THE IMPACT OF SPACE-BASED CAPABILITIES ON THE GLOBAL BALANCE OF POWER, IN THE CONTEXT OF TECHNOLOGICAL AND MILITARY FIELD RECENT DEVELOPMENT

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After the Second World War the technological progress in space systems has increased the relevance of the space domain, which has an essential strategic role in obtaining victory in all battlespace domains. Space capabilities perform a decisive role in all types of military operations, especially those involving the employment of nuclear weapons, in early warning, identification, location of nuclear facilities and launching sites, as well as in destroying them, in support or intermediary operations, collecting information in all warfighting domains, surveillance, reconnaissance, management and coordination of operating systems.

Space-based capabilities are also relevant to the normal functioning of modern societies and can be used in activities characteristic to the entire political, economic, civil, information, cyber, infrastructure, and military spectrum. Thus, their interruption would lead to the suspension of the services on which a functional system, for example a state, its society, or departments depend.

Keywords: space-based capabilities; satellites; sensors; detection; surveillance; tracking;

INTRODUCTION

The goal of NATO and its partner states is to keep up with and overcome the challenges generated by the complex future warfare, by capitalizing on the emerging technologies capabilities to enhance the ability to conduct multi-domain operations. (Diaz, 2021, pp. 2-4).

Space-based capabilities – the capabilities using space systems, which support, among others, military commanders, staff, and forces in all operational domains – influence daily activities, especially in advanced societies. These capabilities provide functions and activities that exert influence on the places of residence, transport, energy networks, banking systems and global communications. Satellites assure access to a wide range of information and provide an extensive scope of services in real time, from knowing the latest news to monitoring and coordinating the actions of armed forces in any geographical area during the day or night. (Congressional Research Service, 2024, pp. 1-2). The great powers' rivalry for supremacy in the domains of military actions has been highlighted since ancient times: in antiquity for the ground domain; in the medieval period it was supplemented with the maritime domain; the beginning of the 20th century was marked by the competition of the great powers (UK, USA, Japan, Germany, USSR, Italy and France) to dominate the ground, maritime and air domain, which had as a result two world wars; at the Warsaw Summit, in 2016, NATO recognized cyberspace as a domain of operations, cyber defence becoming part of NATO's core tasks of deterrence and defence; during the Cold War, the USA and the USSR found out a new confrontation domain – the space. (International Relations, 2022, pp. 398-408).

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Starting with the end of the 20th century and particularly in the 21st century, space has become more and more militarized. The way of waging warfare – through the employment of multidomain operations – will deeply change in the near future. In modern war, military actions will be multidomain, interconnected, and space will have a relevant role. The first evidence of transforming the way of waging warfare was the Gulf War (1990-1991), also called ***The First Space War***, in which the U.S. Armed Forces victoriously employed space-based capabilities in the following domains: Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) as well as in electronic intelligence (European Parliament, 2014, pp. 13-17). Since then, space has become a domain of military actions. As a result, other great powers such as the Russian Federation and the People's Republic of China have developed space-based capabilities to diminish U.S. space supremacy. At the same time, the USA has developed its counter-space capabilities to preserve its superiority. The space has become important not only for the military field but also for commercial and civil activities. Consequently, the great powers are developing space-based and counter-space capabilities to accomplish their national interests. (International Relations, 2022, pp. 397- 408).

The first evidence of transforming the way of waging warfare was the Gulf War (1990-1991), also called The First Space War, in which the U.S. Armed Forces victoriously employed space-based capabilities in the following domains: Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) as well as in electronic intelligence.

Today, strategic competitors confront in all domains – physical, concrete domains: land, sea, air, space, as well as abstract domains: cyberspace, electromagnetic spectrum, information environment and the cognitive dimension. Therefore, the military and economy must be performing to deter and, if necessary, defeat potential opponents (Strategic Studies Institute, 2023, pp. 17-18). The space is used not only for military purposes but also for communications, weather forecasts, financial transactions and navigation, being also a potential source of natural resources, an important aspect for all states. (International Relations, ib.). In 2022, about 50 states and multinational organizations possessed and controlled the functioning of over **5,400** artificial satellites that orbit around the Earth. (Statista, 2022, p. 1).

Strategic adversaries such as the USA, Russia, and China and their allies integrate the use of emerging technologies in military operations according to their strategy and doctrine. They are developing capabilities to support the denying of the current global order through multiple layers of parity in all domains – land, air, naval, space, and cyber, a situation that involves defeating the opponent in all the specific layers of each domain to provide coherence of the actions and to obtain victory. (The U.S. Army, 2018, pp. i-viii, 5-15). They use the space domain to obtain operational, logistical and information

advantages. In addition to the extension of conventional forces, they quickly improve and harmonize their space, counter-space, cyber, electronic, and information warfare capabilities. (U.S. Department of Defense, 2022, pp. 1-2, 63). The strategic competition, including in the space domain, is an assiduously long-term battle that takes place between two or more opponents that follow incompatible interests, which does not mandatorily imply triggering an armed conflict against the other competitors. Standard and friendly competition between allies, strategic partners, and other international actors that are not potentially hostile does not belong to the domain of this concept. (The Joint Chiefs of Staff, 2023, pp. i-ix).

The article will analyse the purpose of space-based capabilities in the implementation of the great powers' security and defence policies in the global balance of power. At the same time, it will be assessed the way of using these capabilities by the main international actors to promote specific interests. It can be seen a powerful connection between the following domains: ***space***, ***sovereignty***, and ***security issues***. This connection is more obvious than ever given that the greatest amount of data and information at present employed in military and security fields have as a source or utilize space-based capabilities. (European Parliament, 2014, pp. 12 -17).

Space-based capabilities include Earth observation satellite constellations, satellite navigation systems, intelligence satellites, and early warning space-based systems. All these systems, starting with the launch on orbit, are considered critical infrastructures, which entails complete protection, against both intended attacks and other actions.

Space-based capabilities have demonstrated not only during military operations but also in daily activities that they are much more efficient than land, naval, or air-based platforms and thus have a relevant contribution to the consolidation of both internal and external security. Space-based capabilities, among other things, include Earth observation satellite constellations, satellite navigation systems, intelligence satellites, and early warning space-based systems. All these systems, starting with the launch on orbit, are considered critical infrastructures, which entails complete protection, against both intended attacks and other actions. Protecting these platforms requires the development of a *Space Situational Awareness* capability, with the mission to monitor and counter the probable threats for both space-based capabilities and ground-related infrastructure.

Space capabilities represent the possession of the assets and expertise to access, employ, and participate in the space' specific *infrastructure, as well as the capacity to exploit and use the common space-based natural resources*. The resources involve the electromagnetic spectrum and the especially necessary space that is occupied by the satellites' orbits (slot allocation). The infrastructure associated with space encompasses satellites and ground-based systems. Common natural resources – in the future – will probably comprise diverse raw materials from asteroids or the Moon, such as metals and water, which would contribute to the Earth-based industry or amplify *"in space"* activities such as manufacturing in space, tourism, operating bases on the Moon and Mars, and so on. (Center for Global Development, 2023, pp. 11-17). Some companies intend to harvest asteroids in space for water and metals, such as the platinum group metals.

The great powers adapt their policies on defending national security regarding the space domain according to national interests. In the last period, military strategists have perceived the space as an operational domain – an area in which offensive and defensive military operations can be conducted – similar to the other domains: land, air, maritime and cyberspace.

The military operations conducted by modern armed forces depend on and exploit the superiority provided by the spatial capabilities and the outcomes of their actions to strengthen the effectiveness of the forces' actions in all domains. Space capabilities ensure a real-time awareness of the situation of own and adversary forces; provide the employment of communications at the global scale; ensure precise and accurate targets employment; support the conduct of expeditionary operations, the deployment in the theatre of operations, movement and manoeuvre; and provide communication flows for cyber electromagnetic operations that support the conduct of joint military actions. These capabilities have a decisive role in the success of large-scale combat actions by ensuring command and control, reliable communications, protected by or not exposed to dangers or risks in extended areas that do not have specific modern infrastructure. (U.S. Department of the Army, 2019, pp. v, 1-1-1-11).

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SATELLITES – CHALLENGES AND PERSPECTIVES

This chapter explains the importance of satellites in today's world. Space has become of decisive importance, having significance not only for the state's national security but also for the daily life of modern society, while also representing a generating threats domain where an increasing number of states and private entities are active.

The space domain is defined as the area above the altitude where the atmospheric effects on airborne objects become negligible. The space domain is a physical area in which military, civil and commercial spatial activities are carried out, and the upper limit extends infinitely outward. The armed forces joint and space operations are impossible to be divided or separated. The typical brigade battle array has over **2,500** positioning, navigation, and synchronization devices and over **250** satellite communication devices employed to execute precise striking, movement, manoeuvre, communications, protection, command and control, and other battle requirements. *The Karman line is a proposed conventional boundary between Earth's atmosphere and outer space set by the International Aeronautical Federation at an altitude of **100** kilometers above mean sea level*. A satellite is an object, which crosses the Karman line, on which a single force acts – gravity, and which moves at a speed of at least **8** km per second, to keep in orbit. (U.S. Department of the Army, 2019, pp. v, 1-1-1-11). ***Artificial satellites are human-made objects deliberately placed into orbit***.

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In creating and maintaining superiority in space, a special role is played by the specific capabilities of electronic warfare, missile launch warning, intelligence, surveillance and reconnaissance, command and control, and cyber and space domain awareness – knowledge or perception. Data collection and advanced analysis tools provide real-time information and advantages in the timely decision-making process. The offensive and defensive cyber capabilities provide protection to space missions and deter adversaries, while satellite technologies, planned or conceived to accurately notify ground troops about the interruption or undermining of the global positioning system (GPS), provide data that ensure a perspective on the situation and advanced awareness in anti-access or denied areas. (O'Brien, 2023,

p. 1). Generally, the national security space capabilities, those that provide communications as well as those used for intercontinental ballistic missile attack warning, probably remain positional/stationary. They, unlike those stationed into the orbit, probably spend most of their lifetime transforming their energy situation and performing manoeuvre operations. This system is made up of satellites that have an orbit located near those with geosynchronous orbit, being intended for space surveillance operations, monitoring the functioning mechanism of other platforms, observing the deviations from a normal, correct functioning, the possible dysfunctions, or the possibly suspicious or aggressive course of action of certain satellites belonging to the opponents. This dynamic, more manoeuvrable approach favours the surprise by gaining the initiative against opponents. The Ukraine conflict has pointed out, in particular, the relevance of space capabilities for surveillance and communications. Russia has tried to jam the GPS and navigational satellite systems used by Ukraine, and Ukraine responded by similar measures (Vergun, 2023, pp. 1-2).

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Tracking and detecting traditional ballistic missiles and manoeuvring hypersonic weapons, which can fly at speeds over **Mach 5,** involve developing a much more powerful network of satellites that will be located in the low Earth orbit, about **2,500** km above the surface of the planet. For better efficiency, the tracking satellites will be launched into the same orbit with tracking hypersonic and ballistic missile space sensors. Thus, they can survey the targets in the same orbit, favouring the common operating of the two types of sensors. (Albon, 2024, pp. 1-4). Maintaining an advantage in future wars is favoured by the space-deployed capabilities – reconnaissance and spy satellites, communications relays, and navigation-supporting assets – utilized by field, sea, and air combatants. (Demarest, 2023, pp. 1-2).

With the introduction of two-way radio stations, military actions, weapons systems, and data transmission/reception applications have become **electromagnetic spectrum**-dependent. Applications comprise: *radio frequencies to communicate with own forces; microwave for transmission of tactical data, radars, and satellite communications; infrared for information collection and the targets*

acquiring; and lasers throughout the full spectrum to communicate, transmit data, and possibly destroy a target. The equipment ensures communication and data transmission, providing timely information necessary for navigation, command and control of forces anywhere on the globe. Current military operations also depend on electronic combat capabilities deployed on satellites, for early warning and surveillance in an extended zone, communications, command and control. Platforms with this destination comprise constellations of infrared systems arranged in space, electronic satellites for collecting information, and radar systems arranged in space. (Congressional Research Service, 2022, pp. 1-2). The employment of data provided by satellites and satellite communications contributes to the development of a resilient society, supporting disaster and crisis management as well as assessing the consequences of climate change.

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The new race on the space domination is in progress. Hundreds of satellites are launched into the Earth's orbit every year for different purposes: ***communications*** and ***the Internet of "things"*** (data collection and exchange), ***navigation/GPS***, ***commercial***, ***government administration***, ***military***, ***environmental monitoring***, ***technological development***, ***civil***, with ***combined purposes*** and ***border security***. Thousands of non-functional satellites orbit around the planet as a spatial waste. In total, there are nearly **8,000** satellites surrounding the planet and this number continues to grow (Science Alert, 2023). In the present era, governments have realized that there are huge advantages and numerous applications that use space capabilities. Thus, satellites represent critical infrastructure for many government activities as well as for daily activity in a society.

Indeed, many organizations, associations, institutes, and bodies monitor, study, and estimate the situation of satellites. They have figures, reference systems and classifications that vary for the same analysis data. For the most realistic information, given that there is no *Treaty regarding space capabilities*, the article presents data on satellites from several sources. Four years ago, there were almost **6,000** satellites orbiting around the Planet and about **60%** of them were no longer working becoming space waste. The Union of Concerned Scientists (UCS) established that **2,666** operational satellites surrounded the globe in April **2020** (Euroconsult, 2021). In the coming years, Euroconsult has assessed that about **990** satellites will be launched every year. It entails that there could be **15,000** satellites in orbit by 2080 (Ib.).

Most operational satellites belong to the commercial field. About **61%** of them are assigned for communications, including a wide range of connectivity satellites from satellite television and the Internet of Things, to the global internet: streaming (a method of transmitting or receiving data, especially video and audio, on a network of computers as a constant flow); video calls; online gaming; remote working and many more are now possible even in the most remote locations, due to the most advanced internet system in the world. After communications, **27%** of commercial satellites were launched for Earth observation reasons, including environmental monitoring and border security. Commercial satellites can perform different missions, thus, for some time, a satellite may have a task to monitor a contested border and, later, can monitor possible mining works, and then the consequences of a natural disaster. (Wood, 2020, pp. 1-5).

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The USA, ranking first in April **2020**, operates almost half of all the satellites, namely **1,308**, China follows in the second position with about **356** satellites, and Russia is the third with **167** satellites in operation, followed by the United Kingdom with **130** satellites ranking fourth. The USA and the USSR (now the Russian Federation) led the space race between the 1950s and 1960s, finding at this time among the first three satellite operators. The data provided by experts of the UCS show that at the time of analysis – **5 May 2023** – there were over **7,560** operational satellites in the Earth's orbit. Of them **5,184** belonged to the USA (Commercial: **4,741**, Military: **246**, Government: **167** and Civil: **30**), **181** to the Russian Federation, **628** to China, and **1,572** to other states. The United States of America, China, and Russia are the states that have dominated the Earth's orbit ranking first on the list of operational satellites. Details are presented in *table 1*.

Table 1: The situation with all Earth's artificial satellites.
(Wood, 2020, pp. 1-5, Union of Concerned Scientists, 2023, pp. 1-3, Pixalytics, 2023, pp. 1-15).

Operational satellite by type / Year		2020 – v.c.	% operational	Jan. 2023 pix./ucs	May 2023 ucs
Commercial	Communications	1,007	61%	4,823	
	Earth observation	446	27%	1,167	
	Navigation/GPS	97		155	
	Tech demonstration & development	87		414	
	Space science / observation			109	
	Earth science			25	
	Other	9		25	
	All commercial satellites (including combination)	1,646/ 1,440	54%	5,280	
Government		436	16%	688	
Military		339	13%	588	
Civil		133	5%	162	
Combination (Other)		112	4%		
Combination (Commercial)		206	8%		
USA		1,308		4,511	5,184
China		356		586	628
Russia		167		177	181
UK		138		561	
Other		697		276	1,572
TOTAL		2,666	100%	6,718	7,560
The Low Earth-orbit		1,918			6,768
The semi-synchronous orbit		137			143
Elliptical		57			59
Geosynchronous orbit		554			590
Defunct satellites		3,200			

Government and civil goals represent **21%** of the total operational satellites of the Earth, and the military purposes are **13%**. ***SpaceX***, founded by Elon Musk, is not only a launch provider for missions to the International Space Station but also the largest commercial operator of satellites on the planet. In July 2020, Amazon was granted approval by the Flight Procedure Program to launch and operate an internet constellation (a group of satellites) of **3,266** satellites (EU Court of Justice, The Year Review, 2020).

Details about the origin country of the satellites that orbit around the Earth are presented in *figure 1*.

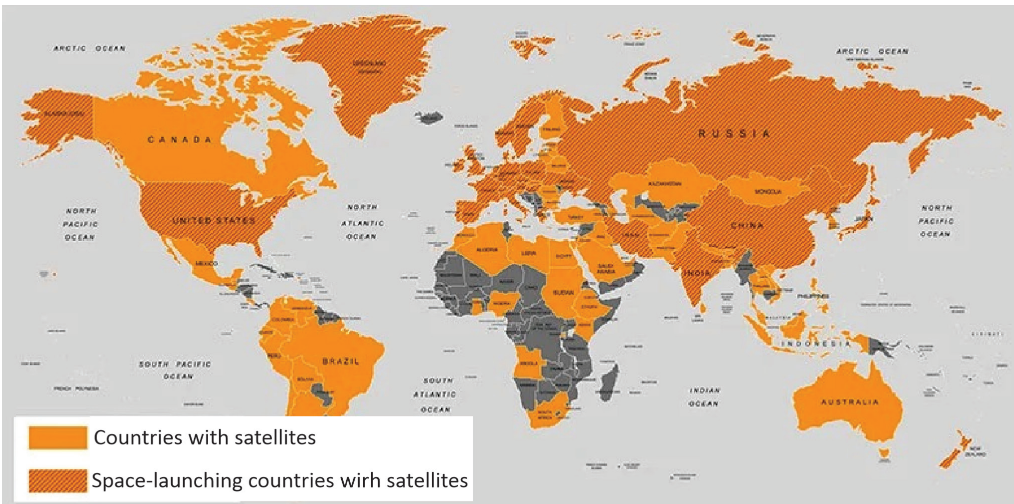

Figure 1: The situation with the states owning satellites
(Union of Concerned Scientists, 2023, pp. 1-3).

According to *The Index of Objects Launched into Outer Space*, updated by the United Nations Office for Outer Space Affairs, at the beginning of July **2023**, around the Earth orbited **11,330** individual satellites. A **37.94%** increase compared to January **2022**. (Pixalytics, 2023, pp. 1-15). The following types of devices are sent to space: satellites, crewed spacecraft, probes, and space station flight equipment.

The satellites and the Earth's ecosystem provide continuous, rigorous scientific data, which evaluates the Earth's surface change. With the help of advanced algorithms that process the data provided by the remote-controlled constellation of satellites, valuable information about water, temperature, carbon and vegetation are obtained.

The capabilities that provide data from the entire electromagnetic spectrum, including optical sensors, radars, passive microwaves, and LIDAR sensors (measures the distance to the nearest obstacle and uses light from a laser), provide different aspects of the physical properties of the Earth. About 200 *Dove* satellites permanently offer a high-resolution [3.7-meter resolution images in four multispectral bands: RGB (red, green, blue) and Near Infrared], continuous and complete image of the Earth's surface. They provide greater visibility, more timely, continuous coverage, evolution by design, and access and integration. Over 300 million square kilometres of imagery are collected each day. (Visual Capitalist, 2024, pp. 1-5).

The orbit of the Earth is separated into three distinct areas. The Low Earth-orbit, the area between **200-2,000** km above the Earth. The semi-synchronous orbit is the area between **10,000** to **20,000** km above the Earth's surface. This orbit is generally used by navigation and communications satellites. Geosynchronous orbit is the area located over **36,000** km above the Earth's Equator surface. The telecommunications and weather satellites in this area can remain in orbit for millions of years. Therefore, the lower the orbit is, the less time is likely to stay in space. (Bhutada, 2021, pp. 1-6).

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THE ROLE OF SPACE-BASED CAPABILITIES IN THE SUCCESS OF MILITARY OPERATIONS, DETERRENCE AND DEFENCE OF NATIONAL SECURITY

This chapter exposes the potential employment of space-based capabilities to promote each state's interests. In the military field, space is critical for the competition and the military actions leading in each domain. Space capabilities ensure the notification about the ballistic missiles' employment and their tracking, critical aspects for the national security of each state, and provide data on the target's location and the optimal moment to strike it accurately. It also ensure the continuity of communications in an environment with extreme conditions to carry out the command and control at the military action's theatre and global level, decisive elements for modern war. Great powers are developing progressively sophisticated capabilities for denying and neutralizing the assets that support the opponents' space missions. As a result, the means of counteracting the space capabilities have diversified, modernized and adapted to the requirements of the present. China has, by this time, deployed ground-based platforms that have the mission and capacity to act against space capabilities. Moreover, it develops programmes for creating or designing new assets and methods in order to disrupt and neutralize the U.S. space capabilities, to achieve a complex structure of space capabilities for supporting armed forces in the execution of strikes at long distances, and precisely to limit the U.S. capacity to carry out joint operations in the Indo-Pacific area. Russia also develops, tests, and deploys the kinetic space-based capabilities as well as ground-based with the mission to neutralize the U.S. space capabilities. The space at this time is an increasingly challenged area by great powers that have space-based capabilities able to trigger activated attacks from space on air, terrestrial and naval forces. (Vergun, 2023, pp. 1-2).

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Space operations are those operations that have a strong effect on or employ space-based and ground-based capabilities to strengthen the power to take military actions and deterrence. (U.S. Department of the Army, 2020, pp. i-xii). Lately, there is information according to which Russia is developing a nuclear weapon to be carried out in space, planned or conceived to disable or destroy the adversaries' satellites. Sufficient data on the missions and characteristics of such a weapon are not public, namely it is not known if it involves the detonation of a nuclear explosive in space or is another anti-satellite capability, powered by a nuclear reactor in space. (Tingley, 2024, pp. 1-2).

The systems for neutralizing space capabilities include kinetic physical means (direct ascent weapons – missiles – scheduled to intercept a satellite and co-orbital that initially is launched on orbit, for example, satellites, and after being activated execute the necessary maneuvers for striking the target), non-kinetic physical (lasers, high-powered microwave weapons, and nuclear weapons detonated in space that create an electromagnetic impulse), electronic (jamming or spoofing radio frequency signals by which space capabilities transmit and receive data) and cyber-targets (the data itself). (Congressional Research Service, 2021, pp. 1-3). In this context, the ability of a state to attribute, unequivocally, a missile attack to an adversary and to select the appropriate and efficient response means becomes critical. Equally important are the capabilities in space or ground that can achieve the deterrence and defence of national security.

The threat represented by the use of ballistic missiles is increasingly present, including by adversaries that do not have great power status, such as North Korea and Iran. These states have proven that they own technologies, such as controlled and guided re-entry vehicles, and in the short term could diversify re-entry vehicles, decoy missiles and other countermeasures to mislead the interception and strike assets after the boost phase. The progress in ballistic missile threat has led to an increase in the importance of satellites, sensors, platforms and capabilities for missile intercepting and detonating starting with the boost phase. The development of detection capabilities, like lightweight gallium nitride-based radar, can result in increasing the radar air platform's role and efficacy, reducing, accordingly, the gaps in detecting and tracking, triggering the neutralization planning situation of the ballistic missiles in the boost phase. Progress in resolution and image processing by infrared sensors can additionally compress the detection timelines of satellites, in the future. Timing, continuous missile tracking, immediately after launch, is a priority for any missile defence system in the boost phase. A constellation of sensors in the boost phase should comprise a complex of platforms and types of sensors to provide prompt detection and tracking. The prompt selection of the timing and place of the missile' striking is also critical for its neutralization in the boost phase and involves a layered defence to preclude the inefficient employment of midcourse trajectory interceptors or to support successful target engagement, many times, in the boost phase. A space-based interception system is the exclusive variant to place interceptors in a sufficiently close layer for the boost phase to neutralize intercontinental missiles. The progress achieved through miniaturized sensors, avionics, and turbo pumps results in the decreased weight of the part designated for target detonation and implicitly the total interceptor mass. To be efficient, space-based interceptors must be provided with protection measures against the adversaries' anti-satellite modern methods and means. (Karako, 2022, pp. 6-7, 15-36, 43).

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Land, sea, and space-based sensors, including satellites and radars, provide *The Ballistic Missile Defence System* with the ability to detect, track, and discriminate incoming ballistic missiles. Details are presented in *figure 2.*

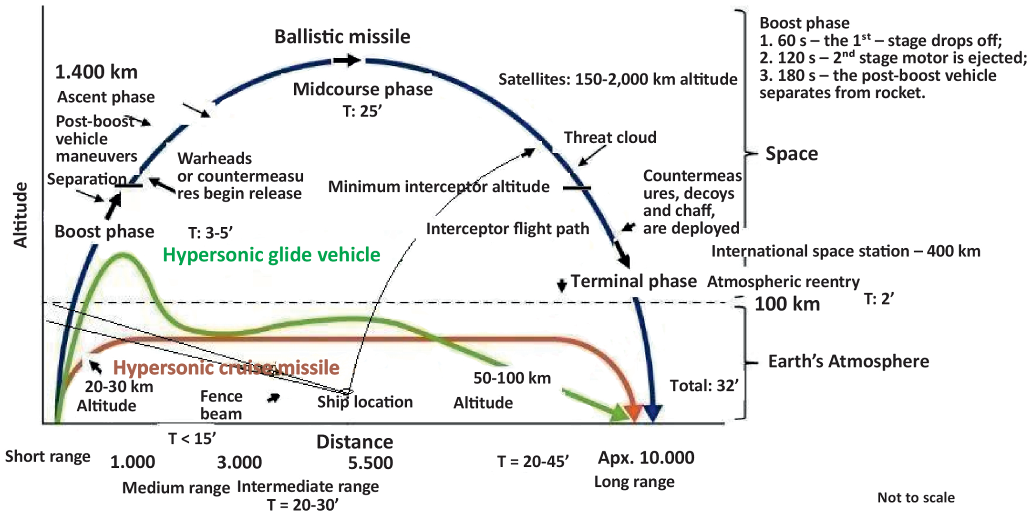

Figure 2: Missile trajectories, their actions during the flight and the reaction of the air and missile defence system
(Kunertova, 2021, p. 55; Bhutada, 2021, pp. 1-6; Karako, 2022, p. 1-7, Boord, 2016, pp. 36, 63, 99).

It was during the Cold War when the U.S. and Soviet governments were in a race to show their technological superiority in the new arena of outer space. The race continued even after the end of the Cold War, the main milestones of this race being as follows: in 1961 The Soviet Union put the first person (Yuri Gagarin) in space; in 1969 first crew landed on the Moon (Apollo 11); in 1981 a reusable spaceship: NASA space shuttle era began; in 2000 the International Space Station welcomed its first crew. It is the most expensive structure ever built; 2004 the new age of commercial space lift started. Spaceship One sent a manned flight to suborbital space and back twice in the span of five days; in 2010 Space Exploration Technologies (Space X) led by Elon Musk launched its Dragon Capsule atop a Falcon 9 rocket; Space X was the first private company to launch a spacecraft to orbit and recover it after re-entry; in 2011 NASA retired the space shuttle after 30 years of operations.

Here are some key players in today's space industry that are vying for private sector space supremacy: ***Old Guard*** consisting of juggernauts such Boeing, Lockheed Martin, and orbital scientists; ***Orbital:*** founded in 1982 is one of the most established companies in the space sector that has operated over 1000 satellites, launch vehicles, and other space-related systems since inception; ***Lockheed Martin*** is a juggernaut

in the aerospace and defence industries and space capable builder; ***Boeing*** is another deep-pocketed aerospace company with ties to space; ***United Launch Alliance (ULA)*** is a partnership between Lockheed Martin and Boeing formed in 2006; ***SNC/Sierra Nevada Corporation*** is developing the *Dream Chaser*, a re-usable space plane designed to carry up to seven people to and from low Earth orbit. Launching vertically on ULA's Atlas V rocket it would land horizontally on a conventional runway; ***Scaled Composites*** was founded in 1982 to develop experimental aircraft; ***New Guard*** is typically founded by billionaire entrepreneurs and aims to reduce costs and develop new technologies; ***Space X***, founded in 2002 by former Paypal entrepreneur and Tesla Motor CEO, Elon Musk, is unquestionably the industry leader, currently operating the largest fleet of satellites in orbit – about 50% of the global total. (Desjardins, 2014, pp. 1-12).

Anti-satellite weapons are weapons that are designed to deceive, disrupt, deny, degrade, or destroy space systems. Around the Earth are orbiting thousands of satellites that contribute to the normal management of activities in the following fields: commercial, civil, strategic and military. The national security and the global balance of power are decisively influenced by the proper functioning of these space capabilities, so some states have developed anti-satellite weapons that can be used to suppress or destroy satellites in orbit. For these military actions, non-destructive means are used, such as cyber attacks or lasers to interrupt the functioning of satellites or destructive means that produce high-speed physical clashes to break the satellites into thousands of fragments that seriously affect the optimal functioning of other spatial capabilities and that can orbit the Earth for decades at extremely high speeds. According to the UCS, the destruction of a single **10**-ton satellite can generate: **8** to **14** million debris pieces between **1** mm and **1** cm in size; **250,000** to **750,000** debris pieces between **1** cm and **10** cm; **5,000** to **15,000** debris pieces greater than **10** cm. Already in space there are about **8,800** metric tons of flying spatial debris. This spatial waste can travel at speeds up to **29,000** km/h (about 8 km/s). At this speed even fragments of millimetre sizes are serious threats for other objects in orbit. The outer space of the Earth is populated with millions of pieces of artificial debris, sometimes arranged in large and dense groups, which represents potential dangers for other functional capabilities. With the launch of the Soviet satellite Sputnik in **1957** the race for supremacy in space was triggered. It also

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led to the accumulation in space of large or small pieces of inert metal. Inactive satellites, the upper stages of the launch vehicles, the disposal of fragments resulting from uncoupling, and even frozen clouds of water and minuscule paint elements continue to exist in orbit beyond the Earth's atmosphere. If one fragment impacts with another, more scraps are discharged. It is estimated that approximately **21,000** fragments of space waste greater than **10** centimetres and half a million fragments of waste between **1** cm and **10** cm are assessed to move around the planet and their number will increase. In space, there are in addition millions of waste fragments smaller than one-third of one centimetre. In the Low Orbit of the Earth, the objects are moving at a speed of **7** km per second. At this speed, a small fragment of paint stores the same energy as a **300**-kilogram object that moves at a speed of **100** km per hour. The impact of critical space technologies with such an object can damage essential components, such as pressurized devices, solar cells, or internet connection devices, but can also generate new scraps that can cause damage. In the last 50 years, space pieces of debris have resulted from the accidental explosion of objects.

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The armed forces of the USA, Russia and China have the needed capabilities to monitor space debris even if they are small in size. Objects up to about **10** cm can be detected by Earth's radars or optical telescopes. Before each launch, the potential orbit of the satellite is screened to avoid possible collisions with fragments of spatial waste. Moreover, the crews of the space shuttles and the International Space Station can modify their orbits if the route of a larger object overlaps with that of the station. Anyway, the satellites and spacecraft have provided a protective coating to avoid interrupting vital components' functioning. (Tillman, 2013, pp. 1-5).

There are only four states – Russia (former USSR), China, USA, and India – that have successfully, **15** times, experienced the two categories of destructive anti-satellite weapons. ***Type one***: co-orbital, weapons that are placed in orbit, perform manoeuvres until they reach a favourable position towards the target and use different means – direct collision, fragmentation, or use of robotic weapons – to neutralize it. ***Type two***: direct ascent, missiles that are detonating satellites in orbit are launched from the surface of the Earth or on-air platforms. (Buthada 2022, pp. 1-3). At this moment, a significant increase in threats against space capabilities can be seen. They include

the detonation of a nuclear weapon in space, threats of kinetic energy, cyber threats, electronic warfare, space capabilities awareness, denial and deception, directed energy weapons, orbital threats, and ground site attacks. (U.S. Department of Defense, 2020, pp. 3-10). The state defence space architecture implies the existence of the necessary space capabilities to support the actions of the ground, aerial, and naval forces, as well as the missile launch warning, tracking, and neutralization. Diversifying and amplifying the constellations of satellites, the orbits, and the achievement of technological advantages contribute to consolidating the architectural structure.

The missile's interval of employment is perceived as a relationship or expression that involves two variables: the time of combustion of the missile propulsion fuel and the compressed time for the missile defence in the calculation of the efficient means of employment, moment and point of the impact.

Given the short flight time of an intercontinental missile to the target, striking it in the boost phase – about five minutes – represents a critical challenge regarding the command and control, the battle management system, signal processing, tighter sensors-shooting integration, the missile defence system, the capabilities of the technical assets – sensors, radars, interceptors, computational technique, directed energy systems, remote-piloted aircraft, striking assets – for detecting, tracking, processing and intercepting a missile. The missile's interval of employment is perceived as a relationship or expression that involves two variables: the time of combustion of the missile propulsion fuel and the compressed time for the missile defence in the calculation of the efficient means of employment, moment and point of the impact. By evaluating all the parameters relevant to the engagement window, in the last 20 years, the following possible engagement openings last from **175** to **235** seconds for slower-accelerating liquid fuel and **125** to **151** seconds for faster, solid fuel. Delays determined by detection and tracking lead to additional requirements for other systems, such as the interceptor speed and range. Theoretically, the interceptor has an average speed of **4** kilometres per second and is launched at an altitude of **15,000** meters. Space-based infrared sensors have the ability to detect a missile after launch at about **45** seconds and after reaching an altitude of **7** km. Once the missile has been detected, a sensor platform must track the missile's flight trajectory to the target and ensure tracking data to the fire control system to determine an interception and detonation point. The space solution with a large coverage, based on a constellation of sensors, interceptors and effectors, arranged in the geographical zone where they can act without limitations, ensures the successful neutralization of missiles. The space-based kinetic interceptors do not have the specific constraints of the other domains, but, due to the permanent motion, they cannot stand or track for a long time an area, involving a constellation of such means to achieve a permanent coverage of areas of interest.

The size of the constellation is determined by the area of interest, the duration of the missile trajectory, and the interceptor's speed and effectiveness. A global coverage starts from **3,000** interceptors, and for missiles launched from Iran and North Korea, orbits between **25 - 45** degrees latitude, about two interceptors would be needed in the action range at any time. To neutralize the liquid fuel missiles launched by the two states, a necessary between **240** and **700** interceptors, with interception speeds of **5** - **6** km/s, has been estimated. The operational requirements of the sensors and interceptors are determined by the correlation between the duration and length of the missile trajectory in this phase and the assumptions regarding the location, relationships, interconnectivity and synchronization of the employment assets.

The main landmarks of the engagement process, in which a decisive role is played by the space capabilities, specific to the boost phase are the following: detection (the time required for sensors to register a boosting missile), missile track establishment, engagement planning (the time required for command control and battle management systems to produce an engagement solution), decision time (the time available for human authorities to decide whether or not to engage a target), engagement (the time required for an effector to neutralize an enemy missile), and kill assessment.(Karako, 2022, pp. 1-7, 15-34).

Today's space is a challenging domain. The threats to space capabilities include jammers, anti-satellite weapons, on-orbit grapplers, tracking satellites, *"nesting dolls"* (anti-satellite weapons, stored in each other), directed energy weapons (and) cyber attacks. China – one of the most active and capable adversaries in space – doubled the number of satellites. In 2023 they had over **700** operational satellites. (Pope, 2023, pp. 1-3).

China – one of the most active and capable adversaries in space – doubled the number of satellites. In 2023 they had over 700 operational satellites.

CONCLUSIONS

The space as a domain for carrying out the warfighting actions is relatively new and has special characteristics compared to the other domains. Analogies cannot be made between the strategies, tactics and capabilities specific to the other domains and those specific

to the space. The competition in the space domain was triggered with the launch of the first object in space – the transformation of space from the object of study to the domain of carrying out warfighting actions – among the USA, Russia and China. Subsequently, other great powers, state and non-state actors have actively participated in this new competition. In space, as in any domain, offensive and defensive military actions can be conducted similar to land, naval and air. It is increasingly obvious that space – as a domain to deploy space capabilities as well as to conduct or coordinate military actions – decisively influences the sovereign control over the state's security and defence policies and activities, determining a high level of complexity of space security governance as well as of security and defence policies. The viability has already been proved for the dual use of space capabilities for both the military and the normal functioning of society.

Starting with the Gulf War, the latest conflicts have confirmed the determining role of space capabilities in achieving success and the importance of space as a domain of operations. It depends on the great powers if the space can be unpredictable, characterized by chaos and destruction, or, on the contrary, by stability, peace and potentiality. The highest risk is determined by their inability to adapt to the pace required by changing this new domain of military actions. Many of the hypotheses that have determined previous assessments are no longer reasonable. A mixture of new threats, strategic risks, and priorities justify the interest in space and space capabilities. The use of anti-satellite weapons can hinder the usability of orbit, pose a direct threat to other satellites, increase the cost of using space, and escalate political conflicts.

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The relatively short ballistic missiles' period of flight together with the very short interval of time in which they must be detected and associated with certain delays in tracking, surveillance, and engagement require a space deployment and higher technical-tactical characteristics for space capabilities as well as effective integration with the ground and space assets for striking. The decrease in missile detection, identification and discrimination time by satellites and sensors as soon as possible after launch and the calculation of the missile hitting point on the trajectory represent critical operational requirements for space capabilities. Sensors with leaps in infrared resolution and image processing have a relevant contribution in reducing detection time. Also, the modern technologies of semiconductors as well as the perfecting storing and manipulating data processes favoured the smaller, lighter and more reliable radar production and the increase in the number of airborne sensors. All the above aspects, together with the selection of reaction, rules of engagement, system of weapons and hitting point, contribute to the missiles' destruction.

Space capabilities can counteract more complex threats than terrestrial ones and the technical developments make this approach more viable. The progress of space capabilities regarding satellites, sensors, interceptors, lasers, remotely piloted aircraft, image processing, radars, detection and tracking increase their potential to influence the balance of global power. Space capabilities provide the implementation of the operational planning process at a global level as well as the means of approach or entry into limited access or denied areas. Also, favourable conditions are provided for applying the principles and laws of the armed conflicts as well as for the requirements regarding the operation's success, namely, freedom of action, air missions, responsiveness, global approach, flexibility in the use of means, speed, synchronization, unity of fighting actions, manoeuvre, depth and persistence. Space capabilities have a great contribution to achieving relevant activities to obtain battle success: communications, intelligence, missile-warning, surveillance operations, operations against space capabilities using jamming, lasers, destructive kinetic and cyber-attack capabilities and anti-satellite systems. Solar geomagnetic storms can cause operating interruption or even destruction of space-based capabilities with catastrophic effects for humanity in the short, medium, and long term.

Space capabilities have a great contribution to achieving relevant activities to obtain battle success: communications, intelligence, missile-warning, surveillance operations, operations against space capabilities using jamming, lasers, destructive kinetic and cyber-attack capabilities and anti-satellite systems.

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