed decisions. In this respect, the U.S. government has made significant investments in AI-managed technologies in order to gain access to a broader data and information pool. For example, a $3.5 million contract was awarded to a U.S. company for the processing of satellite imagery and the analysis of relevant data that would enable the tracking of moving vehicles and the training of AI models in use (11 - 12).

In addition, the Space Systems Command has implemented a program called Tactical Surveillance, Reconnaissance, and Tracking Program (TacSRT) to rapidly deliver analytical and operational planning products across deployed U.S. Space Force components. This aims at creating a strategic advantage and at supporting commanders engaged in combat activities, providing them with a better chance of success (13).

Finally, the National Geospatial-Intelligence Agency is introducing machine learning and computer vision into all its operations, from the battlefield to the highest levels of geopolitical analysis. The agency is using the rapidly evolving artificial intelligence technologies to enable military leaders to have a detailed and accurate "operational picture" (a description of what is happening on the battlefield) and to provide policy-makers with a better understanding of global military threats and dynamics (14-15).

Human Limits in Military Space Operations

Throughout history, humans have developed the ability to survive in an environment characterized by danger and uncertainty. Therefore, the large networks that structure the human brain (default network, executive control network, and salience network) enable us to reflect on the problem, develop new concepts, and identify appropriate solutions. Brain networks also serve as cognitive control and allocate the appropriate attentional resources to the given task (16). On the other hand, the endocrine system determines a state of physiological activation, commonly known as stress, which allows reaction to stimuli perceived as threatening and enables adaptation to environmental conditions. Under threatening circumstances, the neurocircuits that are in charge of vigilance, behavioral reactivity, and emotional management play the dominant role.

Although military personnel generally have a strong set of values and appropriate training to operate in dangerous and complex conditions (17), managing critical and unpredictable space operations can cause fatigue and stress. Chronic exposure to stressful situations, combined with relevant life events or health-damaging behaviors e.g., lack of sleep and exercise, a smoking habit, alcohol consumption, and an unhealthy diet can cause an allostatic overload. Therefore, although military activities are generally conducted under high security conditions compared with those in combat zones (18), stressful circumstances make it more difficult to respond to new challenges. They wear down biopsychosocial well-being, are the aetiological cause of anxiety and depression, and deteriorate resilience (19).

The term resilience derives from the Latin verb *resalio* ('to jump back, bounce back'). It describes an individual's ability to overcome the hardships of life, to adapt to different circumstances or momentary needs, and to respond to the psychophysical wearing to which he or she is exposed. By doing so, he or she manages, in some cases, to strengthen and improve himself or herself (20). Resilience is the product of a dynamic process (21) of interaction between the adverse events to which the individual is exposed, which can vary in terms of type and amount, and his or her personal attitudes, which are supported by cognitive, emotional, familiar, socio-cultural, training, educational and experiential factors (22). Substantially, resilience is a multidimensional and multidetermined capability influenced by psychological, biological, and social variables (23). It can, therefore, be strengthened throughout life, but also weakened due to the intensity of the experiences and the possible lack of some of the factors that support the individual in coping with difficult situations. Resilience is an essential skill for military personnel. Being able to withstand and overcome difficulties is, indeed, a significant factor in boosting self-esteem and motivating the individual to continue to perform well at work. At the same time, failure increases personal vulnerability by exposing the individual to mental and physical problems that can significantly limit his or her quality of life and job performance.

The relevance of this topic was high-

lighted by the them U.S. SoD, Donald Rumsfeld, who specifically praised the resilience of U.S. Special Forces operators deployed in Afghanistan who were forced to learn to ride in handmade saddles to move through mountains controlled by enemy units (24). Rumsfeld stressed that, in modern operations, the ability of commanders to adapt and manage change is a major factor in success (25).

Chronic stress is a serious threat, especially during space operations, because it reduces the ability to identify and solve problems. As a matter of fact, in an emergency, the human organism deploys all available resources to enhance the brain networks and apparatuses responsible of ensuring survival. However, this is at the expense of the neurocircuits that deal with higher-order cognitive activities (26).

The use of AI to support military commanders in emergency situations is a cause for concern (27-28) and it raises ethical questions, especially regarding the level of the machine's autonomy. The uncontrolled use of innovative AI-based technologies can cause cognitive biases (29), generate cognitive fixedness or mental sets, and increase the risk of the decision maker giving up and automatically considering machine solutions more effective (30). Cognitive biases are based on erroneous perceptions or beliefs that influence the view and interpretation of things, promoting the shaping of beliefs that, although wrong, are used to make decisions quickly and effortlessly (31 - 32). There are many types of biases, some of which represent a significant criticality in the processes of interaction between humans and machines (33 - 35). The ability to control the operations of a machine can be compromised by the automation bias (36). The habit of using a specific application as well as the trust placed in its correct functioning can generate errors either of omission (when a situation that would require human intervention is not recognized) or of commission (when the human endorses an erroneous decision made by the machine). These biases limit the possibility of detecting an erroneous decision proposed by AI as well as preventing its implementation (37).

The persistent occurrence of these psychological conditions has been found in many fields (e.g., health care, flight training, etc.) (38), and it always results in severe limitations to organizational performance. Challenges are bound to arise when managing large volumes of complex data and establishing meaningful connections that are useful for understanding evolutions in the typical military operation scenario (which is increasingly hybrid). These challenges reduce the predictive capability and, consequently, the ability to identify solutions that can have a long-lasting effect. This situation characterizes the so-called anchoring bias (39 - 40), a condition in which the decision maker focuses on the scarce and limited information processed by the machine, neglecting the salient or more inconvenient information directly available through the feedback coming from the battlefield. Such an attitude poses the risk of failing to adequately correct the current maneuver or military action.

The short time available to make a decision and the pressure exerted on decision makers, combined with the impact the actions may have in the broader context of public debate, may cause additional biases. In such cases, the failure of specific situational assessment mechanisms is likely to cause individuals to opt for solutions or behaviors that do not provide organizational benefits or tend to preserve the 'status quo' (41-42). Moreover, in dangerous environments such as space, a dystopian narrative (misinformation) regarding AI can have a strong impact on public opinion and reduce the essential social support provided to the Armed Forces in democratic countries (43).

A misinformation campaign carried out on the media, especially on social media, can influence the analysis conducted through new artificial intelligence systems and cause authorities to make poor decisions or ignore possible threat variations. Artificial intelligence is particularly susceptible to deception. The spread of deep fakes can have serious consequences on geopolitical stability and undermine the strategic and military balance as nuclear-armed states become increasingly dependent on artificial intelligence (44).

Errors arising from the Interactions between Humans and Machines

In the context of the interaction between humans and machines in the defence sector, the psychophysical conditions under which an individual makes decisions represent a serious threat to safety and can be the cause of serious failures and accidents. Below is an analysis of some case studies that can explain such risks/threats.

During the U.S.-led invasion of Iraq in 2003, Atherton (45) reports that the decision to launch a Patriot missile against an alleged threat caused the downing of a Royal Air Force Tornado aircraft and the death of the two crew members. In that dramatic event, the detection systems identified the British aircraft as an Iraqi missile designed to destroy their air defense systems and, therefore, suggested the operators to engage and destroy the target. The oper-

ators had very little time to make a decision. In addition, their level of training was not suitable for the specific theatre of operations and it prevented them from identifying false alarms through alternative measures of detection of the approaching aircraft (46). Therefore, they decided to trust the assessment of the machine by endorsing its decision to intervene.

Another important and more recent event concerns the current crisis in the Middle East. In particular, the widespread circulation of information that depicted Hamas as a transitioning movement that was gradually abandoning its jihadist origins and becoming a governmental entity helped shape the protocols of the AI systems used by Israeli intelligence and the related human control modalities (47). The anchoring of such ideas and beliefs, combined with the lack of analysis on Hamas' military and extremist wing, deprived the alert sensor network of the information it needed to perceive that the outputs produced by artificial intelligence were wrong. As a result, this made it impossible to prevent the criminal attack that occurred on October 7, 2023, in which 1,300 Israelis were murdered and about 240 were abducted and taken to Gaza as hostages (48).

The use of an AI-operated targeting system called "Lavender" during Israeli attacks in the Gaza Strip has been a source of concern and has been strongly criticized by international organizations because of the involvement of a large number of civilians. Therefore, for the purposes of this article, the focus of the analysis was on the minimum time available for the operator (approximately 20 seconds) to approve the dropping of a bomb on the identified target and the number of collateral damage deemed acceptable (15-20 casualties) per deployment (49-51). Under such circumstances, it is plausible to assume that some decisions were influenced by cognitive biases or the combat stress to which military personnel had been exposed. The human brain can trigger immediate rapid reactions to a situation if specific procedures have been learned and repeated and if the situation requiring the application of behavioral reactivity in the desired time frame is easily recognized. In these situations, however, it is possible to make mistakes in the assessment and execution of the sequence of learned behaviors because it is complicated to detect changes in the available flow of information. The emotional framework that guided the use of these new applications also contributed to the likelihood of approving the machine's decision and/or preserving the status quo. In this regard, McKernan and Davies (49) report, for example, that during an interview, an Israeli intelligence official admitted, «Everybody, including me, lost people on October 7. The machine did it coldly. And that made it easier.»

Finally, Rashid et al (52-53) point out that the ability of third parties to manipulate alerting systems by spreading misleading information is a serious danger because it can affect the quality of outputs produced by AI-managed decision-making applications. In particular, he described the results of a study based on a tabletop exercise that demonstrated the psychological potential of aggressive AI capabilities. In the simulated scenario, a group called "The World Peace Guardian" published photos and videos showing U.S. Special Forces soldiers cruelly killed in Syria during a confrontation with Russian military instructors. This led U.S. analysts to publicly advocate the use of tactical nuclear weapons as retaliation. There was a widespread circulation of documents and fake news about the activation of protection protocols for American leaders and their families and the initiation of launch procedures at U.S. ammunition depots and air bases. As a result, Russian and Chinese AI-based surveillance systems were prompted to speculate on a possible U.S. air strike. This case proved that a non-state actor was able to create and spread false information that triggered the risk of a nuclear crisis and alerted the diplomatic channels of the three superpowers to ascertain whether this risk could turn into a real threat, before escalating or declaring the state of emergency lapsed. Thus, this demonstrates the high potential of the aggressive use of artificial intelligence capabilities.

The Dark Side of the Military Implementation of AI

The fields of application of AI have become vast and offer the opportunity to modernize society, paving the way for revolutionary innovations that could improve the quality of life and psychophysical well-being of humanity (54-56).

The defence organization is the organizational context in which an increasing number (57-58) of new AI-based applications could be developed (59) in the upcoming years. Ding and Dafoe (60) state that "artificial intelligence is the new electricity" because, similarly to the introduction of electricity into military affairs, new technologies will increase the effectiveness of the Armed Forces as well as improve national security and the ability to compete in the international arena. A country's «Powerforce» is, therefore, increasingly interconnected with the level of modernization achieved, its sustain-

ability and utilization capacity (61-62).

The case studies mentioned above could lead one to believe prima facie that the use of AI in the military poses a danger, as there is an emerging imbalance in favor of the machine in decision-making and control processes. Moreover, it seems that the perception according to which these systems are an "Armageddon" with an anthropomorphic representation and excessive decision-making autonomy is prevailing.

However, this is not entirely correct. We should remember that the algorithm at the core of the development of future military capabilities is simply a list of detailed instructions to perform a task or solve a specific problem. It is, in essence, a human-generated product that returns an output consistent with the instructions received. Therefore, human intervention in making, training, and employing AI is what makes it an opportunity or a danger. There is, unquestionably, a dark side to the use of artificial intelligence in the military domain, due to its vulnerability to attacks and breaches and its dependence on the quality of the algorithm and data with which it is fed/trained. This dark side is at the heart of all attempts to take advantage of its malicious use, to spread unethical behavior, to marginalize and discriminate, to facilitate poor decision-making, to reduce access to services, and to increase the sense of insecurity by limiting the trust placed in this new technology. Using a tool that is unsuitable for the needs that arise during a critical situation, or that requires immediate reaction time, can have a significant impact on military personnel's perception of their self-efficacy, their level of self-esteem, their motivation to continue interacting with AI-managed systems, and their overall health status. It is also necessary to point out that the absence of an appropriate regulatory framework has allowed the proliferation of applications and technologies managed by a small group of multinational corporations. This "Hobbesian state of nature" could amplify the dark side of AI and turn into an additional threat capable of generating chaos and uncertainty in the complicated "chessboard" of international security.

However, it is undeniable that the risks posed by the dark side of AI can be mitigated. The possibility of taking advantage of AI requires a governance centered on the idea of a "Country System" capable of expressing a national vision, identifying the goals to be pursued and aggregating the resources needed to achieve them successfully. Such an approach would make it possible to stimulate the development of new technologies with the input of technicians possessing the appropriate skills and capabilities to understand the needs of the political authority and identify the characteristics and operational requirements of the tool to be implemented. The development of efficient and effective procurement would then support the growth of an ecosystem of companies oriented toward producing the tools necessary to maintain a high level of decision-making agility, timeliness of processing new information, and effective adaptation to change in order to enable military commanders to effectively address the challenges imposed by the fluidity and complexity of the modern international political and operational environment.

Humans at the Heart of the Digital Revolution

This paper describes space as a very complex domain of warfare in which conducting military operations can be challenging. Personnel employed in space activities can suffer from stress-related conditions that, if prolonged, can affect their health and limit their ability to make decisions or solve operational problems. The introduction of AI offers several opportunities to improve work procedures. It allows repetitive tasks and more complex activities to be assigned to the machine. It also makes it possible to optimize staff deployment by assigning available resources to the most relevant phases of an operation, especially during critical situations or emergencies. However, the debate regarding the extensive use of these new technologies is increasing and may limit the internal consensus of the Armed Forces.

Trust in technologies such as AI can only be based on knowledge. It is necessary to understand that the algorithm does not represent an issue if the humans who design, train and use it are professionally and ethically prepared. The digital revolution is a process that must be fully understood and handled by finding the right balance in the relationship between human beings and the machine. Personnel must master and use the available work tools responsibly, especially in decision-making processes (63). Simulations and wargaming can enable a virtuous learning cycle that, through experience and sharing, facilitates organizational change. In complex situations, what is essential is the personnel's awareness that they have the appropriate technical and professional background for the assigned task and that they have the necessary tools to face unexpected challenges. Indeed, this will increase optimism and confidence, reduce stress, and improve self-esteem and self-efficacy.

This knowledge-centered approach, which can increase the personnel's confi-

dence in themselves and in new technologies, seems consistent with the humanist tradition of Italian culture, where human beings are at the core of the historical, political, and socioeconomic evolution. Individuals are the protagonists of every innovative process, master the tools, and shape their own destiny. It is, therefore, key to develop/maintain a digital mindset, acquire new skills and experiences, and prevent technology from turning into an uncontrollable tsunami.

This approach was clearly echoed in the Bill of Law approved by the Italian Council of Ministers on April 23, 2024, which aims at regulating the use of AI nationwide with an anthropocentric view, so as to safeguard the autonomy and decision-making power of human beings (64).

This point of view can not be separated from a national governance effort that focuses on the concept of a "Country System." This is where the decision-making line which is composed of political, military and technical authorities is able to indicate goals, express needs, and draft requirements that through national procurement and the interaction with companies create tailored "smart equipment". In this case, it is inevitable that policymakers must be trained to increase awareness of the potential offered by space and the effective interaction between human beings and the machine.

Future Directions for Research

In conclusion, we believe that decision-making during space military operations is a sensitive topic and that the implementation of AI-based systems and services is essential in the process of modernization of the means available to military personnel to improve their work performance. However, it is necessary to establish an explicit limitation/balance in the relationship between human beings and the machine as well as a practical training policy to make the current digital revolution sustainable and centered on human beings. They are the ones that should continue to represent the actual engine and focus of the process.

In this regard, future research should focus on educating/training a new technology/space culture based on the fundamental principles of international law and on a universally recognized value system resulting from the development of guidelines for implementing the responsible and ethical use of AI in the military. Specifically, there is an increasingly emerging need to regulate the use of AI internationally through uniform and recognized standards. In this respect, the European Union's political initiative and the approval of the *Artificial Intelligence Act* ("AI Act") are essential points of reference (65).

Effective AI management has a significant impact on the quality of military commanders' decisions and can affect national security, the stability of the international relations system, and the continuity of essential services that space provides to citizens and states. For this reason, any further development should take into account the lessons identified/learned by the military personnel actually using AI-based systems/software. Indeed, this would enable experts to take the necessary steps to solve problems deemed critical and maintain appropriate performance standards.

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