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Section of Young Scientists

Connection of Private Remote Sensing Market with Military Contracts – the Case of Ukraine

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The Russian invasion of Ukraine has underscored the strategic importance of advanced space technologies in modern warfare. This paper examines the pivotal role of the private remote sensing market in supporting military operations, particularly through satellite imagery and synthetic aperture radar (SAR) technology. By leveraging high-resolution commercial satellite data, Ukraine has significantly enhanced its situational awareness and operational effectiveness despite lacking sovereign space capabilities. The study explores the integration of private remote sensing services into military contracts, their benefits, and the implications for future conflicts and space policy. It also addresses the challenges of data sovereignty, transparency, accountability, and the ethical use of satellite imagery. This research employs a multi-faceted approach, including a comprehensive literature review, case study analysis, and qualitative assessments of current remote sensing technologies and their applications in military and humanitarian contexts. Key sources include peer-reviewed articles, government reports, and accounts from industry experts. The study also examines the regulatory frameworks governing remote sensing data and the evolving relationship between private companies and governmental agencies.

Keywords: remote sensing, satellite imagery, synthetic aperture radar (SAR), military operations, data sovereignty, ethical guidelines, space policy, commercial satellite technology.

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Introduction

On 24 February 2022, Russia's invasion of Ukraine marked a significant escalation in the ongoing conflict, underscoring the strategic importance of integrating advanced technologies into military operations (Höyhtyä & Uusipaavalniemi, 2023). This conflict has highlighted the crucial role of outer space in modern warfare. Although the use of space technology in military operations dates back to the 1991 Persian Gulf War (often referred to as the "first space war" due to the use of global positioning systems and other space-based technologies), the Russo-Ukrainian war represents a new dimension as both sides leverage space-based resources (Burbach, 2022). The Russian aggression against Ukraine has brought significant attention to the role of satellite imagery in armed conflicts. Satellite images, once primarily used for military and intelligence purposes, now permeate all aspects of armed conflict. Their importance in influencing the course of conflicts will continue to grow as advancements in deep learning make automated analysis increasingly feasible (Sticher et al., 2023). Emerging technologies have already played a crucial role in this conflict, including arms control monitoring and the use of satellite imagery. Satellite images have provided critical information on urban changes and damage assessments, as evidenced by studies of the Mariupol conflict (Huang et al., 2023). These technologies have enabled enhanced real-time monitoring and assessment of battlefield conditions and infrastructure damage, facilitating both military and humanitarian responses. Even longtime industry veterans like Stephen Wood, an imagery analyst who has spent the last 22 years with Maxar, are awestruck – and often horrified – by what they are seeing. Wood, currently the senior director of the Maxar News Bureau, which provides satellite imagery and analytics to news organisations to inform news coverage, notes, "We have been doing this since the beginning of the launch of our satellites, from September 11 with the first overhead images of the World Trade Centre towers to the conflicts in the Middle East to the aftermath of the Japanese tsunami," he tells Via Satellite. "The war in Ukraine has elevated satellite imagery, particularly the data we've been providing, to a level never seen before. I'd even say that this war is probably the most documented in history. I've been looking at a lot of these types of conflicts for many, many years, and I've never seen the avalanche of data we have today" (Torrieri, 2022). Wood is not alone in his view that the role of high-resolution commercial satellite imagery in the Ukraine conflict is unprecedented. The extensive use of satellite imagery has not only provided real-time battlefield intelligence but also fostered a level of public transparency and awareness unprecedented in modern conflicts (Albon, 2022). This transparency has influenced global public opinion and policy decisions, further illustrating the power of satellite technology in contemporary warfare. An important aspect of this conflict is the commercialization of space technology in military contracts, exemplified by the deployment of Starlink terminals to support communication capabilities in the early days of the Russian invasion of Ukraine.

This development highlights the growing importance of commercial space technologies in modern warfare and their potential implications for future conflicts. The integration of these technologies has raised new questions and challenges regarding the regulation of satellite data, information privacy, and the potential for espionage abuses (Vaynman, 2021). Understanding these dynamics is crucial to developing effective space policies and strategies. The war against Ukraine has shown the vital importance of SATCOM, PNT, and EO/ISR services to situational awareness and command and control (C2) on the modern battlefield. It has also demonstrated the convergence of competition in space with the contest to achieve information and decision advantage. Russian attempts at jamming, spoofing, or hacking satellite networks supporting the

Ukrainian Armed Forces have been a feature of the war since its outset. In February 2022, for example, only an hour before the invasion, Russia launched a cyberattack on the ground-based infrastructure of ViaSat's KA-SAT network, causing thousands of European users, including the Ukrainian government and military, to experience widespread disruption. Though the Ukrainians were able to adapt quickly to this attack, with Western help, the ViaSat incident presaged the central role that commercial space systems would come to play in supporting the early Ukrainian war effort.

Even 15-20 years ago, access to space capabilities was limited to only the most powerful states, primarily the US, China, and Russia, with even major economies and global players such as the UK, France, Germany, or Japan having only a handful of military satellites. Since the invasion in February 2022, however, Ukraine has been able to offset its lack of sovereign space capabilities by buying in commercial data and services from a fast-burgeoning market, primarily from private US companies (Ogden et al., 2024). The proliferation and sophistication of such commercial space services provide huge opportunities for Ukraine, enabling it to compete in and through the space domain. Even for better-funded militaries with their own ISR constellations, commercial EO satellites can provide more coverage, added redundancy, and improved revisit rates compared to high-demand, low-density government-owned satellites. Such commercial assets supplement the sensing capabilities of government systems, reducing costs and offering capabilities such as electro-optical sensors, synthetic aperture radar (SAR), and AI-assisted data analytics and mapping (Ogden et al., 2024). This paper aims to examine the relationship between the private remote sensing market and military operations, using Ukraine as a focal point. It investigates the impact of new technologies, particularly satellite imagery, on arms control monitoring. High-resolution optical and synthetic aperture radar (SAR) satellites have significantly improved the ability to accurately monitor urban change in conflict zones (Vaynman, 2021). For instance, satellite data from Mariupol revealed significant urban damage, providing critical information for humanitarian and military assessments (Huang et al., 2023). This progress has enabled rapid and accurate damage assessments even in the absence of ground surveys (Huang et al., 2023). Thus, there is the critical intersection between the private remote sensing market and military operations. The use of satellite imagery to monitor urban changes and assess damage in conflict zones exemplifies the significant role of new technologies in modern warfare (Huang et al., 2023). As the commercial space sector continues to grow, its relationship with military contracts is likely to deepen, raising important considerations for future space policies and strategies.

The benefits of private remote sensing services

Private suppliers of remote sensing data offer significant advantages that enhance military operations, especially in conflict zones like Ukraine. These benefits include high-resolution imagery, synthetic aperture radar (SAR) capabilities, 24/7 surveillance, and automated, customer-focused processes. This section discusses these benefits in detail.

High-resolution imagery

One of the primary advantages of private remote sensing services is their ability to capture high-resolution imagery. Commercial satellites can achieve resolutions as fine as thirty centimeters, and with advanced processing, some can even reach ten centimeters. According to Wood (2022), this level of detail is indispensable for reconnaissance, surveillance, and

monitoring activities during conflicts. High-resolution images enable decision-makers to track the movement of materials across land, sea, and air, from military assets to humanitarian supplies, thereby providing actionable insights for strategic planning and real-time responses (Torrieri, 2022). These precise imaging capabilities have proven invaluable in various sectors, including environmental monitoring and mining, where satellite data are crucial for mapping and tracking changes over time (Borotkanych, 2022). In addition to their military applications, high-resolution images are essential in civilian contexts. For instance, optical images from the Sentinel-2 satellite have been instrumental in damage assessment following natural disasters. These images facilitate the detection of changes in urban areas, such as the extent of fires and damaged buildings, thus aiding rapid response and recovery efforts (Aimaiti et al., 2022). Furthermore, remote sensing data have been pivotal in monitoring environmental impacts, such as the increased air pollution caused by fires in Ukraine (Shevchuk et al., 2022).

Synthetic Aperture Radar (SAR)

SAR technology marks a significant advancement in remote sensing. Unlike optical sensors, SAR can penetrate cloud cover and operate effectively in darkness, making it particularly useful for monitoring the movement of people, tanks, and other materials under diverse weather conditions. This capability is critical for continuous surveillance and reconnaissance, providing vital data that optical sensors might miss. SAR data enable the detection of missile movements and GPS jamming, offering comprehensive situational awareness (Torrieri, 2022). The mining industry employs SAR technology to monitor slope stability and detect terrain changes, thereby ensuring operational safety and efficiency (Borotkanych, 2022). The utility of SAR extends to urban conflict zones, where it can accurately assess building damage. For example, SAR imagery was effectively used to map damage in Kyiv, Ukraine, highlighting its potential in war-related damage assessment (Aimaiti et al., 2022). By combining SAR and optical data from Sentinel-1 and Sentinel-2, limitations posed by adverse weather conditions can be overcome, providing a comprehensive picture of affected areas. Additionally, SAR's ability to detect environmental impacts, such as water pollution from destroyed hydraulic structures, underscores its versatility in both military and environmental monitoring contexts (Shevchuk et al., 2022). Highlighting the practical applications and importance of SAR technology, Payam Banazadeh, CEO of Capella Space, explains: "We have been super active in Ukraine, for example. When the invasion started, it was cloudy over Ukraine a lot, so optical sensors were not usable a large portion of the time. As a result, SAR became one of the most important tools for monitoring the situation in real time" (Gangware & Swartz, 2023). This example underscores SAR's critical role in providing reliable, real-time data under challenging conditions, further cementing its value in various high-stakes scenarios.

24/7 surveillance

The integration of SAR and electro-optical remote sensing satellites ensures round-the-clock monitoring of the Earth. This 24/7 surveillance capability is akin to having "body cameras for our planet," as described by Rafal Modrzewski, CEO of Iceye, a Finnish SAR company (Torrieri, 2022). The ability to continuously observe and record ground activities enhances situational awareness and the operational effectiveness of military forces. This continuous monitoring proved particularly beneficial during the initial stages of the Russian invasion of

Ukraine, where Maxar's satellite imagery provided critical information about the infamous 40-mile convoy approaching Kyiv (Torrieri, 2022). In other contexts, such as environmental monitoring, continuous surveillance allows timely detection and assessment of natural disasters, facilitating rapid response and mitigation efforts (Sergieieva, 2024). Continuous surveillance is also essential for tracking the environmental impact of military conflicts. For example, ongoing monitoring of fires and smoke plumes in Ukraine has provided valuable data on air quality and environmental damage (Shevchuk et al., 2022). This capability supports natural resource management and disaster response by enabling prompt and informed decision-making.

Automated customer-oriented processes

Another benefit of private remote sensing services is their emphasis on customer-oriented, automated processes, from the initial request to the delivery of interpreted products. Services like Spymesat.com exemplify this approach, ensuring that users can efficiently obtain the necessary data tailored to their specific needs. This streamlined process enhances the utility of satellite imagery, making it more accessible and actionable for various stakeholders, including military planners and humanitarian organizations. In the mining sector, automated processes facilitate rapid analysis and distribution of data, enabling companies to make informed decisions quickly and effectively (Borotkanych, 2022). Automated processes also enhance the effectiveness of environmental monitoring. Automated data analysis has been crucial in assessing the environmental consequences of the Russia-Ukraine war, allowing for the rapid detection and evaluation of pollution events and habitat destruction (Shevchuk et al., 2022). This approach guarantees the swift processing and dissemination of pertinent data, thereby facilitating timely interventions and policy responses.

Case studies and impacts

The practical applications of these advantages are evident in several case studies full-scale Russian invasion in Ukraine. For instance, the high-resolution imagery provided by Maxar played a crucial role in documenting and verifying the massacre in Bucha. As Russian forces occupied and then withdrew from Bucha, videos surfaced showing Ukrainian civilians lying dead in the streets. Maxar's satellite imagery verified the date, time, and location of these bodies, corroborating the authenticity of the footage and aiding in refuting Russian authorities' claims of staged videos (Torrieri, 2022).

Similarly, SAR technology has been instrumental in tracking the movement of Russian forces and materials, offering a continuous stream of data even under adverse weather conditions. This capability has been essential for both military strategy and humanitarian efforts, ensuring that accurate and timely information is available for decision-making. In the realm of environmental monitoring, the use of satellite imagery has been critical in assessing the impact of mining activities and ensuring compliance with environmental regulations (Borotkanych, 2022).

The impact of remote sensing extends to broader environmental monitoring efforts. For instance, the war against Ukraine has largely relied on the analysis of remote sensing data to identify and quantify environmental damage, such as water body pollution and fire spread (Shevchuk et al., 2022). These case studies highlight the transformative potential of remote sensing technologies in various applications beyond military operations.

Comprehensive benefits beyond military applications

The advantages of private remote sensing services extend well beyond military applications. Environmental monitoring uses high-resolution imagery and SAR capabilities to track deforestation, monitor wildlife habitats, and assess coral reef health. Continuous surveillance enables early detection of illegal activities such as poaching and logging, allowing for timely interventions. Automated processes expedite the analysis and dissemination of environmental data to pertinent authorities and organisations, thereby bolstering conservation efforts (Sergieieva, 2024).

In disaster response, the ability to obtain real-time, high-resolution images is crucial for assessing damage and planning rescue operations. After natural disasters such as earthquakes, floods, and hurricanes, remote sensing data can provide detailed maps of affected areas, guiding emergency responders to the most impacted zones. The integration of SAR technology allows for effective monitoring even during adverse weather conditions, ensuring that critical information is available when it is most needed (Sergieieva, 2024).

The advantages of private remote sensing services, including high-resolution imagery, SAR capabilities, 24/7 surveillance, and automated processes, have significantly enhanced the ability to monitor and respond to dynamic situations in conflict zones and other critical areas. The ongoing Russian invasion in Ukraine has underscored the importance of these technologies, highlighting their potential to transform military operations and other applications such as environmental monitoring and disaster response.

In summary, the integration of high-resolution imagery and SAR technology provides unparalleled situational awareness, essential for modern military operations. Continuous surveillance and automated, customer-oriented processes ensure that data is both timely and actionable, enhancing decision-making in critical situations. The demonstrated impact of these technologies in Ukraine and other areas underscores their transformative potential.

Government as a priority customer

The expanding role of private remote sensing services underscores the significance of government contracts. Governments have emerged as the primary customers for private remote sensing companies due to their urgent and large-scale needs, driven by geopolitical tensions and the existential nature of the problems they face. This chapter explores why government markets are prioritised, how they influence the growth of the remote sensing industry and the potential future trajectory of this relationship. One of the primary reasons private remote sensing companies focus on government contracts is the maturity and scale of these markets. Government agencies, particularly those involved in defense and intelligence, have well-established infrastructures and substantial budgets dedicated to acquiring high-resolution satellite imagery and other remote sensing data. As noted by Payam Banazadeh, CEO of Capella Space, "Today we're primarily focused on government markets because they're mature, they are supply constrained, and they face problems that are often existential, which creates an urgency to move fast on products that can help solve them. They are also massive markets growing at a pretty high rate because of geopolitical tensions" (Gangware & Swartz, 2023). The urgency associated with government needs arises from the critical nature of national security and defense operations. For example, during the Russian invasion of Ukraine, the immediate deployment of Starlink terminals for communication support highlighted the necessity for rapid technological integration in military contexts (Torrieri, 2022). This urgency drives governments to invest heavily in advanced remote

sensing capabilities to gain real-time intelligence and maintain strategic advantages (Höyhtyä & Uusipaavalniemi, 2023). Geopolitical tensions significantly boost the demand for advanced remote sensing technologies. The ongoing Russian aggression against Ukraine exemplifies how such tensions can escalate the need for continuous monitoring and assessment of battlefield conditions. High-resolution imagery and synthetic aperture radar (SAR) capabilities provided by private companies have proven invaluable for military intelligence, urban damage assessments, and humanitarian responses (Vaynman, 2021; Huang et al., 2023). Banazadeh's assertion that government spending on remote sensing is increasing despite global economic challenges further underscores this point. "Despite the global macroeconomic situation, government spending is not decreasing. The demand has gone up significantly across the board for our SAR capabilities, in part because of what is happening in Ukraine" (Gangware & Swartz, 2023). This consistent and growing demand ensures that government contracts remain a stable and lucrative market for remote sensing companies. The integration of high-resolution optical and SAR technologies into governmental frameworks addresses significant supply constraints. Government agencies often require large volumes of data to monitor and respond to dynamic situations, such as military conflicts, natural disasters, and environmental changes. The ability of private remote sensing companies to meet these demands through advanced satellite constellations and continuous surveillance capabilities is crucial (Gangware & Swartz, 2023). Furthermore, these technologies' scalability to meet large-scale government needs is evident. For instance, the significant increase in satellite imagery collection and the expansion of satellite constellations by companies like Capella Space demonstrate their capacity to manage extensive government contracts (Gangware & Swartz, 2023). This scalability is vital for maintaining operational effectiveness in diverse and high-stakes scenarios.

Engagement of private remote sensing data suppliers with governmental and intergovernmental projects

The integration of private remote sensing data suppliers into governmental and intergovernmental projects has significantly expanded in recent years. This section explores various examples of such engagements, highlighting the strategic benefits and implications for military and non-military applications.

National reconnaissance office

The National Reconnaissance Office (NRO) has been pivotal in leveraging commercial remote sensing capabilities. In January 2022, the NRO awarded contracts to five companies – Airbus U.S., Capella Space, ICEYE U.S., PredaSAR, and Umbra – to provide synthetic aperture radar (SAR) imagery. These contracts aim to validate commercial SAR capabilities and integrate them into national geospatial intelligence missions (Strout, 2022). The focus on SAR technology is particularly notable because it can operate in all weather conditions and provide critical data on material properties and precise movements, which is invaluable for intelligence missions.

These initial six-month contracts, with options to extend up to 30 months, emphasise the NRO's commitment to quickly scale up based on operational needs and the performance of the providers. The ability to rapidly procure and validate commercial SAR data enhances the NRO's flexibility and capacity to respond to dynamic global situations (Strout, 2022).

In May 2022, the NRO further expanded its engagement with commercial remote sensing companies by awarding 10-year contracts to BlackSky, Maxar, and Planet. This substantial

investment is part of the NRO's largest commercial contracting effort to date. These contracts are designed to secure a steady supply of high-resolution satellite imagery to support a wide range of intelligence and reconnaissance operations (Erwin, 2022).

Maxar has been a significant contributor to U.S. government projects. The company was awarded a renewal of its Global Enhanced GEOINT Delivery (G-EGD) contract in September 2022, ensuring continued access to mission-ready satellite imagery for various U.S. government agencies (Maxar, 2022). Maxar's high-resolution imagery has been instrumental in monitoring geopolitical developments and environmental changes, showcasing the critical role of commercial providers in enhancing national security and operational effectiveness.

NATO's Alliance Persistent Surveillance from Space (APSS)

The North Atlantic Treaty Organisation (NATO) has also engaged with commercial remote sensing data suppliers through its Alliance Persistent Surveillance from Space (APSS) initiative. This program aims to integrate commercial satellite capabilities into NATO's surveillance and reconnaissance operations, providing member states with enhanced situational awareness and operational readiness (NATO, 2023). The APSS leverages high-resolution imagery and SAR data from commercial providers to monitor global hotspots, detect potential threats and support humanitarian missions.

Broader implications and future directions

The involvement of private remote sensing data suppliers in government and intergovernmental projects highlights a significant shift towards leveraging commercial space capabilities for strategic advantages. These collaborations offer several benefits:

- Enhanced flexibility and capacity: government agencies can rapidly procure high-resolution imagery and SAR data to address urgent needs and dynamic situations.
- Innovation and resilience: leveraging commercial technologies drives innovation and ensures that the best available capabilities are integrated into national and international security frameworks.
- Operational efficiency: automated, customer-oriented processes streamline the acquisition and dissemination of critical data, supporting timely decision-making and effective responses.

Collaborations between commercial satellite imagery providers and governmental organisations are not limited to the NRO and NATO. The broader scope includes partnerships with various international bodies and other national governments. For example, in December 2023, the NRO signed agreements with five commercial suppliers of electro-optical imagery – Airbus U.S., Albedo Space, Hydrosat, Muon Space, and Turion Space. These agreements allow the NRO to assess and potentially integrate these companies' products into their operations, further diversifying the range of available satellite data (Erwin, 2023).

As geopolitical tensions and global challenges continue to evolve, the reliance on commercial remote-sensing data suppliers is expected to grow. Future space policies and strategies will likely emphasise further integration of commercial capabilities, ensuring that government agencies can maintain a strategic edge in intelligence, surveillance, and reconnaissance operations (Strout, 2022; Erwin, 2022).

In summary, the engagement of private remote sensing data suppliers with governmental and intergovernmental projects has proven to be a transformative approach to enhancing situational

awareness, operational effectiveness, and strategic readiness. The ongoing collaborations with the NRO and NATO exemplify the significant potential of commercial satellite technologies in addressing both military and non-military challenges.

Future trajectory and dual-use growth

While government markets are the current priority for private remote sensing companies, the commercial market is rapidly emerging as a significant growth driver. Banazadeh highlights the dual-use growth roadmap, indicating that while the focus remains on government customers, the commercial market is expected to eventually match or exceed government demand. "We see government being a key customer for a very long time – in fact, forever – but the commercial market is picking up quickly and will be a significant growth driver in the coming years" (Gangware & Swartz, 2023).

This dual-use approach ensures that private remote sensing companies can diversify their revenue streams and mitigate risks associated with reliance on a single market segment. As the commercial market for remote sensing technologies continues to grow, driven by applications in agriculture, environmental monitoring, urban planning, and disaster response, the interplay between government and commercial markets will shape the future landscape of the industry (Huang et al., 2023; Shevchuk et al., 2022).

Investment and technological advancements

Significant investments in technology and infrastructure are essential to meet the growing demands of government customers. Private remote sensing companies have leveraged substantial capital to expand their satellite constellations and enhance their data processing capabilities. The investment in technology not only supports the current operational needs but also paves the way for future advancements, such as the fusion of multiple sensor types and the development of new analytics capabilities (Gangware & Swartz, 2023).

The integration of different sensor technologies, including optical, SAR, and other emerging modalities, will enhance the versatility and applicability of remote sensing data. This technological fusion will address the diverse needs of government customers, providing comprehensive and actionable intelligence across various domains (Gangware & Swartz, 2023).

The relationship between the private remote sensing market and government contracts is pivotal for the ongoing development and application of advanced satellite technologies. Governments, with their mature, urgent, and large-scale needs, provide a stable and significant market for remote sensing companies. The current geopolitical landscape, exemplified by the war against Ukraine, further amplifies the demand for real-time and high-resolution data, underscoring the importance of government customers in this sector (Höyhtyä & Uusipaavalniemi, 2023; Burbach, 2022).

As private remote sensing companies continue to innovate and expand their capabilities, the dual-use growth strategy will ensure that both government and commercial markets benefit from these advancements. The future trajectory of the industry will be shaped by the integration of diverse sensor technologies, increased investment in infrastructure, and the evolving needs of government and commercial customers alike (Gangware & Swartz, 2023).

Ukraine's current capabilities and challenges in space

Ukraine's space capabilities are deeply rooted in its significant technological heritage, which traces back to its Soviet-era achievements. During this period, the Ukrainian SSR played a crucial role in the development and construction of satellites, with key contributions from the Kharkiv Kommunar and Monolit plants, Kyiv's Arsenal factory, and the Evpatoria Space Center. These institutions were instrumental in launching the first satellite into orbit in 1957. Notably, the OKB-586 workshops, now known as the Pivdenne Design Bureau, established the production line for Dnipro a satellites, also known as Cosmos and Intercosmos (Polyakov, 2023).

Following its independence, Ukraine aspired to develop its satellites. However, the country faced significant challenges, including a lack of orders and an outdated industrial and technical base, remnants of its Soviet legacy. Despite these hurdles, recent advancements in the private aerospace sector have shown promise. Both state and private firms have successfully launched Ukrainian-developed satellites, marking a positive turn in the country's space endeavors (Polyakov, 2023).

A notable achievement in Ukraine's independent satellite history is the Sich series. Following the dissolution of the USSR, Ukraine leveraged its agricultural prowess by utilizing satellite technology to monitor farmland conditions. This initiative led to the creation of the Sich satellites, beginning with Sich-1 in 1995. Developed by the A.M. Makarov Pivdenne Machine Building Plant, Sich-1 provided valuable data on vegetation, soil, water bodies, and other physical and geological structures. Its success extended until 2001, surpassing its planned operational life (Polyakov, 2023).

Building on the success of Sich-1, Ukraine launched Sich-1M in 2004, featuring improved optical capabilities. This was followed by Sich-2 in 2011, which was equipped with advanced scientific equipment for studying space plasma and the Earth's upper atmosphere. Unfortunately, Sich-2's mission was cut short due to a power supply anomaly in 2012. The latest satellite, Sich-2-30, launched in 2022, faced communication challenges that limited its operational capabilities. Despite these setbacks, the Sich series exemplifies Ukraine's persistent efforts in space technology (Polyakov, 2023).

Ukraine had ambitious plans to launch seven satellites between 2021 and 2025. However, the full-scale Russian invasion significantly disrupted these plans. The war has necessitated reliance on active satellites from other countries, such as the Finnish SAR satellite ICEYE, which Ukraine rented to maintain its orbital monitoring capabilities. Consequently, the war's impact has paused many of Ukraine's satellite initiatives, shifting hopes for the space sector's revival to the private aerospace industry (Polyakov, 2023).

In this context, the private sector has played a pivotal role in enhancing Ukraine's satellite capabilities. The Serhiy Prytula Charity Foundation's acquisition of a satellite from ICEYE marked a significant milestone. This satellite, known as the "People's Satellite," provided the Ministry of Defence of Ukraine with vital intelligence, leading to the destruction of substantial Russian military assets. The satellite's SAR technology, capable of capturing high-resolution images regardless of weather conditions or time of day, proved invaluable in military operations and environmental monitoring (Defence Express, 2022; Prytula, 2023).

The Defense Intelligence of Ukraine reported that the ICEYE satellite had helped in their activity. This cooperation between private enterprises and the Ukrainian government underscores the critical role of private sector innovation in national defense and space technology (Defense Intelligence, 2023).

Ukraine's journey in space technology is marked by significant historical achievements, persistent efforts despite challenges, and a promising future driven by private sector innovation. While geopolitical challenges have impacted the country's space ambitions, the synergy between state initiatives and private enterprises holds potential for Ukraine's re-emergence as a significant player in space technology.

To support these initiatives, the Situational Centre of the General Staff of the Armed Forces of Ukraine plays a crucial role. This structural unit contains the specialists responsible for conducting space activities in the field of defense and national security. Its tasks include planning, organizing, and implementing space support for the Armed Forces of Ukraine and other defense components. The primary responsibilities are:

- Conducting space activities in the field of defense and national security of Ukraine.
- Organizing and implementing space information and analytical support in the Armed Forces of Ukraine.
- Organizing the deployment, maintenance, and development of the space support system for the Armed Forces of Ukraine.
- Organizing and implementing space support for the strategic planning and use of the Armed Forces of Ukraine and other defense components (Ministry, 2023).

Following the Draft of the Act on the State Regulation in the Field of Remote Sensing of the Earth from Space, the National Space Facilities Control and Test Center serves as the operator of national space remote sensing systems. According to the Draft of the Act on the State Regulation in the Field of Remote Sensing of the Earth from Space, state users are entitled to receive remote sensing data free of charge from national space remote sensing systems or foreign (commercial) space remote sensing systems if the data is purchased at the state's expense or obtained through other legal means. The operator provides remote sensing data to users on a contractual basis. Information on customers of ultra-high spatial resolution remote sensing data on the territory of Ukraine is submitted by the operator of national space remote sensing systems and official distributors to the Security Service of Ukraine (On the approval, 2013).

From a broader legal perspective, international principles also govern the use and sharing of remote sensing data. Specifically, GA Resolution 41/65 "Principles Relating to Remote Sensing of the Earth from Outer Space" states: "As soon as the primary data and the processed data concerning the territory under its jurisdiction are produced, the sensed State shall have access to them on a non-discriminatory basis and on reasonable cost terms. The sensed State shall also have access to the available analysed information concerning the territory under its jurisdiction in the possession of any State participating in remote sensing activities on the same basis and terms, taking particularly into account the needs and interests of the developing countries" (UN, 1986).

Challenges

On the international front, the landscape of remote sensing data security has become increasingly complex, as illustrated by recent geopolitical tensions. For instance, the U.S. Treasury Department imposed sanctions on Spacety, a Chinese operator of commercial synthetic aperture radar (SAR) satellites, for allegedly providing imagery to Russia's Wagner Group through a shell company (Jones, 2023). These sanctions underscore the global dimension of

remote sensing data security and highlight the necessity for robust regulatory frameworks to prevent misuse.

Adding to these complexities, the U.S. Department of Commerce's Office of Commercial Remote Sensing Regulatory Affairs (CRSRA) enforces stringent conditions on American companies with advanced satellites. During periods of heightened national security concerns or foreign policy interests, these companies may be required to limit data collection and dissemination. The CRSRA categorizes each private space-based remote sensing system it licenses based on whether the system produces or can produce unenhanced data already available from other entities. For example, in July 2023, NOAA modified the licenses of its Tier 3 licensees, removing 39 individual temporary conditions (Jones, 2023).

Operational security remains a significant concern for Ukraine. ICEYE CEO Rafal Modrzewski emphasized the company's policy of not releasing imagery of conflict zones or politically sensitive areas to media outlets, recognizing the potential misuse of such data (ICEYE, 2022). This caution is echoed by Kateryna Chernohorenko, Ukraine's Deputy Minister of Defense, who noted that Russia might be acquiring satellite imagery through third-party companies, potentially using it in armed aggression against Ukraine (Wood, 2024).

A notable example of this risk occurred on May 18, 2022, when a request was made to Maxar to capture imagery of a large square in the town of Lubny. Two days later, a missile strike targeted that location, and another request soon followed to capture post-strike imagery (Wood, 2024). This pattern raised alarms within the Ukrainian military about the potential misuse of commercial satellite imagery in planning and executing attacks.

As noted by Harrison and Strohmeyer (2022), space remote sensing has been a critical component of U.S. intelligence collection and power projection capabilities for over six decades. Traditional paradigms, such as government-developed satellites, human processing, and siloed data, served the nation well throughout the Cold War. However, advances in commercial space remote sensing offer the potential to alter these paradigms, providing new advantages. The commercial space remote sensing industry is rapidly advancing in satellite technology, sensors, sensing methods, large constellations, and high revisit rates. Furthermore, the industry leverages AI systems to quickly process raw sensing data into actionable products for human analysts and uses secure cloud-based systems for storage and dissemination, eliminating data silos. Despite these advances, commercial systems cannot entirely replace government-owned and operated space remote sensing capabilities.

Some missions may not be suitable for commercial sensing capabilities. However, as recognized by Congress and the National Space Council, commercial space remote sensing should be a significant component of the overall ISR architecture for the Department of Defense (DoD) and the Intelligence Community (IC) (Harrison & Strohmeyer, 2022).

One of the main obstacles to effectively leveraging commercial capabilities is the acquisition and contracting system within the U.S. government. The traditional approach of purchasing space remote sensing capabilities as a product rather than a service is incompatible with the business model of many commercially oriented firms. Moreover, the multiyear requirements development and funding process typically used by the DoD and IC for acquisition programs is too slow to keep pace with the innovation cycle of commercial space companies and the capabilities of U.S. allies and adversaries. To fully leverage the innovation, capabilities, and additional capacity offered by commercial space remote sensing companies, the U.S. government must adjust its acquisition approaches to focus on purchasing services rather than products and creating contract on-ramp opportunities on a more frequent basis (Harrison & Strohmeyer, 2022).

The term "space data" encompasses information collected from various sources in outer space, such as satellites, telescopes, space probes, and other instruments. This includes satellite imagery, remote-sensing data, astronomical data, space weather data, space-based navigation and communications data, planetary exploration data, and more. Applications for space data are extensive and include scientific knowledge, environmental monitoring, agriculture, disaster response, mapping, urban planning, military planning, and more (National, 2023). States could, for example, claim national security interests by demanding the deletion of satellite images over their military installations or the deletion of location data about their sensitive space assets. However, given customary international norms and laws around ISR and espionage, these demands may lack significant legal or moral force. Furthermore, such national security demands conflict with the pressing need for better space situational awareness (SSA), which requires more awareness of where space assets are to avoid collisions and other interference, regardless of ownership or purpose. Domestic privacy laws can also create tensions, as stakeholders like Native American tribal nations and farmers may lack the same access or ability to understand EO data as their competitors or negotiating parties. Balancing privacy and commercial interests with the public good in domestically sharing EO and other space data presents another challenge (National, 2023).

In summary, the international and domestic landscapes of remote sensing data security and operational security present significant challenges that require robust regulatory frameworks and innovative acquisition strategies. The evolving nature of geopolitical tensions, the rapid advancement of commercial remote sensing technologies, and the need for comprehensive space situational awareness underscore the complexity and urgency of these issues. Addressing these challenges will be critical for maximizing the strategic benefits of remote sensing data while ensuring its secure and ethical use.

Conclusions

The rapid deployment of advanced technologies for Ukraine, such as synthetic aperture radar (SAR) and high-resolution imagery, underscores the urgent need for scalable solutions to address supply constraints. Investments in expanding satellite constellations and enhancing data processing capabilities are essential to meet the growing demands of government customers. Integrating diverse sensor technologies and leveraging artificial intelligence (AI) for data analytics can provide comprehensive and actionable intelligence, thereby enhancing operational effectiveness across various domains.

The Ukrainian case vividly illustrates the transformative impact of commercial remote sensing technologies on modern military operations. The integration of private satellite imagery and advanced data analytics into Ukraine's defense strategy has significantly enhanced situational awareness and operational effectiveness. This example underscores the broader potential of these technologies in other sectors, including environmental monitoring and disaster response.

This paper highlights the substantial benefits of private remote sensing services, such as high-resolution imagery, SAR capabilities, continuous surveillance, and automated processes. However, it also identifies critical challenges that must be addressed to optimise the use of these technologies while aligning with ethical standards, data sovereignty, and security concerns.

Data Sovereignty

Strategic partnerships between private remote sensing companies and government agencies are pivotal in enhancing data sovereignty. These collaborations should be governed by strict due diligence processes to vet customers and their intended use of imagery, ensuring compliance with ethical standards, and preventing misuse for hostile purposes. Contracts must include clauses prohibiting the resale of imagery to unauthorised entities, particularly those from sanctioned countries or with malicious intentions. Additionally, implementing advanced technology controls and tracking mechanisms will monitor the end-use of satellite imagery and ensure compliance with usage agreements.

To foster these partnerships, governments should establish clear frameworks that encourage private companies to share data responsibly while maintaining control over sensitive information. Regular audits and compliance checks will ensure adherence to data sovereignty principles. By leveraging commercial capabilities through strategic partnerships, governments can enhance situational awareness and operational readiness while maintaining strict control over the dissemination and use of critical satellite data.

Transparency and Accountability

Transparency and accountability in the remote sensing industry are paramount for maintaining public trust and ensuring the ethical use of satellite imagery. Enhancing private companies' liability in contracts for the misuse of their imagery, including imposing penalties and obligations, is critical. Liability should be shared between the state and private companies based on the company's level of due diligence and control over the end-use of their data.

Government regulation should be strengthened to ensure that private companies adhere to ethical and legal standards. This includes mandatory reporting of data usage and regular audits to verify compliance. Encouraging collaboration between the state and private companies will enable better monitoring and control of satellite imagery distribution and usage.

By focusing on buying services rather than products, governments can more effectively integrate commercial capabilities into their national security frameworks. This approach allows for more frequent contract opportunities, keeping pace with the innovation cycle of commercial space companies. Such partnerships should emphasise the role of commercial providers in supporting both military and humanitarian missions, leveraging their advanced technologies, large satellite constellations, and rapid data processing capabilities to enhance transparency and accountability in the use of remote sensing data.

Privacy and human rights

Developing and enforcing ethical guidelines for the sale and use of satellite imagery is crucial to protecting privacy and upholding human rights, particularly in conflict zones. The Recommendation on Space Data Ethics (2023) underscores the necessity of managing such imagery with care to prevent further trauma and exploitation of vulnerable populations. The misuse of satellite imagery for propaganda, as seen in Bucha and Mariupol, demonstrates the severe psychological impact and manipulation of public perception that can result from unethical practices. Strengthening legal frameworks to regulate the dissemination and use of satellite imagery is imperative to prevent misinformation and conflict escalation.

Transparency in data collection, processing, and sharing, coupled with consultation with local communities, ensures that the use of imagery aligns with ethical standards and mitigates psychological harm. By mandating the careful depiction of war impacts and applying strict standards to minimise distress, robust ethical guidelines can safeguard against harmful purposes. Integrating these considerations into legal frameworks will harness the benefits of satellite data while protecting against its potential harms, enhancing global security and humanitarian efforts.

The evolving relationship between the private remote sensing market and military contracts, particularly in the context of Russian aggression against Ukraine, highlights the transformative potential of commercial satellite technologies. While these technologies offer significant benefits in enhancing situational awareness and operational effectiveness, it is crucial to address the challenges of data sovereignty, ethical usage, and regulatory compliance. By implementing stringent vetting processes, enhancing liability clauses, and fostering international cooperation, we can ensure that the use of satellite imagery aligns with ethical standards and contributes positively to global security and humanitarian efforts.

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Perspectives of Global Digital Governance for Space Exploration

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The article reveals the latest perspectives of global digital governance for space exploration. Approaches to the formation of a general concept of global digital governance, which is focused on ensuring security, stability and inclusiveness in the digital space, are analysed. It was revealed that the formation of a model of global digital governance is characterized by certain trends that reflect the aspirations of states to ensure national security, technological leadership and economic growth. The key trends in the formation of digital governance have been identified. The importance of global digital governance for space law is determined. The main possibilities of global digital governance for space exploration are highlighted: development of international coordination and cooperation; ensuring security and infrastructure protection; development of technological innovations; expansion of economic opportunities and inclusiveness; development of science and education in the field of space law; guaranteeing environmental responsibility.

Keywords: outer space, space relations, space legal relations, development, global administrator, global administration.

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Introduction

The development of the Internet significantly accelerated the process of global digitalization. This progress illustrates how technology can transform the infrastructure of communication, governance, and development globally. In the same way that the Internet has facilitated global communication and collaboration, digital technologies can have a significant impact on the research and management of various fields, including space law.

Global digital governance is currently a separate component in the methodology for space exploration, as it allows various states and private organizations to coordinate their efforts and resources. Modern technologies (for example, artificial intelligence) can contribute to the

development of new mechanisms for managing and monitoring space operations, ensuring transparency, security and efficiency.

One of the main advantages of global digital governance is the possibility of creating a single information space where all participants can exchange data in real time. This can contribute to more accurate forecasting of space weather conditions, coordination of spacecraft launches, and monitoring of the condition of satellites and other objects in space. In addition, global digital governance can contribute to the development of international norms and standards for the exploration and use of outer space, which, for example, may include issues of ownership of space resources, protection of the space environment, and ensuring the peaceful use of space.

Despite the potential benefits, the implementation of global digital governance in space exploration faces a number of challenges. Among them are technical barriers related to the integration of various digital systems, as well as political and legal issues that arise in the process of forming a model of international cooperation. Cyber security is also a separate issue, which is becoming more and more relevant in the context of global digital governance. Protecting data and infrastructure from cyber-attacks is critical to ensuring the continuity of space operations and protecting the interests of all participants in space exploration.

Thus, global digital governance opens up new perspectives for space exploration, contributing to international cooperation, increasing the efficiency and safety of space operations. However, in order to fully realize these opportunities, a number of legal, technical, political and other challenges need to be resolved, which requires the joint efforts of all interested parties.

The Content of Global Digital Governance

Global digital transformation began with the invention and commercialization of the Internet. Despite the clear governance challenges posed by digital technologies, early state intervention was largely boycotted by stakeholders. Only recently have we noticed a global trend towards increased regulatory accountability of digital platforms. To answer why global digital governance has increased in recent years, rather than earlier, one must review the history of digital development and the evolution of global digital governance (Jia & Che, 2022). That is, at first digital technologies developed almost without state intervention, as governments did not see an urgent need to regulate a new, still little-known field. This situation persisted due to active opposition from stakeholders who feared excessive control and stifling of innovation.

Today, leaders around the world are faced with the task of shaping global digital governance. To date, digital governance can be described as nascent at best. The future certainly promises much larger governance at the national level with less certainty about the global dimension. This governance must go far beyond technical aspects to address issues of economics, security and values. Now is the time for a significant investment of policy development resources, leadership time and political will to implement sound governance design in all areas of life (Cainey, 2021).

To date, digital governance has been largely technical in nature, with standards developed and agreed upon by Standards Development Organizations (SDOs) at national and international levels. According to one document, "more than two hundred (SDOs) develop standards for information and communication technologies (ICTs), many of which are led by the private sector (International, 2020; Cainey, 2021). The strengthening of the role of global digital governance in recent years is a response to the rapid development of digital technologies and their impact on global society. This process demonstrates the importance of adapting regulatory mechanisms

to new realities, as well as the need for international cooperation and the formation of the latest norms of international influence.

Examples of international collaboration in the global digital space include the International Telecommunication Union (ITU), a UN agency, and the 3GPP, a private sector-led consensus-based organization (Brown, 2020; Cainey, 2021). Although corporate and national interests always played a role, the discussion focused primarily on a technically appropriate solution while preserving the benefits of common standards. 3GPP claims that "its consensus-based and transparent approach, procedural rules and elected leadership promote regional balance" and "have been successful in preventing fragmentation of the GSM ecosystem (and its successors)" (Brown, 2020; Cainey, 2021).

In addition, digital governance refers to regulatory initiatives that are considered at the national level or through independent or self-regulatory initiatives, but which may have an international impact. Examples include the Digital Services Act (DSA) or the Artificial Intelligence Act in Europe; provisions relating to Section 230 of the Communications Decency Act in the United States; Australian Code of Media Agreements; or the Brazilian Marco Civil. They may also include self-regulatory initiatives such as the Oversight Board, the Christchurch Call, the Partnership for Trust and Security (DTI), etc. It is more like digital management (Komaitis & Carter, 2023).

The global digital governance space is now more active than ever. At the UN level, various agencies and organizations are exploring the policy implications of digital technologies in areas such as human rights, the future of work and sustainable development. There are dedicated groups discussing the norms of responsible state behaviour in cyberspace and working on a convention on cybercrime. UN member states are expected to agree on the Global Digital Compact (GDC) in 2024 and begin work on the 20-year review of the World Summit on the Information Society (WSIS) in 2025. And a high-level advisory group established by the Secretary-General is developing recommendations for the international governance of AI (Global, 2024a).

Consequently, legislative trends in the field of global digital governance reflect a gradual transition from limited regulation to increased regulatory responsibility of digital platforms. The initial stage of the development of digital technologies was characterized by minimal state intervention due to the active resistance of interested parties. Subsequently, awareness of the risks and challenges of digitalization led to a significant strengthening of regulatory measures.

International cooperation, particularly at the level of the UN and other organizations, includes discussion of the political implications of digital technologies, cyber security and sustainable development. An important step in this direction is the preparation for the creation of the Global Digital Contract. Legislative initiatives are also aimed at protecting user privacy, combating mass surveillance and ensuring cyber security.

In general, current trends emphasize the importance of inclusive and representative decision-making, which involves involving different groups in the policy-making process and ensuring equal opportunities for all participants in the digital space. In conclusion, the current legislative trends are aimed at creating a transparent, safe and fair digital ecosystem that takes into account the interests of states, the private sector and ensures the rights and safety of users.

Continuing to characterize the content of digital governance, it should be emphasized that digitalization is perhaps the most important strategic challenge that will be faced by the government in the next decade. Digitization offers valuable opportunities to achieve Sustainable Development Goals 16 and 17, particularly Goal 16.7 on "inclusive, shared and representative

decision-making at all levels" (Sustainable, 2024). At the same time, new governance challenges arise from digital disruption, including the loss of privacy through mass surveillance, the closing of civic space on the Internet, and the transfer of governance from citizens and national institutions to unaccountable Internet corporations in foreign capitals. The most important understanding is that digital technologies are neither good nor bad in themselves, and they are never neutral. Furthermore, the use of technology tends to reflect broader political and economic interests that are at work anyway (Roberts, 2021).

One characteristic that seems to fit digital governance is that the term is more appropriate when referring to specific issues related to technologies, applications, and services that use Internet protocols and standards (i.e., its infrastructure), but also differ from it, that is, artificial intelligence. With this in mind, digital governance points to issues that are more targeted, affect users' daily online habits, and require structures that consistently address these issues. It may therefore be useful to think of problems belonging to the domain of digital governance in the same way that public health is thought of: problems that affect a large number of users, a level of severity that is significant, mode 'transmission' usually involves a single user transmitting the problem other users and finally the fact that they create the need to activate frameworks that ensure security, quality control and efficiency (Komaitis & Carter, 2023).

The distinction between digital governance and Internet governance is important for understanding the complex structure of today's digital world. Internet governance provides the technical foundation and stability of the network, while digital governance covers the broader context of the use of digital technologies, focusing on protecting users' rights and ensuring the security and efficiency of digital services. Both concepts are critical to ensuring the stable and secure functioning of the digital environment in today's world.

Although digital governance and Internet governance are distinct fields, they are certainly related. The existence or success of many new technologies that are at the heart of the digital governance debate depend on the Internet. In turn, their development and needs should shape the evolution of the Internet. Thus, the Internet and digital governance are distinct, but they are not separate – they are consequential and one informs the other (Komaitis & Carter, 2023). Internet governance, on the other hand, "is the development and application by governments, the private sector, and civil society in their respective roles of shared principles, norms, rules, decision-making procedures, and programs that shape the evolution and use of the Internet." This definition, developed by the Internet Governance Working Group, dates back to 2005 and remains unchanged. It aims to reflect the absolute requirement for engagement and participation as it relates to the management of protocols and standards that underpin the existence and future of the Internet. They have been developed historically and must remain the purview of a multi-stakeholder model driven by a combination of market dynamics, decentralized architectures and the need to adhere to the regulatory framework that has developed over the years of governing and governing the Internet (Komaitis & Carter, 2023).

Thus, the transformation that took place in the world, which formed the need for global digital governance, tentatively consisted of the following stages: the creation of the Internet; formation of the Internet management model; expanding the possibilities of the Internet in the public sphere; the stage of active digitalization of society; emergence of the need for global digital governance.

Global digital governance is growing in response to the dual process of globalization and digitalization. Serving the innovation and application of digital technologies, global digital governance requires global cooperation to achieve economic benefits and overcome the

challenges of digital transformation, covering issues such as the Internet, digital taxes, and cross-border data flow (Jia & Che, 2022). Scholars Daniel F. Runde and Sundar R. Ramanujam believe that global digital governance encompasses the norms, institutions, and standards that shape the regulation of the development and use of these technologies. Digital governance has long-term commercial and political implications. Naturally, there is an ongoing struggle between democratic and illiberal actors, each side seeking to share its vision of the digital economy (Runde & Ramanujam, 2021).

In general, global digital governance encompasses the conceptual principles, organizational, technical and institutional mechanisms that regulate the development and application of digital technologies at the international level. This governance is critical in ensuring security, stability and inclusiveness in the digital space, creating the conditions for the effective use of technology to achieve sustainable development. In particular, digital governance contributes to the achievement of the Sustainable Development Goals, such as inclusive and transparent decision-making.

It is important to understand that digital technologies are neither good nor bad in themselves, but their use always reflects broader political and economic interests. Thus, the regulation of digital technologies must take these interests into account, ensuring a balance between innovation and the protection of users' rights. Digitalization, along with its many advantages, also brings significant challenges. In particular, mass surveillance can lead to a loss of privacy, and the closing of civic space on the Internet limits freedom of speech and access to information. In addition, the transfer of governance from national institutions to large Internet corporations based abroad raises questions about accountability and control over user data.

Digital governance focuses on specific issues related to technologies and services that use Internet protocols. This includes artificial intelligence, cyber security and other innovations. At the same time, Internet governance refers to the management of the Internet infrastructure itself, the development and application of principles and norms that ensure its functioning. Both spheres are closely related and mutually influence each other, forming a single regulatory complex.

One of the key characteristics of global digital governance is the need for international cooperation, which requires the involvement of various stakeholders: governments, the private sector, civil society, and international organizations. Joint efforts are aimed at developing regulatory mechanisms that ensure economic benefits and overcome the challenges of digital transformation, including issues of digital taxes and cross-border data flows.

Effective global digital governance requires the development and implementation of strategies that take into account the rapid development of technology and changes in the digital environment, including the creation of a regulatory framework for cybersecurity, data protection, regulation of artificial intelligence and other innovative technologies. It is also important to ensure the inclusiveness and accessibility of digital technologies for all segments of the population, with a special emphasis on the protection of human rights in the digital environment.

The question of forming a model of global digital governance

Currently, technologies are developing by leaps and bounds. States are scrambling to catch up, diverse regulatory approaches are emerging and, as a result, calls for consistency and consistency. While the constant need for reliable, stable connections provided by the Internet is almost a simple infrastructure today, the new "digital technologies" in the headlines – from artificial intelligence to platform regulation – are not, and may require new ways of understanding

and managing them. Influence in other words, the necessity and reality of digital governance are evident, but the broad framework is not (Komaitis & Carter, 2023).

In digital governance, the issues are more recent, and deeply philosophical questions about where the rights and interests of users lie are being debated. Governments have always played a key role in defining the public interest in this, so it is not surprising that they are working with the familiar, state-based approaches of the UN to better address them. This does not mean, of course, that input from other stakeholders should not be sought, but ultimately states are legitimate agents when it comes to matters of public interest. Partly for this reason, the resolution of such issues is also often a regulatory task, at least in part, further pointing to the need for an important role for nation states (Komaitis & Carter, 2023).

While it is clear that governments and politicians cannot leave the digital space unsupervised or unmonitored, the question is how exactly the core functions of government should be performed – the provision of public services and infrastructure, the formulation and implementation of public policy, the maintenance of social order and security, governance social programs that promote economic growth, etc., will be implemented in both the physical and digital worlds. The answer lies partly in existing government digitization initiatives around the world, the experiences and lessons learned from them, and partly in research and reflection based on those experiences. However, since there is no universal model for informing government digitization efforts in different national, local, and sectoral contexts, progress can only be achieved by simultaneously conducting multidisciplinary research that is itself based on administrative, economic, engineering, legal, social, and other disciplines, policies and practices (Janowski, 2015).

Governments around the world are struggling to create a framework for technological innovation while establishing norms and ethics for digital governance. The US, China, and the EU are competing for technological leadership and seeking to protect their national interests in times of growing geostrategic competition in cyberspace (Global, 2024).

While digital governance regulations are mainly shaped at the national and (in some cases) sub-national levels, there are currently two visions of the future of digital technologies that may create two different models of digital governance. An authoritarian vision drives the first model. In particular, China is becoming the standard bearer of this model with its desire to "restore the Internet." China seeks to uphold the concept of "cyber sovereignty" allowing countries to control Internet access, censor content and impose data localization requirements as a pretext to protect particular national interests. Politically and economically, spreading this model around the world (especially among developing countries) could lead to long-term stability and sustainability issues, undermining the free, open, and interoperable nature of the Internet that allows the digital economy to flourish. To achieve this result, China relied on multilateral processes and institutions such as the International Telecommunication Union. China's autocratic government is taking advantage of its large domestic market to develop, test, and institutionalize digital tools that support its repressive regime. Using its bilateral prerogatives, China is also exporting some of this technology through the Digital Silk Road to undermine freedom and democratic values around the world. China has been particularly successful in offering its 5G communications technology as a low-cost model to several low- and lower-middle-income countries with a growing middle class (Runde & Ramanujam, 2021).

The second model is the European Union's General Data Protection Regulation (GDPR), which provides a more democratic concept of digital governance. This model is primarily aimed at protecting the privacy and rights of Internet users and consumers of online content. Adopted with overwhelming support by the European Parliament in 2014, the GDPR came into effect

in May 2018, giving companies that rely on digital technology the ability to change their data use and privacy policies. The adoption of GDPR marked a turning point for global Internet governance, as consumers gained unprecedented control over their data in a way that preserves freedom and openness on the Internet. GDPR has also strengthened companies' cybersecurity efforts, protecting them from potential data breaches. Ultimately, the level of compliance required by GDPR has proven to be a powerful way for companies to increase consumer trust. However, critics argue that the GDPR may not be balanced in a way that encourages private sector innovation. In addition, this model (although applicable in Europe) may not be easily adopted in other parts of the world. This may be most true in developing countries, where countries struggle with issues of state capacity and law enforcement (Runde & Ramanujam, 2021).

That is, in the world today there are two sharply contrasting models of digital governance, which form different approaches to Internet management and data protection. On the one hand, the authoritarian model represented by China emphasizes cyber sovereignty and control that aims to secure national interests, even at the cost of limiting freedom and transparency on the Internet. On the other hand, the European Union's democratic model aims to protect users' rights and maintain an open Internet, while encouraging businesses to raise cybersecurity standards. These two approaches not only determine the policies of individual countries, but also have a significant impact on the global nature of the Internet, creating potential conflicts and challenges for the international community in regulating cross-border data flows.

Significant differences in approaches to digital governance create a foundation for tensions and challenges that require global efforts to harmonize domestic regulations with international standards, thus ensuring a balanced development of digital transformation. Yes, it can be noted that thanks to global Internet connectivity, digital data can easily be transferred across borders at almost zero cost. However, as countries have established different domestic data governance institutions, the cross-border flow of data has been limited between countries, leading to demands for global governance to balance domestic regulation and global development. In the history of global digital development, global cross-border data flow was not a critical issue until the explosion of the Snowden incident, which exposed the US government's data eavesdropping behaviour. Due to national security concerns, other countries have started to restrict or even block the cross-border flow of data, leading to an important global governance issue in recent years (Jia & Che, 2022).

In general, the formation of a model of global digital governance is characterized by several important trends that reflect the desire of states to ensure national security, technological leadership and economic growth, as well as meet the challenges that arise in connection with the rapid development of digital technologies.

The first trend is increasing attention to cyber security and protecting critical infrastructure. Growing reliance on digital technologies makes states vulnerable to cyber threats, so governments are increasingly focusing on developing national cyber security strategies. This includes measures to protect critical infrastructure, strengthen international cooperation in the fight against cybercrime, and implement cybersecurity standards in the public and private sectors.

The second trend reflects the differences between authoritarian and democratic models of digital governance. The authoritarian model, exemplified by China, aims to tightly control the Internet, censor content and localize data to protect national interests. At the same time, the democratic model, particularly represented by the European Union, emphasizes the protection of user privacy and their rights. These two models have a significant impact on the global digital landscape, creating potentially conflicting approaches to internet regulation.

The third trend is related to the need to develop flexible and adaptive regulatory frameworks that can be applied in different national and local contexts. As digital technologies change rapidly, governments must be able to respond quickly to new challenges and opportunities. This includes both the development of legislation and the implementation of effective administrative practices that allow maintaining a balance between innovation and regulation.

The fourth trend emphasizes the importance of international cooperation and multilateral initiatives in the field of digital governance. Given the global nature of the Internet and digital data, no country can effectively regulate cyberspace in isolation. Therefore, international organizations play a key role in the development of global standards and norms. In addition, cooperation between countries can facilitate the exchange of best practices and support global stability in the digital sphere.

The fifth trend concerns the development of multidisciplinary research and innovation that contributes to effective digital governance. Administrative, economic, engineering, legal and social sciences must work together to develop comprehensive solutions that take into account all aspects of the digital environment. This will ensure the sustainable development of the digital economy, taking into account both technological innovations and social and legal challenges.

Thus, the formation of a model of global digital governance requires the integration of many approaches and balancing between national interests and global challenges. Collaboration, flexibility, protection of user rights and innovation are the key ingredients that will determine the success of this process in the future.

Opportunities of global digital governance for space exploration

The basic principles of space activity were adopted 60 years ago. They are extremely important, but the least need to be reformatted, and ideally – the development and implementation of new principles and rules of behaviour in space. After all, collective security has always been considered and is considered in the territorial context and related to the inviolability of the sovereignty of countries. But the space is limitless and there is no place for the sovereignty of any country. Therefore, it is necessary to create space security using new approaches, but taking into account the mistakes of the past (Soroka, 2023).

Global digital governance creates numerous opportunities across various fields, including space law. The following main capabilities of global digital governance for space exploration can be formed:

1. Development of international coordination and cooperation. Global digital governance will enable the development and implementation of international standards and protocols for sharing data and space resources, which will facilitate cooperation between countries and organizations in space exploration. It will also be important to organize international cooperative space exploration missions, where the participation of various states and private companies can ensure more efficient use of space resources.

It should be noted separately that the newest dimension of international coordination and cooperation should be of a peaceful nature of space exploration, with the use of all resources equally for each of the partners. Space and space objects cannot become the property or property of one entity, mankind must peacefully and safely explore outer space, coordinate its own actions and develop this coordination for the benefit of mankind. In a global partnership, it is quite important to comprehensively use global digital governance for the development of global management of space research and the formation of a high-quality strategic relationship between

partners for the study and development of outer space. The latest dimension of global partnership should focus on involving the largest number of states, both progressive and developing, for the formation of international norm-setting for the study of outer space, the exchange of expert experience, the development of scientific platforms, and the guarantee of human safety during space exploration. At the same time, progressive countries should act as the main interested parties that should develop global partnership, help and encourage developing states (Levchenko et al., 2022).

2. Ensuring security and infrastructure protection. Global digital governance will enable the development and implementation of cyber security strategies to protect space infrastructure from cyber-attacks and unauthorized access.

Also, as an example, in the event of a violation of the conditions of demilitarization and denuclearization by an aggressor state, the international community should form a special methodology that should include effective and timely joint activities, various sanctions, and in some cases even temporary disconnection from the Internet. Active cooperation and effective diplomacy between various countries and international organizations is necessary for the successful implementation of control from space as a necessary tool for countering global aggression. Control from space in the conditions of demilitarization and denuclearization of the aggressor states should be created to avoid nuclear manipulations and provide real global security. Control from space will allow, first of all, to quickly take measures to counter aggression, contribute to the prevention of conflicts and simplify the diplomatic process of solving global crises, which in general will really protect the lives of thousands of people, preserve the integrity of nature and guarantee peace in the world (Levchenko, 2023).

3. Development of technological innovations. Global digital governance optimizes the use of artificial intelligence to automate and optimize space exploration processes, including data analysis and spacecraft management.

4. Expansion of economic opportunities and inclusiveness. Global digital governance will optimize the commercialization of space and access to space data and technology for developing countries, which will contribute to their economic growth and scientific progress.

5. Development of science and education in the field of space law. Global digital governance will bring together international and transnational scientific research to achieve new discoveries in space.

A direct factor in the dynamics of international relations is the active development of the space industry and scientific potential. The constant transformation of their social and extra-social environment leads both to the general improvement of globalization and integration processes, and to the aggravation of the problems of geo-ecopolitics (Danylenko et al., 2022).

Further development and implementation of global educational programs aimed at training new generations of specialists in space research and technology is important in this regard.

6. Guaranteeing environmental responsibility. Global digital governance will help ensure environmentally responsible use of outer space, including space debris management and protection of the space environment.

Modern international space law does not sufficiently regulate the relations that arise between subjects of space activities regarding the pollution of outer space and responsibility for such actions. In addition, modern trends in space activity, such as its commercialization, an increase in the number of participants in space activity also at the expense of non-state actors, lead to an increase in the number of space objects in Earth orbit, which are potential space debris (Danylenko et al., 2022).

Thus, global digital governance opens wide opportunities for space exploration, ensuring international cooperation, security, innovation and sustainable development. The integration of different approaches and the balance between national interests and global challenges will be a key success factor in this area.

Conclusions

The concept of global digital governance has not yet been formed in the world; however, the world vision of such governance is focused on ensuring security, stability and inclusiveness in the digital space. Global digital governance includes organizational, technical and institutional mechanisms that regulate the development and application of digital technologies at the international level.

The key trends in the formation of digital governance are:

1) cyber security and protection of critical infrastructure;
2) diversity of national models of digital governance;
3) the need to develop adaptive legislative and administrative practices for quick response to new challenges of the digital space;
4) development of international cooperation;
5) multi-disciplinarity of digital space research.

Global digital governance opens up many opportunities for various fields, including space law. The main possibilities of global digital governance for space exploration are: – development of international coordination and cooperation; – ensuring security and infrastructure protection; – development of technological innovations; – expansion of economic opportunities and inclusiveness; – development of science and education in the field of space law; – guaranteeing environmental responsibility.

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Space Policy and Space Law of Ukraine: "Relatives" or "Strangers"

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The purpose of this article is to analyze Ukraine's space policy from the viewpoint of its correlation with space law, to clarify the peculiarities of the respective interaction, its advantages and weaknesses, as well as to develop recommendations for improving the efficiency of space activities using the mechanisms of strategic planning and improving the systemic links between policy and law. The study is carried out in a chronological context: from the collapse of the USSR and the formation of an independent Ukrainian State to the present day, taking into account the dominant trends at each stage. Based on a systematic analysis of political processes and their correlation with law-making and law enforcement mechanisms, the author concludes that the current state of Ukraine's space activities is in crisis. This situation is largely due to the absence/insufficiency of strategic planning of space activities in Ukraine. Until Ukraine is placed outside the brackets of the world's space powers, it is necessary to pay serious attention to the development of a doctrine of Ukraine's space activities with the broad involvement of science. On its basis, having taken into account all economic, political, infrastructural, technological factors, as well as current existential challenges, the Strategy of Space Activities of Ukraine should be elaborated, with a legal component as an organic part of it.

Keywords: Ukraine; Space Policy; Space Law; Space Strategy, Concept, National Space Program.

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Introduction

Policy and law represent two main regulators of social relations, which are closely interconnected and mutually determined. Their interrelationships largely influence the progress in promoting the State development as a whole, as well as the efficiency of social processes in particular sectors. This thesis is relevant for all territorial and temporal dimensions. But the most important thing is to maintain adequate links between policy and law in the context of social transformation and existential challenges. The objective of this article is to identify the patterns of space law and space policy development in Ukraine during different stages of independent statehood, to determine the gaps in this way and, on this basis, to elaborate proposals for ensuring the sustainable development of space activities in Ukraine by adapting its political and legal system to modern existential challenges.

Some theoretical concerns

For many years in modern legal, political, sociological literature, the debate on the correlation between policy and law has not ceased. The starting points of the research are either the analysis of law in the political dimension and policy in the legal dimension (Kresina, 2003); or the determination of the predominance of one of the two categories in comparison with the other: the eternal problem of "chicken and eggs" (Yushchyk, 2014; Perehuda, 2006), or the main directions of interaction between policy and law, such as unity, disagreement, mutual support, confrontation, blocking, etc. (Skrypniuk, 2006).

The most promising is the analysis of policy and law in the paradigm of their interconnection and interdependence, their ability to regulate social relations on the basis of justice and national interests. After all, for both, policy as well as law, the only object of targeted influence is relations in society, the desire to achieve their expediency and sustainable ordering. The struggle for power and its retention, the formation and functioning of state institutions – this is what some researchers consider to be sphere of policy (Skakun, 2001). Sometimes policy is called a kind of search mechanism for social development, in the framework of which projects for such development are elaborated, and law is seen as a mechanism for making these projects of a generally valuable nature (Kresina, 2003).

I consider the relationship between law and policy to not be unidirectional and linear. In a democratic State governed by the rule of law, such relations should be formed and realized in the opposite direction, and should have a mutual influence over each other.

State policy determines the strategic course of the State and has three successive dimensions (stages):

1) elaboration of policy courses (there may be several of them, coming from different groups),

2) course selection (ideally, a single course is chosen in a competitive way, which can also be a symbiosis of positive ones coming from the presented ones),

3) implementation of the chosen course.

At all these stages, policy and law interact. At the first stage, it is politically impossible to propose something that does not fit into the general metamodel of legal regulation in the State.

At the second stage (course selection), the link between policy and law is established through the consolidation of this course in the normative acts of political significance: laws, governmental regulations, departmental/interdepartmental orders, i.e. legal acts that enact political guidelines: concepts, basic principles of policy (strategy), state programs, action plans.

In some areas, there is a doctrine as a separate type of political guidelines that precedes the concept. However, the elaboration and adoption of a doctrine is an exception rather than a rule that is not common to all areas. Normative acts defining the political course in a certain area are developed for the perspective: long-term (more than 5 years), medium-term (from 1 to 5 years) or short-term (up to 1 year). But such a time frame is inherent in the conditions of normal social development. Another concept is the so-called "emergency lawmaking," which is used for extraordinary conditions, in particular, for martial law and long-term planning of post-war reconstruction. It is in these conditions that Ukraine has been living since the armed aggression of the Russian Federation against it, and perhaps it is to these conditions that our political and legal strategic planning should be tied today, because, unfortunately, we cannot define a specific time frame.

Finally, at the 3rd stage of the political process, law begins to play a major role, because policy must be implemented through various state and public institutions, through law-making and law enforcement mechanisms, i.e., through legal acts.

Policy and law are only effective and socially beneficial when they have a common goal, are based on shared values, defined priorities, are understood by society and are supported by realistic possibilities of achievement.

It is very important to maintain a link between the declared policy and its implementation in lawmaking and subsequently in law enforcement. If the real legal reality reflected in positive law significantly "deviates" from the course determined by political means, this leads to rejection of such reality by society. And this, in turn, cannot but affect the attitude towards the political force whose course the society has preferred.

Here, we will try to extrapolate the above theoretical guidelines to the sphere of space activities in Ukraine, considering it in the historical context.

Development of Space Law and Space Policy in Ukraine since gaining independence

After the collapse of the Soviet Union in the early 1990s, Ukraine inherited a third of the former Soviet state's space potential: 120 space industry enterprises, including the flagships of the former space industry: Pivdennyi Machine-Building Plant and Pivdenne Design Bureau, as well as a dozen and a half research institutes of the National Academy of Sciences of Ukraine.

Ukraine's space policy has faced new challenges and the need to make a choice: first, whether to maintain close ties with segments of space activities of other post-Soviet states that used to be part of the unified space complex of the USSR, or to seek a new integration framework. The second problem, dependent on the first, required determining the main directions of development of the Ukrainian space industry: to maintain its traditional focus, namely the design and construction of launch vehicles and the provision of launch services, or to expand the areas of domestic space activity, taking into account global trends in space development, Ukraine's existing space potential, and the future needs of the national economy, science and technology development, as well as the security and defense sector. The second approach was more complex and resource-intensive in the short term, but in the long term it would have been promising in terms of gaining true independence of the industry from the old integration framework, primarily from the Russian Federation. Unfortunately, a simpler and more understandable path was chosen – to continue using the resources available at the time and develop traditional space technologies. This became the basis of Ukraine's space policy during

the first two decades of independence (from the early 90s of the XX century to approximately the early 10s of the XXI century).

An important achievement of the Ukrainian Space policy in the first years of independence was the beginning of its formation on the basis of the National Space Programs, which were developed for a 5-year perspective. This was primarily facilitated by the establishment of the National Space Agency in 1992. Although at that time the respective programs were not preceded by long-term strategies and concepts, the development and adoption of national programs was of great importance for forecasting and planning space activities in Ukraine.

Looking ahead, we would like to note that to date, 5 such programs have been adopted and implemented in Ukraine: 1) 1994-1997; 2) 1998-2002; 3) 2003-2007; 4) 2008-2012; 5) 2013-2017.

In the context of our interest, it is significant to trace the relationship between law and public policy, which was enshrined in the National (later the State) Space Programs. It should be noted that this connection was closest and most direct in the 3 first Space Programs, which testified to the prudence of space policy, which was not only proclaimed politically but also implemented through law-making and law enforcement mechanisms, managed from a single center, the core of which was the NSAU. The most important sign of this symbiosis was the adoption of the Law of Ukraine "On Space Activities" (1996) during the implementation of the first Space Program. It is the adoption of this law that finalized Ukraine's status as a Space State, which already had a state body to manage the space sector, the main regulatory legislative act (at that time, no more than 10 world countries had relevant comprehensive space laws), and a developed space industry (Malysheva, 2018).

Ukraine's space status was confirmed not only by its technological capabilities, but also by the existence of a structure for the creation of rocket and space technology and the launch of spacecraft for various purposes, their operation in orbit and the use of the information received (Fedorov, 2019). The law gave normative significance to the process of space policy formation by adopting the National Space Program for 5 years.

All the main factors, directions and features of space policy in the initial period were adequately reflected in legal norms. One of the basic political postulates enshrined in the Law "On Space Activities" is the compliance of the political and legal system with the requirements of international space law, primarily the United Nations Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty, Art. 6). Hence the reflection in this Law of the international legal principle of State responsibility for all space activities carried out in Ukraine and abroad under the jurisdiction of Ukraine. The legislative regulation of these relations is carried out through the consolidation of the NSA of Ukraine's powers to license space activities, register space objects, certify space equipment, organize international cooperation, etc.

In an effort to preserve the traditional space infrastructure inherited from the Soviet era, Ukrainian legislation has stipulated that space activities be carried out exclusively by state entities. And this postulate remained intact until 2019, when amendments to the legislation allowed activities related to the development, testing, production and operation of launch vehicles, including their space launches for any purpose, to be carried out by institutions and organizations of any form of ownership and legal form.

Starting from the 2000s, the priority of the space industry for scientific, technical, economic development, defense and security of the State was embodied in legislation. Thus, in 2000, the Law "On State Support of Space Activities" was adopted, according to which enterprises of the

space industry were granted significant tax, customs, insurance and other benefits, as well as privileges in settlements for export-import operations.

To ensure the implementation of the guidelines of the first National Space Programs, in addition to the formation of a specially authorized government body – NSAU, a number of important organizational structures were established by way of legislation: The National Center for Spacecraft Control and Testing, the National Center for Aerospace Education of Youth, the International Center for Space Law, and some others.

An important factor that ensured the close connection between space policy and law in Ukraine was the proclamation in political documents and legal enshrinement of the decisive role of science in regulating and managing space activities. This was reflected primarily in the consolidation of the basic principles of space activities, the provision on forming the National Space Program with the participation of the National Academy of Sciences, the creation of two scientific institutions of dual subordination: NAS of Ukraine and NSAU, namely the Institute of Technical Mechanics and the Institute of Space Research.

The dominant political orientation of Ukraine's activities in the field of space exploration and use in the early decades was accurately reflected in the State's international cooperation. Ukraine became a party to four of the five major UN treaties on outer space and has gained membership in the most influential international space organizations, in particular, the UN Committee on the Peaceful Uses of Outer Space. The geography of bilateral relations in this area is illustrative: at the initial stage, it was in the "lion's share" focused on cooperation with the Russian Federation and some other post-Soviet states within the framework of traditional cooperative ties and the use of existing markets. These include a number of agreements on the joint use of space infrastructure facilities (for example, the Yevpatoria Center for Long-Range Space Communications), framework treaties on the principles of cooperation in the space sector, some agreements on the implementation of joint space projects. Such agreements overwhelmingly served the interests of the Russian Federation, but made it possible to use existing Ukrainian infrastructure capacities, which were sometimes redundant for self-use.

At the same time, the designs and innovations of the leading Ukrainian space companies have formed the basis for some international commercial projects that go beyond traditional post-Soviet ties. The most ambitious of these projects was Sea Launch. The Dnipro project on the conversion of defense space technologies, the participation of Ukrainian enterprises in the European Vega project, and some other commercial projects were also successful. In total, in 1992-2016, 140 domestically produced launch vehicles launched 370 spacecraft at the request of customers from 25 countries. In addition, 27 spacecraft developed by the Pivdenne Design Bureau and manufactured by the State Enterprise Pivdenmash were launched (Fedorov, 2019: 121).

To summarize the above, it should be noted that during the 1990s – 2010s, space policy and space law were quite organically linked. It is important to emphasize that the first 4 National Space Programs provided their legal support as a mandatory part of the program body.

At the same time, this connection is gradually becoming weaker, as is the overall decrease in government attention to the space sector as a priority. This situation has begun to increasingly affect the strategic formation of the space policy. The attitude of the State to a particular sector is most clearly demonstrated by the level of appropriate funding. In this regard, it should be emphasized that when approving only the First Space Program, the Law charged the Cabinet of Ministers of Ukraine with the following: to provide for the allocation of funds for each year

of the Program, in full with their attribution to *protected budget expenditures*[1]. In the Second Program, was stipulated that the amount of the annual funding is determined at the level of not less than 0.2 percent of the planned gross domestic product. In the Third, Fourth and Fifth Programs, funding for the Program was declared in amounts based on the capabilities of the State Budget of Ukraine, which of course gradually reduced such funding to certain percentages of the planned amount. For example, while the Fourth Space Program (2008-2012) was funded at almost 38% of the planned amount, the planned amount of funding for the Fifth Program (2013-2017) was not only almost 80% lower than in the previous period, but only 30% of the planned amount was executed.

It should also be noted that this last program document did not provide for legal support of the National Space Program at all.

The current development of Ukraine's Space Policy and its relation to Space Law

Since 2018, for the seventh year already, Ukraine has been in the absence of un approved National Space Program. This is a serious violation of the Law on Space Activities, which in itself not only breaks the link between space law and policy, but also has a detrimental effect on the State's space activities. Let us leave aside the analysis of the reasons for this situation in this article. They are not linear and unambiguous; they have objective and subjective components, and we will only note this as an analysis of the reasons for this situation will be left aside.

At the same time, we will try to find out what policy instruments currently determine the political priorities for the national development of space activities, and thus serve as a guide for the development of space law in Ukraine. What is the current relationship between policy and law in the field of space exploration and use? Back in 2011, the Government of Ukraine approved a long-term Concept for the Implementation of the State Policy in the Sphere of Space Activities, which was designed for the period up to 2032 (Concept, 2011). The problem that was declared to be solved as a result of the Concept realization was a significant disproportion between the level of space potential and its impact on solving urgent national and social tasks. The concept was planned to be implemented by 2032 in 4 stages: the first – for 2011-2017, the second – 2018-2022, the third, in which we are currently, – 2023-2027, and the fourth – 2028-2032. In January 2012, the Action Plan for the execution of this Concept was approved (Plan, 2012).

The directions of the Concept realization were defined as follows:

- ensuring the development of space technologies and their integration into the real sector of the national economy and the sphere of national security and defense;
- obtaining new knowledge, improving the scientific, technical and educational level of its citizens;
- improvement of rocket and space engineering and technologies for its creation;
- ensuring commercialization of space activities;
- deepening international cooperation in the field of space activities.

Assessing the relevant Concept, we have to admit that it can serve as a negative example of a strategic document that was envisioned as an example of good wishes without the necessary economic, technical, technological, scientific, and financial revision. In the context of our interest,

[1] In accordance with Article 55 of the Budget Code of Ukraine, "protected budget expenditures are those expenditures that cannot be changed in the event of a reduction in approved budget allocations".

we note that the goals expressed in the Concept have not been embodied either in lawmaking or in law implementation. Is being observed a growing gap between political proclamations and their enforcement in Ukrainian legislation. Here are a couple of examples. Thus, the most important way to ensure investment attractiveness of space activities, the Concept calls improvement of the mechanism for providing state support to the space sector. However, the scope of such support, which was laid down in 2000 by the Law on State Support of Space Activities, was gradually nullified by subsequent amendments to the legislation. Among the priorities for the development of space application, the Concept named the satisfaction of social needs in the field of remote sensing of the Earth, as well as satellite navigation and telecommunication services. Among these 3 areas, only telecommunications relations have received legal support: the Laws of Ukraine "On Radio Frequency Resources" (June 1, 2000) and "On Telecommunications" (November 18, 2003) were adopted; both expired after the adoption of the Law of Ukraine "On Electronic Communications" (December 16, 2020) (On Electronic Communications, 2020). However, the destiny of the legislation on remote sensing and satellite navigation turned out to be much more complicated. Back in 2013, the Concepts of two laws of Ukraine were approved: "On State Regulation in the Field of Satellite Navigation" of 03.01.2013 (On State Regulation in the Field of Satellite, 2013) and "On State Regulation in the Field of Remote Sensing" of 28.08.2013 (On State Regulation in the Field, 2013). The following year, draft laws were elaborated in these two areas. However, to date, these important laws have not been adopted, although their adoption is the part of Ukraine's obligations under the EU-Ukraine Association Agreement.

An important part of the long-term Concept up to 2032 is devoted to international cooperation in the space sector. It is hard to imagine how a strategic document that is still now in force recognizes Russia, a state that has been waging aggression against Ukraine since 2014, as the first priority for cooperation in this area. And after it – the USA, the EU, and other countries are listed.

The measures envisaged by the Action Plan also turned out to be completely unrealistic. In particular, one of the results of the second stage, ended in 2022, was to ensure systematic data acquisition from the national space system for Earth observation and geophysical monitoring "Sich" in the amount of 5 spacecraft, and by the end of the deadline, 10 such spacecraft were to be launched. Today, this looks absolutely impossible.

When evaluating this so-called strategic policy document in total, we would like to point out the main thing: the basic principles of strategic planning were ignored in the process of its elaboration, first of all, the impossibility of defining the concept of the *state policy implementation without defining the substance of the state policy itself*.

Another attempt to define the state space policy was made at the agency level in 2015, when Strategy of Space Activities of Ukraine for the period up to 2022 was approved by Order of the State Space Agency №100 of May 21, 2015 (Strategy, 2015). It should be noted that the document identified problems that really needed to be addressed, set the appropriate goals, and determined adequate priorities. The motivations for the adoption of this Strategy were the recognition that the policy of preserving and modernizing the space achievements of previous periods and adapting them to new launch sites or new projects was ineffective; the lack of focus on the introduction of modern spacecraft manufacturing technologies; and the insufficient involvement of other sectors and industries in space activities. It was noted that the focus of the sector's enterprises on financing from the state budget or attracting loans under state guarantees did not allow for sufficient financing, and thus for the innovative development of the industry. It was noted that the focus of the industry's enterprises on obtaining funding from the state budget

or attracting credits under state guarantees did not allow for sufficient financing, and thus for the innovative development of space sector.

Based on the problematic situation in the space sector, the Strategy's goal was to increase the efficiency of space activities, solve urgent national security and defense problems and realize the geopolitical interests of the State, promote socio-economic, scientific, educational, environmental and cultural development of society, enhance the prestige of Ukraine as a space power on the world stage, and transform the space industry of Ukraine into a multiplier of high-tech development of the national economy. In the context of our study, it is important to emphasize the Strategy's emphasis on the need to create legislative motivational grounds for attracting investment in the space sector on the principles of public-private partnership and private entrepreneurship (Strategy, 2015). In this regard, is it possible to note that there was a clear correlation between the proclaimed strategic guidelines and their implementation in law? It is partially yes, since in 2019 amendments to the legislation on Space Activities were adopted, which, among other things were made important modifications to part 2 of Article 4 of the Law "On Entrepreneurship" and removed restrictions on the implementation of activities related to the development, production and operation of launch vehicles, including testing, production and operation of launch vehicles, including their space launches for any purpose (On Amendments, 2019). At the same time, it was not succeeded in achieving a legislative solution to the stimulation of public-private partnerships as a way to attract investment in the sector of space activities before the expiration of the Strategy in 2022. In general, we have to state that the strategic guidelines of the relevant Strategy were not implemented by 80%. This was largely due to the suspension of the programmatic approach to planning, financing and implementation of space activities.

The path to the adoption of the 6th Space Program is not easy for Ukraine. Two concepts of such a program have already been developed and approved by the Cabinet of Ministers: for 2018-2022 (Concept, 2018) and for 2021-2025 (Concept, 2021). But even today, in 2024, such a program has not been adopted.

Evaluating the quality of the political documents (strategies, concepts) adopted in Ukraine in the modern period (provisionally – in the last decade, and especially after the expiration of the fifth National Space Program), we must recognize that most of the goals set in them have not been achieved. This is primarily due to the unrealistic nature of the goals that were set, as they still could not break away from the capabilities of structures and facilities that historically were part of a single all-Union complex. The state's underestimation of the importance of space potential and the related lack of adequate funding for the industry cannot be ignored. And the focus on private sector participation in space activities was proclaimed and implemented too late and was truncated which did not allow the private segment to effectively demonstrate its capabilities.

International cooperation has also not become a tool for achieving the goals of space policy guidelines. Despite the political intentions expressed in strategic documents, the opportunity to integrate into the European Space Agency was not used. At the same time, Ukraine has practically no space projects of its own, and is not a participant in international or European space projects (Fedorov, 2019:142). The only exception in recent years is the signing of the international Artemis Program Agreements in December 2020. However, Ukraine's real participation in this program has not yet been operationalized (Malysheva, 2021). Ukraine's participation in international space projects has been reduced to individual Ukrainian enterprises performing work for foreign customers (among the most successful are the American Antares project and the ESA Vega project).

State space governance also began to show its inefficiency: especially authorized space bodies were in a mode of constant turbulent structural, functional and staff changes that were not always scientifically justified; and rapid legislative changes often occurred without strategic justification and taking into account positive foreign experience.

Compared to the previous period, the connection between space policy and space law has significantly decreased. It is observed at all stages: at the stage of choosing political decisions that would fit into the framework of general legal guidelines, during the period of coordinated implementation of the political goals in legal norms, during the process of enforcing them and evaluating the results.

Ukraine's space sector faced special requirements in the context of existential challenges due to Russia's brutal aggression. This required a decisive change in the state's space policy, its reorientation to the primary use of space capabilities to the country's security and defense issues. Here, the connection between space policy and law becomes crucial, since Ukraine is currently going through a stage of large-scale social transformations, when the direction of political and legal interaction is determined not so much by internal preconditions as by external factors (Pereguda, 2006). Unfortunately, the legal and institutional measures that were initiated in this regard in the initial period of the full-scale invasion were not brought to a logical conclusion.

Having carried out this analysis, we arrive at the following inference: the link between space policy and law in Ukraine was quite adequate in the first years of independence, but became increasingly unbalanced over the years. And after the completion of the 5th National Targeted Scientific and Technical Space Program, it was practically lost. Its restoration at the level of strategic planning is an indispensable condition for the successful space activities to ensure sustainable development of Ukraine.

Conclusions

Concluding this research, it should be noted that Ukraine's space activities are currently facing a crisis. The current situation in the sector was formed gradually. Its prerequisites were laid in the first years of independence due to the inherited space infrastructure having a clear orientation to be a segment of the powerful space complex of the USSR. This segment was very large in scale and disproportionate to Ukraine's own needs. On the other hand, it was not multifunctional, providing Ukraine with a full cycle of space activities. Therefore, since the first years of independence, the national space industry has chosen the simplest and least resource-intensive path, focused on preserving the traditional framework of international cooperation. Such cooperation was mostly initiated by Russia and was primarily aimed at satisfying its interests. But the availability of Ukraine's own high-quality launch vehicles in the early decades also ensured international cooperation in providing launch services to other countries. At the same time, Ukraine's space activities did not become a powerful factor of innovative sustainable development inside the country, and did not sufficiently serve its economic, social, environmental, security, and defense needs. All of these factors gradually pushed the space sector out of the top priorities and into the backyard of development.

The biggest problem of Ukrainian cosmonautics in the modern period is the lack of strategic planning of space activities (Fedorov, 2019), despite the existence of a significant number of political guidelines enshrined in various strategies, concepts, action plans, etc. A prerequisite for the formation of the relevant Strategy should be its scientific grounding and well-established economic, political, financial, technological, and infrastructural aspects, as well as ensuring the

inextricable link between the political and legal components. All strategic decisions should be subject to legislative enactment and law enforcement.

Law without policy has no strategic guidelines for development. And a policy without law has no legal framework for introduction, and as a result, remains a good wish.

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EU Space Doctrine – Sustainable Development or a New Arms Race

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Strategic documents of the European Union (EU) in the space sphere are analyzed in this Article. It is concluded that despite the active use of the "space doctrine" concept in the EU, regulating public legal relations through the establishment and adoption of the corresponding branch doctrine it is not an ongoing practice. The author substantiates the view that the "space doctrine" concept is not sufficiently studied today. Despite the claim that the term "doctrine" is of military origin, security and defense doctrine can be a tool of command, of education, or transformation. The dialectic-materialistic method of cognition was used as a general scientific method, which enabled to carry out a comprehensive scientific analysis of doctrinal provisions in the development of the concept of the EU space doctrine, which is proposed to be used as a unifying term for the latest European acts in the field of space security and defense.

Keywords: space doctrine, space activity, space policy, Strategic Compass, Security, Defense, EU Space Strategy, arms race.

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Introduction

The reason for the emergence of the Cosmic Doctrine as a legal phenomenon was the expansion of the frontiers after a man entered space. This has raised many questions for scientists about the knowledge of the nature of law as a special tool of social engineering of space activities, which is not only the regulator but also the main management mechanism for the transition of civilization to a sustainable future under comprehensive penetration of space technologies and services into people's everyday life. The changing paradigm of humanity's attitude towards the opportunities for space exploration is the main factor in the formation of the new Cosmic Doctrine. After all, the global scientific revolution has made this space the common heritage of all mankind; the countries have an equal right to freely explore, develop and use outer space and its celestial bodies; the space activities in all States should contribute to economic development. Besides, progress should contribute to the safety, survival and development of mankind, promote friendly cooperation among the nations.

However, the war in Ukraine, Russia's nuclear blackmail, China's active exploration of outer space, as well as the aggressive policies of Iran and North Korea have put an end to the world community's hopes for sustainable development and peace. Space has become a "battleground" for control of life on Earth.

Therefore, in the current geopolitical context of increased competition for power and threats, the EU takes measures to protect its space assets and interests, deter hostile activities in space, and strengthen its strategic position and autonomy (EU Space, 2023). In 2022, EU leaders identified space as a strategic direction in the Strategic Compass (A Strategic, 2022) and called for the development of an EU Space Strategy for Security and Defense.

An attempt to regulate public-law relations through the creation and adoption of a relevant sectoral doctrine is not a sustainable practice for the EU; in other countries, however, it has been used as a source of law for some time. For example, Military Space Doctrine (Document, 1982) and Joint Doctrine Publication (JDP) 0-40 and UK Space Power (First Edition) are key elements of the space doctrine in the USA and the United Kingdom respectively (Guidance, 2022).

When preparing this paper, we researched, analyzed and used the works by foreign authors-experts in field of law, philosophy, cosmology, sociology, history, military affairs, theory of law and the State, public administration, etc.

For example, we studied a research paper on military affairs "Space Doctrine of the 21st Century," which was developed by Robert D. Newberry for the graduates of the US Air Command School Research Department. The specified document directly indicated that the "developed doctrine includes the principles of space management, operational arts of space warfare and space force deployment strategies" (Newberry, 1997). When preparing this work, we also used the research by other scholars – specialists in air military doctrine: Robert Frank Futrell (Futrell, 1971), Barry R. Posen (Posen, 1984), David E. Lupton (Lupton, 1988). All of them viewed the "military doctrine" as part of an extensive strategy directly related to military means.

The authors of the comprehensive study "Escalation and Deterrence in the Second Space Age" Todd Harrison, Kaitlyn Johnson, Zack Cooper, and Thomas G. Roberts conducted the analysis of the US military space doctrines and came to the conclusion that we are now in the second space age, therefore legal regulation of space activity on the basis of legal instruments adopted in the 1960s no longer meets modern requirements. The authors also analyzed the report by the Center for Strategic and International Studies (an analytical institute in the

USA) and put forward the thesis that the available US military space deterrence doctrine has experienced crisis in the second space era (Harrison et al., 2017).

Thus, all studies dedicated to the space doctrine were carried out with an emphasis on the military purpose and did not take into account its importance for the sustainable inclusive and innovative development of space activities.

Indeed, "doctrine" has always been associated with war and was mostly a military term in world practice, at least during the 20th century (Høiback, 2011). That is, having analyzed the above examples of space doctrines, we can state that almost all existing scientific developments were related to military purposes or defense. However, this concept has not been sufficiently studied today. After all, the doctrine of security and defense cannot or should not be everything and for all people. On the contrary, such doctrine may be an instrument of command, education, or transformation.

If we turn to the theory of law, it operates such a concept as "legal doctrine", an important component of which is the evaluation and forecasting component with the programme provisions of recommendatory-guiding nature and constituting the result of a critical analysis of State and law-making practice (Soroka, 2020a). This issue was specifically studied by Mark Van Hoecke and François Ost (Van Hoecke & Ost, 1998: 197), who studied the relationship between systematization, legal interpretation and legal doctrine. According to them, the conceptual basis, which is also the basis of any legal norm as well as legal reasoning, is formed by legal doctrine.

Some scientists believe that the main task of legal doctrine is the theoretical justification of new ideas and concepts, strategic directions, which do not need to be recorded in any document (Soroka, 2020a). But we believe that the main value of the legal doctrine lies in its practical application in the life of society, since it is focused on solving practical problems in the legal sphere, that is, it is practically meaningful. In addition, that legal doctrine is a system of theoretical and scientific provisions about law that have a convincing force and an application value, it is still as a source of law should be authorized by the State in the form of a regulatory act (Soroka, 2020b).

Hence, doctrines-acts in the field of security and defense are a source of law, which are authorized by the State and designed to regulate the most important social relations in the specified field; they contain a strategic vision regarding the regulation of the specified areas and relations in the context of their sustainable development in the long term and are always adopted by higher authorities. Therefore, in our research, we will use this concept when characterizing European space strategic documents.

A Strategic Compass for Security and Defense

The war in Ukraine pushed European politicians to develop and adopt new strategic documents in the field of security and defense. As the High Representative of the European Union for Foreign Affairs and Security Policy Josep Borrell correctly pointed out: "The threats are rising and the cost of inaction is clear. The Strategic Compass is a guide for action. It sets out an ambitious way forward for our security and defense policy for the next decade. It will help us face our security responsibilities, in front of our citizens and the rest of the world. If not now, then when?" (A Strategic, 2022a).

The first version of the Strategic Compass was presented by the High Representative in November 2021, based on the first ever threat analysis joined by the intelligence services of

27 EU Member States and a phase of structured dialogue between epy EU Member States, institutions and experts. Successive versions were discussed in February and March 2022 to reflect the debate between the Member States and take into account the Defense and Space Commission package of 15 February and recent international developments, including Russia's military aggression against Ukraine (A Strategic, 2022a). The Strategic Compass was approved by the Council of the European Union at its meeting on March 21, 2022 (A Strategic, 2022b).

When developing the Strategic Compass, various aspects of the EU's security and defense policy were taken into account, but they were all established around four pillars:

- Act more quickly and decisively when facing crises;
- Secure our citizens against fast-changing threats;
- Invest in the capabilities and technologies we need; and
- Partner with others to achieve common goals (A Strategic, 2022c).

After careful analysis of existing EU security and defense threats, it was decided to conduct such an analysis every three years starting from 2022. It should be noted that such a comprehensive study of existing and potential threats was conducted for the first time. Based on this evaluation, among other threats, it was also determined that there is a risk of restricted access to the high seas, outer space and digital sphere. In addition, it is acknowledged that the return of the politics of force is taking place at the global level.

The contemporary international reality is based on the combination of dynamics with a growing number of actors seeking to expand their political space and challenge the security order. Armed aggression against Ukraine demonstrates a willingness to use the highest level of military force, regardless of legal or humanitarian considerations, combined with hybrid tactics, cyber-attacks and external information manipulation and interference, economic and energy pressure, and aggressive nuclear rhetoric. These aggressive and revisionist actions, for which the Russian government, along with its ally Belarus, carries full responsibility, seriously and directly threaten the European security order and the safety of European citizens (A Strategic, 2022c).

In the analyzed strategic document, outer space has been defined as overburdened and contradictory because of the irresponsible behavior of various actors. Due to the fact that space activity is a key factor for the development of many earthly spheres (because without surveillance, monitoring, navigation and communication today is unlikely to exist and develop), outer space has been defined as a strategic direction and an operational area.

The Strategic Compass confirmed the EU's intention to work on a proposal for a space-based global secure communications system of the EU, including through the Union Secure Connectivity Programme for the period 2023-2027 (EU secure, 2023; A Strategic, 2022c) with the following objectives:

- to provide worldwide access to secure government satellite communications services for critical infrastructure protection, surveillance, external action and crisis management;
- to enable the private sector to provide business services such as high-speed broadband and uninterrupted connectivity across Europe and the Union (EU), thus eliminating "dead zones" – one of the goals of the proposed 2030 Digital Decade (EU secure, 2023).

In order to strengthen the ability to predict, deter and respond to current and rapidly emerging threats and challenges, as well as to protect the security interests of the EU, a decision

was made: 1) to boost its intelligence analysis capacities; 2) to develop Hybrid Toolbox and Response Teams bringing together different instruments to detect and respond to a broad range of hybrid threats; 3) to further develop the Cyber Diplomatic Toolbox and set up an EU Cyber Defense Policy to be better prepared for and respond to cyberattacks; 4) develop a Foreign Information Manipulation and Interference Toolbox; 5) develop an EU Space Strategy for Security and Defense; 6) strengthen the EU's role as a maritime security actor (A Strategic, 2022a).

Therefore, the need to develop and adopt the first-ever policy document in the field of space security and defense, which was enshrined in the EU Strategic Compass, should be recognized as a relevant and timely response of the European Community to the destabilizing challenges in this area.

EU Space Strategy for Security and Defense

It is uncontested that space is crucial to societies and economies, and is a key factor in security and defense. The first EU Space Strategy for Security and Defense, which, in our opinion, can be called the first EU Space Doctrine, was published in 2023 after the recognition of outer space as a strategic sphere and operational area in the EU Strategic Compass. After all, it has long defined EU policy in the space sphere, declaring the main goals: "protecting its interests, deterring hostile activities in space, and strengthening its strategic position and autonomy" (European, 2024).

It should be noted that the "restraint of hostile activities in space" is a rather radical turn for European space policy. After all, all previously adopted documents, including the EU Space Program (Regulation, 2021), declared that all measures in outer space will be "aimed at security; advantage for users; economic growth and competitiveness" (European, 2024). All these programs were more "service" than security. According to Daniel Fiott – Head of the Defense and Statecraft program at the Center for Security, Diplomacy and Strategy of the Brussels School of Governance – this marks a paradigm shift in how the EU sees space and defense, and recognition at the highest political level that space and defense cannot be ignored (EU, 2023a: 4).

So, what does the European community consider to be "hostile activity" in space? And who are the EU's strategic competitors in space?

First of all, the Strategy defines a new scope of its operation – a space domain. According to this new definition, the space domain includes all elements related to the functioning of space systems and the provision of space services, that is, physical space environment, various orbits and spacecraft, their ground and launch infrastructure, radio frequency communication channels, user terminals, information related to and delivered from these space assets, the relevant cyber environment and basic industrial space sector (EU, 2023b).

Secondly, threats created by counterspace capabilities are defined, namely directed against: space systems, their auxiliary ground infrastructure, data transmission channels between space systems and ground infrastructure, the space sector and its supply chains. Counterspace capabilities include direct-ascent and co-orbital anti-satellite systems, cyber-attacks, electronic warfare and directed energy (European, 2024).

The Strategy proposes actions to strengthen the resilience and protection of space systems and services in the EU. For this purpose, the European Commission put forward a number of initiatives, in particular:

to develop EU space law to provide a common framework for safety, security and sustainability in space;
- to create an Information Exchange and Analysis Center (ISAC) to raise awareness and facilitate the exchange of best practices;
- to start preparatory work on long-term autonomous EU access to space, in particular taking into account security and defense needs;
- to enhance EU technological sovereignty by reducing strategic dependency and ensuring security of space and defense supply in close coordination with the European Defense Agency and the European Space Agency (EU, 2023b).

With regard to strategic competitors, the strategic documents under consideration do not indicate which countries they are. The document entitled "ESPI Report 75 – European Space Strategy in a Global Context – Full Report," which was published in 2020, the following countries are named as strategic competitors in the space sphere: the United States, Russia, China, India, Japan (ESPI, 2020: 9). The report also emphasizes that one of the most striking trends characterizing the evolution of the space industry in recent years is a sharp increase in the number of entities – both public and private ones – capable of conducting space activities. In terms of public sector involvement, a significant number of new space countries have emerged in recent years (i.e. countries that have gained access to space capabilities, or more likely launched their first satellites), as well as several new space agencies were created. In the past five years alone, eight countries have established national space agencies (ESPI, 2020: 9). Thus, according to the Union of Concerned Scientists (UCS) as of May 01, 2023, the total number of available satellites in space is 7,560, of which the United States: 5,184; Russia: 181; China: 628; Europe: 396; Japan: 80; India: 58; Others: 1033 (UCS, 2023).

With regard to the arms race in outer space, the official page of the European Commission in the analysis of the EU Space Strategy for Security and Defense states that the EU seeks to prevent such a race and actively advocates for the reduction of the space threat by means of norms, rules and principles of responsible behavior (EU, 2023). The European institutional budget for civil and military space activities – in terms of research and development funding programmes and institutional procurement of space products and services – is a small fraction (approximately six to seven times less) than in the United States. This is primarily due to the fact that there are few European space military programs compared to all others space States, less developed synergies between the civil and defense sectors, and lack of European interest in an autonomous human space mission (i.e., human-evaluated systems) (ESPI, 2020). At the same time, the EU has to cope with new security challenges, including in the space sphere. With the help of the Space Strategy for Security and Defense, the EU intends to protect its security interests in space (EU, 2023). Therefore, this document defined a "defense-oriented" (EU, 2023a: 4) transition in space policy.

In conclusion, we would like to cite a phrase from the EU Space Strategy for Security and Defense: "The use of space for defense and security purposes acts as a potent force multiplier, improving military operations' efficacy and the resilience of vital infrastructure and public services" (EU, 2023a: 6).

Conclusions

The current stage of global trends is more uncertain, less stable and transparent, which affects space activity and creates disturbing prospects for peaceful international co-existence

in the space sphere. In general, rising tensions and changes in the balance of power revive a new era of superpower rivalry that extends to space; this is primarily reflected in the expansion of military space activities. All this is reflected in the new EU space doctrine. After all, the EU space policy has passed a number of transformations regarding the definition of the goals of such policy, namely: at the beginning there were political goals (prestige), then economic goals (creation of jobs and the welfare of EU citizens); at the current stage it is a defense-oriented approach, but with social-economic justification. All these changes require the adoption of a new European Space Law, which will establish common standards and rules for the national legislation of the EU Member States and the Community as a whole.

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Preventing the Risks of Inadequate Human-Computer Interaction (HCI) Systems in Manned Spacecraft Missions: Toward an International Public Policy Framework Proposal

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This scientific research paper analyzes the link between space technology and space law through specifically designed Human-Computer Interaction (HCI) systems applied in manned spacecraft missions, notably by the National Aeronautics and Space Administration (NASA). The risk of inadequate HCI systems may lead to a wide range of undesired consequences, including risks of error or failure of mission objectives, wrongly displayed information, unavailable data and confusion of the data presented, this potentially putting astronauts aboard the spacecraft in life-threatening circumstanced within their extraterrestrial working environment. Consequently, the blame is put on the lack of appropriate policies addressing the regulation of space-related HCI systems. Hence, an international public policy framework is proposed in order to ultimately ensure astronauts' safety in space exploration, as well as minimizing the risk of space-related accidents occurring during manned spacecraft missions.

Keywords: Space Law; HCI; Space Technology; Public Policy; International Regulation.

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Introduction

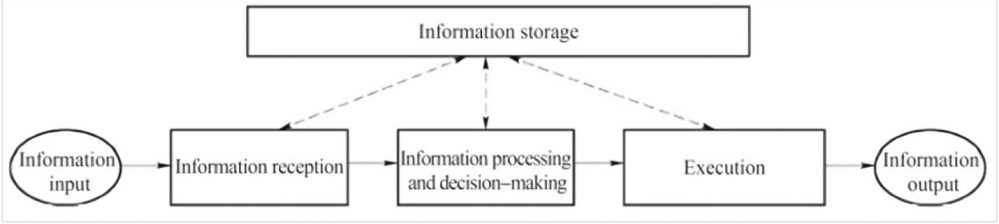
The meaning of advanced space-related technology and its continuous developments within the space industry represents a very important question in which humankind should be relatively interested. As Professor Svetla Ben-Itzhak speculates how space technology would have multidimensional impacts upon our thriving society, including such from a political aspect, where relations between States are further classified (or rather challenged) at three primary levels: (1) the *individual* level, (2) the *state* level and (3) the *system* level (Ben-Itzhak, 2022: 1). Be that as it may, Ben-Itzhak notably describes the political interests of space-faring nations from the prism of global space economy and the formation of space alliances for achievements which seem fairly futuristic and accompanied with highly advanced technological outcomes against the background of the current technologically developed state of our society. Therefore, the political interests of space-faring nations are included in a manner that such separate classifications, as emphasized above, do not demonstrate a direct and strong correlation with space-related technology developments. This would already indicate the fine lines of discrepancy between the practical implementations of space-related technology and the theoretical adaptations of space law, policies and regulations. Nevertheless, it is within the common knowledge of every space lawyer and legal practitioner that the legal branch of space law was established particularly due to the burgeoning outer space technology (Maitin, 2022: 229; Launius, 1999). By following this legal trend, space law would expectedly advance in a parallel manner with the developments in space exploration and space-related technology. For that matter, important issues related to the further development of space law must be raised within a timely manner. However, we may simultaneously notice the unfortunate absence of space regulation being largely evident as technologies continue to rapidly advance, particularly considering their extensive magnitude and scope within the space industry. Furthermore, the challenge of providing a clear and unambiguous understanding in regards to the unbreakable link between space technology and space law could also be described as very complex and dynamic when taking into account manned spacecraft missions and space exploration itself, generally speaking. One might even claim the both concepts are "locked" within a constant state of interdependence. In other words, contemporary developments in space technology had always represented a struggle for the legal regime of international space law, where interdisciplinary collaboration would often be necessary in regards to solving such interrelated issues. At this moment, the space industry must ask itself what the further development and advancement of space-related technology means for legal or regulatory objectives. While advancements in space technology would undoubtedly have a significant impact upon multiple aspects in our human society, it is almost needless for us to additionally point out that such advancements manifest the requirement for new policies and regulations (Pagallo et al., 2023: 23). As Steven Freeland argues, appropriate legislatures and regulatory policies must accept the advancements in space-related technology due to the demand of adapted legal reviews over limited periods of time (Freeland et al., 2018: 129). Given the rather broad scope of space-related technology as implemented in manned space missions, the purpose of this scientific research paper is to attempt to improve the developments of space law through the prism of human performance in consideration of working with space-related HCI systems.

Critical analysis

Enthusiastic space actors from all over the globe – be they space-faring States or private spaceflight companies – strive toward the continuous advancement of space technology as implemented within manned spaceflight missions. One of them undoubtedly represents Human-Computer Interaction (HCI) systems, given that they play an essential role by primarily encompassing interfaces between astronauts and computers or other machines, automation and controls. Such increasingly sophisticated systems are designed for ensuring the deployment of new manned spacecraft mission systems and technology (Thompson, 2011). The incorporation of HCI within the space industry in practice is not a new occurrence, but rather dates back several decades. Namely, there have been discussions about HCI on space stations even during the late 1980s, where it is emphasized how far-reaching requirements also take into consideration their implication (Hayes, 1987: 151). This seems logical enough, as we bear in mind that HCI only had emerged in the early 1980s as an area of research and practice. More importantly, the focal points upon certain changes regarding space station interfaces was deemed necessary even for that period of time – by citing the reasoning behind such expectation of changes, as well as the ways of planning for it (Hayes, 1987: 172). At the National Aeronautics and Space Administration (NASA), HCI refers to the design, evaluation, and implementation of interactive systems that are efficient and easy to use (NASA, n.d.), which had also strived toward its numerous benefits immediately after its appearance in the then-contemporary world of technology. One evident demonstration of such interest was NASA's establishment of the Human-Computer Interaction Laboratory (HCIL) in 1984 which, among other research objectives, had aimed toward designing spacecraft computer-based workstations and HCI's, as well as research developments resulting in specific guidelines for space station human-computer interface (Rudisill & Gillan, 1989: 55). In addition, it had also considered intense efforts in testing HCI in virtual (or synthetic) environments (Noor, 1996: 2). And even after several decades later, it could be confirmed that there is still an on-going interest in HCI addressing the purposes of space exploration and manned spacecraft missions in recent years, such as NASA's contemporary Ames HCI Group (NASA, n.d.) Other researchers have also been enthusiastic for addressing HCI for space explorations through the annual Space CHI Conferences (MIT Media Lab, n.d.), while some have specifically focused on developing various types of HCI systems which are designed to support human's physical and mental performance in extraterrestrial environments (Pataranutaporn et al., 2021). For instance, Wanling Li and Hongjing Cheng have analyzed the requirements HCI systems of manned spacecrafts in deep space exploration (Li & Cheng, 2021), while on the other hand Dr. Simon B. Thompson believes that newly received interests and advances in space technology have contributed for the use of established knowledge in HCI fields and in medicine, which is invaluable in order to progress further in space exploration (Thompson, 2011). The truth of such assertion may be further confirmed by taking into account the implementation of health care informatics in space science (Djorgovski et al., 2015: 2959), as well as the technological role of health care informatics in medical devices and the field of healthcare in general (Acharya, 2010: 2957). Hence, in order for future manned spacecraft operations and missions to be best supported on a global scale, collaborative research between HCI and other areas of research is crucial (Thompson, 2011). One of such other areas of research includes space law, regulations and policies for regulating manned spacecraft missions, given that HCI is a critical component of any space-based system (Heinrich et al., 2023: 11). One question that should often be debated by space lawyers and legal practitioners is that of what policies should be adopted for HCI systems

implemented in manned spacecraft missions. Considering that HCI significantly contributes towards the success of the manned spacecraft mission, simultaneously challenges space law (Pagallo et al, 2023: 7). However, academic discussions revolving around policy-making of HCI systems in manned spacecraft missions are, unfortunately, relatively scarce. Scholars had already discussed about how the Outer Space Treaties no longer provide an adequate framework to regulate the increasing use of space in regards to new technologies (de Zwart, 2018). Hence, drastic changes in space law and regulations are expected due to advancements in outer space technology (Martinez, 2021: 322). Another important aspect in the midst of emerging space-related technologies such as HCI systems in manned spacecraft missions, regulations must address their effects on safety and security, as well as sustainability (Legal Vidhiya, 2023). The development of space technology increases in a continuous manner along with human activity in outer space, where it is suggested the importance of establishing laws that would regulate HCI in manned spacecraft missions due to the risks of various legal problems, including the safety of astronauts regarding potential space-related accidents (Ruhaeni & Izadi, 2019: 369). Namely, the risks and benefits of HCI systems in manned spacecraft missions include the safety and security standards that all manned spacecraft missions should meet and guarantee. This becomes a problematic issue not only in the public sector, as *"government policy is incapable of moving fast enough to stay in front of where investment is leading us,"* but in the private sector as well, where the stark contrast between the speed of technological developments and the slowness of regulations is the main cause for "friction" experienced firsthand by industry leaders (Goessler, 2022). As further argued by Steven Freeland, manned spacecraft missions operating in high altitudes would represent yet another challenge in terms of defining the holder of responsibility for regulations stemming from manned space flight (Freeland, n.d.), where implications of both national and international legal principles as well as governing structures must consider the function and application of HCI systems of manned spacecraft. Appropriately, this scientific research paper analyzes requirements of HCI systems in deep space exploration missions, predicts the development trend of HCI systems in future manned deep space exploration mission, puts forward the conceptual model and architecture design of HCI systems based on deep space exploration mission, and discusses the implement approach. For that matter, we adopt a comparative analysis approach by adapting designs of HCI systems in manned spacecrafts in order to build up a policy framework proposal.

Figure 1: Basic Function Diagram of Human-Computer Interaction System



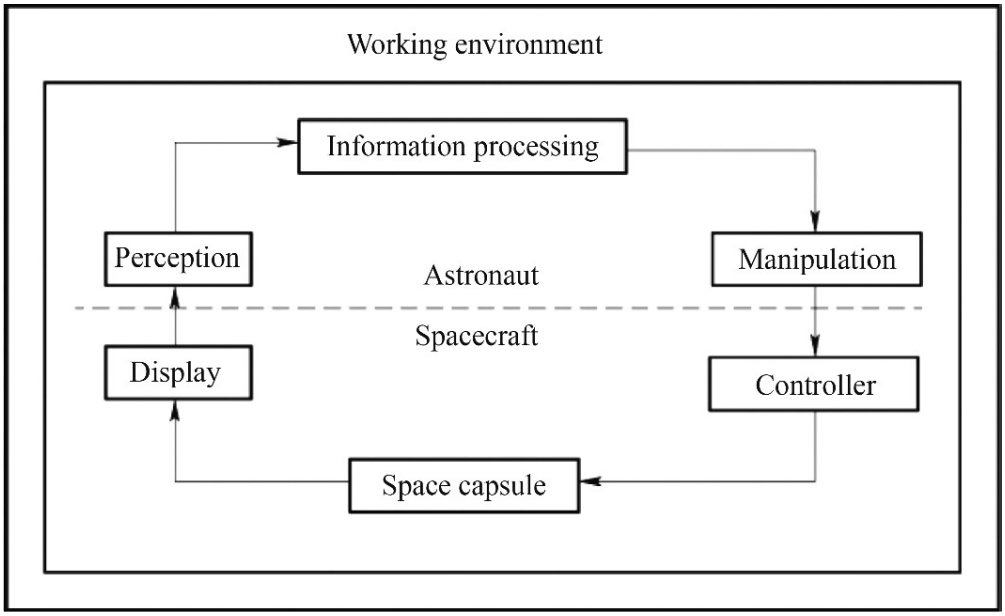
Note. Adapted from "Manned Spacecraft Technologies" (p.51) by H. Yang, 2020, Springer Nature.

The starting point of our comparative analysis begins with discussions on the basic functions of HCI systems as depicted by the "Basic Function Diagram of Human-Computer Interaction System" in Figure 1, where the entire process of "information storage" is consisted of five main components, those being the following:

1) Information input;
2) Information reception;
3) Information processing and decision-making;
4) Execution; and
5) Information output;

However, the information storage is not simultaneously reciprocal with the beginning process of information input and the ending process of the information output, because both components do not represent the astronauts' overall participation in the mental processing of the given information by the HCI system. Namely, the "information input" means that the HCI systems is receiving signals and/or commands from outer sources, while the "information output" means that the HCI system is performing and/or sending the processed information. On the other hand, information storage is simultaneously reciprocal with information reception, information processing, decision-making, and execution. Firstly, through the "information reception" component, the astronaut enters the role of the reader and makes an individual reception or interpretation of the information input displayed by the HCI system. This component is consequently followed by the astronaut's psychological approach to processing, storing and retrieving the information input displayed by the HCI system through the use of both his or her senses and previously acquired knowledge. Once the astronaut mentally assesses the alternative solutions offered by the HCI system in order to address a certain issue, he or she enters the process of making a choice through making a single decision – either rational or irrational – which represents the "information processing and decision-making" component. Lastly, for the astronaut to visually see his or her decision being completed, it is necessary to practically perform or conduct such previously made decision, which represents the "execution" component prior to the HCI system manifesting the information output, thus rounding off the entire "information storage" process, respectively. Even though the basic functions of an HCI system would seem straightforward and comprehensible for astronauts, there are some additional components identified within applicable HCI systems operating within manned spacecraft missions. Namely, when particularly discussing within the context of preventing space-related accidents, circumstances of inadequate HCI systems must be appropriately addressed by regulations aimed at preventing addressing the potential risk or endangerment of astronauts. According to the NASA Report titled *"Evidence Report: Risk of Inadequate Human-Computer Interaction,"* for instance, the risk of inadequate HCI among other core contributing factors, includes requirements, policies and design processes (Holden et al., 2013: 3). Hence, our comparative analysis continues with discussions on the HCI system in manned spacecraft missions, as depicted by the "Schematic Diagram of Human-Compute Interaction System in Manned Spacecraft" in Figure 2, where within an extraterrestrial surrounding, the "information storage" represents the main product of a continuous cycle being consisted of five interrelated components, which are simultaneously divided between each other.

Figure 2: Schematic Diagram of Human-Computer Interaction System in Manned Spacecraft



Note. Adapted from "Manned Spacecraft Technologies" (p.53) by H. Yang, 2020, Springer Nature.

Namely, the astronaut's working environment is strictly located within the spacecraft, where an easily distinguishable division between the "astronaut" segment and the "spacecraft" segment may be simultaneously observed within the entire process of how the HCI system is designed to operate for the purposes of a manned spacecraft mission. We first begin analyzing the "astronaut" segment, which is consisted of the following components: (1) *perception;* (2) *information processing;* and (3) *manipulation*. The components obviously represent the astronauts' participation in the mental processing of the given information by the HCI system. For instance, with the astronaut becoming aware of and interpreting the signals and/or commands received by the HCI systems from outer sources through neurophysiological processes of seeing and/or hearing such signals and/or commands, represents the "perception" component. Or, the astronaut being said to use his or her cognitive processes in order to simultaneously acquire, store and use knowledge previously obtained for the purposes of the astronaut mentally assessing the alternative solutions offered by the HCI system in order to address a certain issue deemed necessary for the success of the manned spacecraft mission, represents the "information processing" component. On the other hand, the "spacecraft" segment is consisted of the following components: (1) *controller*; (2) *space capsule*; and (3) *display*. The components obviously represent the HCI's design features for the astronaut's proper use and operation during the manned spacecraft mission. For instance, the "display" component would represent the HCI system's output device displaying the signals and/or commands received from outer sources, as well as the performance and/or sending the processed information – most commonly in textual and/or pictorial form – with which the

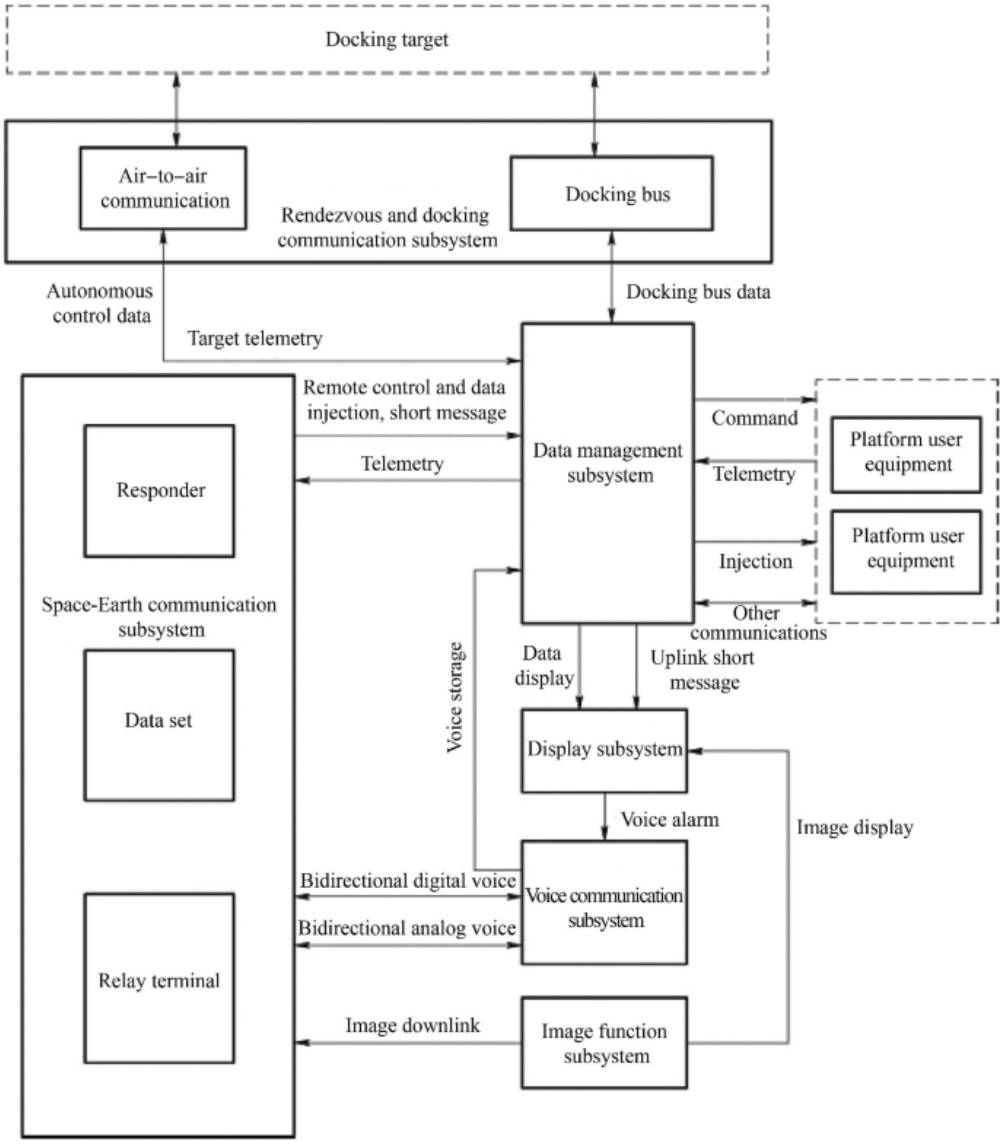
astronaut directly comes into contact through his or her senses. Altogether, the "astronaut" and "spacecraft" segments should constitute the entire operation process of an HCI system designed for and simultaneously applied in manned spacecraft missions. Nevertheless, the acceptance of error-prone HCI systems otherwise deemed workable by uncertain astronauts pulls down the risk of life-threatening endangerments and jeopardizing the entire manned spacecraft mission along with it. Unfortunately, NASA had also reported such high-risk occurrences due to the presumed lack of proper regulations addressing HCI-related issues. In other words, the displacement of both HCI regulations and astronauts' abstracted perceptions of HCI systems only increases the risk of inadequate HCI creating unsafe circumstances within extraterrestrial working environments (Holden et al., 2013: 9-10). With the priority of space flight safety, the primary goal of designing the manned spacecraft mission has to be to maximize this objective whilst achieving mission success (Shayler, 2009: 47). Hence, we emphasize once more that it would be preferable for researchers working on space-related HCI systems for manned spacecraft missions to cooperate with policymakers without either getting lost in translation (Spaa et al., 2019: 1). By further considering a socio-technical perspective toward our comparative analysis, manned spacecraft missions include yet another significant aspect – namely, the information systems which are also a crucial component for the anatomization of space-related HCI systems. The composition of the information system is shown in Figure 3 below. Generally speaking, the information systems of a manned spacecraft may be divided into six functional subsystems, where they cooperate with each other for the purpose of performing the functions of information systems:

(1) Data management subsystem;
(2) Display subsystem;
(3) Image subsystem;
(4) Voice communication;
(5) Space-Earth communication subsystem; and
(6) Rendezvous and docking communication subsystem;

The involvement of HCI within information systems is reflected in its task of manifesting interrelated collaboration between the above-mentioned subsystems for the purpose of maintain control of the spacecraft (Yang, 2020: 22) characterized by crew autonomy through a human-machine interface (HMI) allowing the astronauts aboard the spacecraft to send commands to their vehicle and review essential subsystems (Campan et al., 2022: 473).

Operating a spacecraft by the principle of crew autonomy, however, is a complicated process similar to the operation of a spacecraft by ground control, due to the fact that modern spacecraft are complex machines with more and more sophisticated software (Faller & Schmidhuber, 2022: 118). While communication is a key success element within the crew aboard the spacecraft (Uhlig & Söllner, 2022: 157), astronauts may act spontaneously to events and act less deterministically that computers (Göttfert et al., 2022: 325). This is due to the design of the spacecraft, and consequently the way how to operate them, being defined by their manufacturer (Faller & Schmidhuber, 2022: 118). This alone raises separate liability-related issues of manufacturers who specifically design space-related HCI systems in manned spacecraft missions (Vershchetin, 1990: 13). And even if there are already established policies addressing HCI development efforts, their impracticality (including such from a financial aspect), are often prone to being either waivers or entirely ignored (Holden et al., 2013: 12). At the same time, international cooperation which is developing on a broad scale in the field of exploration and use of outer space also requires an improvement of its judicial mechanism (Vereshchetin, 1990: 12).

Figure 3: Composition of Information System



Note. Adapted from "Manned Spacecraft Technologies" (p.23) by H. Yang, 2020, Springer Nature.

Conclusions

Space-related technology, including HCI systems specifically designed and applied in manned spacecraft missions, as well as space exploration in general, offer continuous advancements to our thriving society (Magagula & Witten, 2019: 813). Unfortunately, such

advancements have often been built upon risks and endangerments which may lead to life-threatening consequences for astronauts(Shayler, 2000: 3). The blame could be partially placed upon the lack of appropriate public policies and regulations – on national, international and even commercial levels – addressing space-related HCI systems. In addition, given that fact that there are multiple space-faring nations currently possessing the technological capacities to launch spacecrafts and other similar objects into orbit, it would be fair enough to consider proposing an international public policy as a result of the potential cooperation between both space lawyers and HCI scientists, even though the latter had not contributed significantly in the area of policymaking before (Lazar et al., 2015: 71). The belief of this cooperation being crucial lies in the necessity for space lawyers to properly comprehend the regulatory requirements of space-related HCI systems (Freeland, n.d.).Namely, an international public policy framework regulating space-related HCI systems, especially designed and applied in manned spacecraft missions should be envisioned as a multidisciplinary (Kaneria & Pandey, 2024: 34). Meanwhile, the term "public policy" would consider both government and non-governmental aspects (Lazar, 2015: 69), as reflected in Lazar's statement that *"taken broadly, public policy includes not only laws, regulation, enforcement actions, lawsuits, and court actions, but human rights treaties, international technical standards, non-governmental organizations, and multinational organizations"* (Thomas, 2017: 474). However, it must also be understood that providing an international public policy framework regarding the proper regulation of HCI systems in manned spacecraft missions can be particularly challenging due to some obstacles that were present even in the early days of establishing space regulations parallel to outer space exploration, including the lack of political will of leading space-faring nations or the international community, as well as the disproportional developments between space technology and space law (Perek, 1990: 19). In other words, international space-related policies regulating HCI systems in manned spacecraft missions may need to evolve so that technology does not outpace it (Schrepferman, 2020). Hence, it is firmly believed that the importance of this scientific research paper may be further reflected upon technology policy and the space industry, as we acknowledge that any space flight represents some degree of risk and working in space, as in aviation, comports some hazards. When envisioning that suddenly and at any time during a mission, a situation may occur that will threaten the life of the astronauts or radically alter the flight plan, it is thus critical to the success of the mission and security of the crew is the complex process of interaction between astronauts and their spacecraft, not only in routine operation, but also in unforeseen, unplanned, and life-threatening situations.

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The Dilemma of Realistic Utopia: On the Conception of "Peoples" in Rawls's Theory of International Justice[1]

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Rawls formulates an international theory of justice with the name The Law of Peoples based on the conception of Peoples endowed with a moral nature. "Peoples" are not equivalent to states in the general sense, but states whose exercise of political power has legitimacy and, therefore, has membership in the society of all peoples. The legitimacy manifests itself in the fact that peoples, as members of the society of peoples, must be reasonable and rational, and in particular, rationality must be restricted by the reasonableness. For Rawls, the willingness to give other peoples a proper respect in a reasonable sense is an essential part of the idea of peoples. However, the tolerance conception of the Law of Peoples centered on liberal peoples and the attitude of liberal peoples towards "outlaw states" and "burdened societies" have betrayed the idea of reasonableness and reciprocity. Although Rawls highlights the concept of "realistic utopia" in the hope that the Law of Peoples is reasonable and necessary, featuring liberal peoples as cores, putting decent hierarchical peoples, outlaw states and burdened societies in an inferior position, The Law of Peoples will be eventually in a dilemma for lack of justice and practicability.

Keywords: Rawls, Peoples, Law of Peoples, International Justice

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Introduction

John Rawls is renowned for his masterpiece *A Theory of Justice*. However, the boundary of his theory of justice is domestic society, so it is mainly about a theory of domestic justice. Rawls also claims that the two principles of justice do not apply to relations between nations. Although he does refer in his book to how justice as fairness can extend to the field of international law in order to judge the aims and limits of a just war, and briefly explores several basic principles governing international relations, including the principle of equality, self-determination, self-defence, *pacta sunt servanda*, etc. (Rawls, 1971). A Theory of Justice does not deal with international justice overall, which is one of the reasons why it has left itself subject to widespread criticism.

For more than 40 years, many scholars have been thinking about the possibility of applying Rawls's theory of justice to international relations, while Rawls' s later book *The Law of Peoples* shows his own attempts and efforts in this regard (Rawls, 1999). Rawls puts forward a conception of "peoples" in this book and constructs a set of international justice principles of his so-called "the law of Peoples" based on the conception. Scholars' arguments on "the law of Peoples" focus on this conception to a great extent. Therefore, clarifying it is key to understanding Rawls' s whole theory and related arguments.

The Connotation of "Peoples": A Moral Character

In the theory of international law, the nation-state is regarded as the most basic and main subject, while Rawls chooses the collective concept of "peoples" in constructing his "law of Peoples". Rawls explains that peoples have different characteristics compared to states, because the state is traditionally imagined as having two powers of sovereignty, which is inappropriate. In the section "Why Peoples and Not States," Rawls further argues that the traditional concept of state sovereignty has been incorporated into positive international law for more than 300 years since the Thirty Years'War (1618-1648), including the right to wage war abroad and the right to autonomy in dealing with its people, but both powers have gradually been severely restricted since World War II.

This restriction is closely related to the basic characteristics of states, which "are often seen as rational, anxiously concerned with their power – their capacity (military, economic, diplomatic) to influence other states- – and always guided by their basic interestsю" This is the significant difference between states and peoples. Especially" if rationality excludes the reasonable (that is, if a state is moved by the aims it has and ignores the criterion of reciprocity in dealing with other societies); if a state's concern with power is predominant and if its interests include such things as converting other societies to the state's religion, enlarging its empire and winning territory, gaining dynastic or imperial or national prestige and glory, and increasing its relative economic strength – then the difference between states and peoples is enormous" (Rawls, 1999). Therefore, Rawls points out that the right of the state to wage war and the right of internal autonomy should be restricted according to the idea of "The Law of Peoples." So, what are the differences between peoples and states? Rawls expounds three basic characteristics.

First of all, there is a reasonable and just constitutional democratic government that serves the basic interests of peoples. This government does not pursue its own political ambitions but protects and is responsible for the basic interests of the people as stipulated in the written or unwritten constitution. Second, peoples are united by common sympathies, which do not require a complete origin of common language, history and political culture, as well as shared historical

consciousness, because these characteristics are difficult to fully satisfy. The Law of Peoples is based on the need for such common sympathies. Finally, peoples have a moral character; that is, peoples are reasonable and rational. They are willing to cooperate with other peoples under fair conditions, and they would respect these conditions even if they benefit by violating them (Rawls, 1999).

By comparing Rawls's arguments on the characteristics of states and peoples, it is not difficult to find that Rawls's rejection of the concept of state originates from his dissatisfaction with the state's lack of morality. Of course, this is Rawls's conclusion after examining the history of international relations motivated by national interests and power, filled with scenes of human tragedy.

Although Rawls painstakingly attempts to distinguish peoples from states, many scholars believe that the so-called peoples resemble states to a large extent (Benhabib, 2004; Buchanan, 2000). Allan Buchanan points out clearly that, from the principles of the Law of Peoples, if the term "peoples" does not mean some groups who own their states, it would be meaningless to attribute powers paralleling sovereignty to peoples, because only those groups who have their own states can have these powers. Therefore, Buchanan asserts that peoples are politically organized groups whose form of organization is actually the state (Buchanan, 2000).

However, Rawls tries to explain the meaning of peoples by expounding and emphasizing the moral nature of peoples. Actually, Rawls's peoples with moral nature in most cases are only the so-called liberal peoples. With this, he extends the conception of liberal justice to peoples' society, which is similar to "justice as fairness" in *A Theory of Justice*, but more general. It accommodates cultural diversity not mentioned in *A Theory of Justice*, and the Law of Peoples even contains non-liberal decent societies as equal partners for liberal peoples. *A Theory of Justice* does not take into account the hierarchy of justice, but the Law of Peoples highlights tolerance. Based on this, Rawls puts forward the concept of "decent hierarchical peoples" in the second part of ideal theory and lists the following criteria:

First of all, such societies have no aggressive goals and recognize the need to achieve their legitimate goals through peaceful means like diplomacy and trade while respecting the political and social order of other societies;

Secondly, the decent peoples' legal system complies with their common good idea of justice to ensure that their people acquire human rights; moreover, the decent peoples' legal system must impose *bona fide* moral obligations and responsibilities on all persons in its territory, within which the administrators of the legal system, such as judges and government officials, shall have a sincere and reasonable belief that the law is indeed guided by a common good idea of justice(Rawls, 1999).

The main difference between decent hierarchical peoples and liberal peoples is that liberal peoples regard the individual as the ultimate goal of morality. Decent hierarchical peoples do not recognize this, but emphasize the collectivism that society is superior to the individual. Both peoples together constitute well-ordered societies, and its representatives also choose and agree on the basic principles guiding the world order under the veil of ignorance similar to that in *A Theory of Justice*.

However, different from the two principles in *A Theory of Justice*, Rawls puts forward eight principles that constitute the Law of Peoples. These eight principles prescribe the main rights and obligations of peoples. Taking these principles into account, we can find that most of them are a restatement of the basic principles of international law, such as mutual respect for the equality, independence and freedom of the peoples, non-interference, self-defence, observance

of the rules of war, and conformity with treaty obligations. Nevertheless, the connotation of these principles is worth pondering over. Especially the respect for human rights and the duty to assist peoples living under unfavorable conditions proposed by Rawls in principles 6 and 8 impart a Rawls's interpretation to "peoples."

In fact, the conception of "peoples" expounded by Rawls is not equivalent to states in the general sense. With this conception Rawls intends to give some national governments a type of legitimacy. In other words, peoples are states whose exercise of political power has legitimacy and, therefore, membership in the society of all peoples.

The legitimacy manifests itself in the fact that peoples, as members of the society of peoples, must be reasonable and rational, and in particular, rationality must be restricted by the reasonableness. It is this characteristic that makes peoples different from states in the general sense. This is because the basic interests of peoples are limited by reasonableness. For example, the fundamental interests of liberal peoples are to protect their territories, ensure the safety of citizens, maintain their liberal political systems and various free cultures of domestic societies, and liberal peoples shall strive to guarantee reasonable justice for all their citizens and all peoples. Furthermore, liberal peoples may coexist with other peoples with the same characteristics to uphold justice and maintain peace.

According to Rawls, there is another very important interest for all peoples, namely, *amour-propre*. This interest is their proper self-respect as peoples, which is based on their common awareness of their history, culture and achievements, and is reflected in their insistence on obtaining a proper respect and recognition of their equal status from other peoples. The key point that distinguishes peoples from states is that just peoples are fully willing to give the same appropriate respect and recognition to other peoples as equal ones. In this way, peoples' willingness to provide fair conditions for political and social cooperation for other peoples has become an integral part of their rationality and reasonableness. These fair conditions are those which peoples sincerely believe that other peoples will accept even if they can profit from the violation. This also reflects the reciprocity criterion. For Rawls, the willingness to give other peoples a proper respect in a reasonable sense is an essential part of the idea of peoples.

Unfortunately, as we can see below, the tolerance conception of the Law of Peoples centered on liberal peoples and the attitude of liberal peoples towards "outlaw states" and "burdened societies" have betrayed the idea of reasonableness and reciprocity.

Tolerance and equality in the law of peoples

Rawls argues that human rights in The Law of Peoples, unlike the rights of democratic citizenship, expresses only a number of specific types of urgently necessary rights, including, inter alia, the right to life (means of subsistence and security); the right to liberty (freedom from slavery and forced work, adequate measures of conscience to ensure freedom of religion and thought); the right to property (personal property); and the right to formal equality expressed in the rules of natural justice (i.e. similar treatment in similar cases). In Rawls's view, human rights play a very special role in the Law of Peoples because "they restrict the justifying reasons for war and its conduct, and they specify limits to a regime's internal autonomy. In this way they reflect the two basic and historically profound changes in how the powers of sovereignty have been conceived since World War II. First, war is no longer an admissible means of government policy and is justified only in self-defense, or in grave cases of intervention to protect human rights. And second, a government's internal autonomy is now limited" (Rawls, 1999).

Considering Rawls's rejection of the concept of state in constructing the Law of Peoples and choosing people as the subject, it is not difficult to find that Rawls's people is only a state with limited sovereignty restricted by human rights obligations. The moral character of the so-called people lies in its respect for the supremacy of human rights.

Rawls stresses that human rights can not be rejected as special freedoms or exclusive ideas of Western tradition, and they are not politically regional. Human rights set a necessary standard for the acceptability of the domestic political and social system and its legal order. The toleration of decent hierarchical peoples is just based on their respect for human rights. Although Rawls defines decent hierarchical peoples in detail, these criteria essentially point to the requirements of human rights obligations both within and outside the system. For Rawls, the most important thing is that decent hierarchical peoples abandon aggressive war a means of promoting its comprehensive doctrine while respecting the basic human rights of its members of society. Regardless of the principles on which such societies are organized, they must protect the human rights of their members and allow them the opportunity to participate in political decision-making through a decent hierarchy of consultations, even if that approach and opportunity may be very different from that of a liberal democratic society. Rawls believes that as long as decent hierarchical peoples respect these requirements, they can be accepted by liberal peoples as a kind member of peoples' society, which is the real meaning of tolerance.

In order to demonstrate how decent hierarchical peoples can be tolerated by liberal people, Rawls coins an Islamic society called Kazanistan. While in Kazanistan only Muslims have the highest political and military power, they also allow followers of other denominations to exist. Besides, Kazanistan respects human rights, including the right to life, liberty, property and formal equality before the law. Although Kazanistan is not a democracy, she may allow all members of society, including religious minorities, to participate in public life through a decent consultation hierarchy.

This consultation hierarchy needs to meet the following guidelines: All groups must be consulted in the decision-making process. Every member of a society must belong to a particular group. Each group must be represented by an institution that includes at least some members of the group, who are aware of and share the group's basic interests. The rulers of Kazanistan consult the representative bodies of all groups, which means their views and opinions must be taken into account when making final decisions, and if they so request, judges and other officials must explain and justify the decisions made by the rulers. Rulers should also take the particular priorities of Kazanistan seriously in their decision-making process, including the construction of a decent and rational Muslim people who respect religious minorities. These special and important priorities should form part of the conditions for equitable cooperation, which should be expressed openly (Rawls, 1999).

Rawls firmly believes that although Kazanistan is not a democratic system, it still guarantees a certain degree of justice. Therefore, liberal peoples should tolerate decent hierarchical peoples and treat them as equals. In a word, whether or not to meet the human rights standards proposed by Rawls is the limit of whether liberal peoples should tolerate non-liberal peoples.

Rawls's tolerance not only means that sanctions can not be imposed on non-liberal peoples, but also that liberal peoples recognize the equal status of non-liberal peoples in society of peoples. Rawls sees this tolerance as the most effective way to encourage liberal reform among non-liberal peoples. However, let us look at Rawls's exposition of the original position at the international level in the Law of Peoples. We can find that essentially this kind of "equality" centers around liberal peoples, and decent hierarchical peoples are only in a subordinate position.

Rawls argues that the original position in the international level characterized by the representatives of the peoples in a fair and equal position. More than that, these peoples should be set as rational ones. Their representatives also need to think carefully about the appropriate topic, which is the Law of Peoples, and their consideration follows just reasons (limited by the veil of ignorance). Finally, choosing the principle of the Law of Peoples is based on the fundamental interests of the peoples, determined by the concept of freedom of justice in this case.

Obviously, the veil of ignorance seems to be more transparent in that the parties know they represent liberal peoples and that they have more favorable conditions than other societies because constitutional democracy can be made possible only by a certain amount of material resources. Since the Parties know that the peoples they represent adhere to a just sense of freedom, they consider the fundamental interests of liberal peoples while the interests of decent peoples are ignored. As representatives of liberal peoples, in order to promote their basic interests and safeguard justice, they will choose the basic principles of the Law of Peoples to adjust the relationship between liberal peoples and between liberal peoples and other peoples. Based on the consideration of the basic interests of liberal peoples, Rawls contends that they will choose the eight principles, with the obligation of respect for human rights as the core, for the Law of Peoples.

However, as mentioned earlier, the interests of decent hierarchical peoples are not considered in choosing these principles. In fact, Rawls used two original positions at the international level. First, as described above, decent peoples are excluded; they could only participate in an isolated, restricted original position and could only decide whether to accept or reject the principles of the Law of Peoples chosen by liberal peoples. Rawls believes they would choose to accept because they do not fight for aggression; their representatives respect the domestic order and integrity of other peoples. Secondly, because a decent hierarchical society holds a common sense of good, its representatives strive to protect human rights and the good of the people, as well as to maintain their independence and security. They focus on the interests of trade and accept the idea of mutual assistance between peoples (Rawls, 1999). This explanation is actually a simple repetition of the criteria for decent hierarchical peoples. It is hard to imagine that they are willing to accept these principles liberal peoples choose for their own sake. Moreover, the subordination of the decent hierarchy of peoples in this process is itself contrary to the principle of equality between peoples, entirely in conflict with the requirements of reasonableness and reciprocity. Thomas Pogge further points out sharply that the people of non-liberal or non-decent societies are not represented in the original international state; thus, the interests of their members are completely ignored (Pogges, 2003). This seem to make the moral peoples immoral to a large extent, which in turn infringes on the legitimacy of peoples. It will be further discussed below.

Peoples Behind the Moral Nature

The superior status of liberal peoples to decent peoples weakens the principle of equality in the Law of Peoples, but Rawls still makes arduous efforts to emphasize their equal status or a superficial equality. However, for societies other than peoples, Rawls completely abandons the principles of independence and equality. His argumentation shows the arrogance of the peoples under the cover of the moral nature.

Rawls first mentions the concept of "outlaw states", the first kind of societies other than peoples. According to Rawls, Nazi Germany during World War II belongs to this kind. Outlaw

states do not abide by the Law of Peoples. Instead, for them, the pursuit of rational rather than reasonable interests suffice to wage war. Therefore, the well-ordered peoples have the right to wage war against outlaw states for the purpose of self-defense, as long as they reasonably and sincerely believe that their security is threatened by the expansion policy of outlaw states. However, they will explain the reasons for going to war against outlaw states in various ways for the sake of their goals. Rawls reluctantly acknowledges this, and says that if a society goes to war in pursuit of economic wealth, acquisition of natural resources, or even for hegemony and empire-building, then this society will shift from a people to an outlaw state. But Rawls gives no answers to this situation.

If outlaw states do not pose a threat to others or any danger to other countries, can they be intervened by force just because they violate human rights? Rawls confirms this, stressing that outlaw states, not respecting human rights, cannot participate in the social cooperation system. Even if they participate, their only aim are to gain their own interests. For this reason, Rawls maintains that military interference for the protection of human rights is necessary and legal if the violations are unusually serious and other political and economic sanctions do not work.

However, whether for the threat of security or for the protection of human rights, the war against outlaw states may be subject to the criticism that it directly contradicts the principles of independence, equality and non-interference. A possible answer is that the above principles apply only to well-ordered peoples and not to outlaw states. But if so, How can outlaw states be interfered for the reason they don't conform to the Law of Peoples?

Rawls believes that through the war of self-defense, the ultimate goal is to turn the outlaw states into liberal or decent peoples, and thus bring them into the peoples's society. The same purpose is also embodied in the treatment of the second societies outside peoples – burdened societies, but the way peoples treat them varies because of the different reasons for their non-compliance with the Law of Peoples.

Unlike outlaw states, burdened societies do not observe the Law of Peoples because they "lack the political and cultural traditions, the human capital and know-how, and, often, the material and technological resources needed to be well-ordered" (Rawls, 1999).For these societies, well-ordered peoples should assume a duty of assistance, but the duty advocated by Rawls is very limited. He contends that the transition from a burdened society to a well-ordered society does not require a lot of wealth. Rawls reintroduces the principle of just savings in domestic societies described in the *Theory of Justice*. The purpose of the principle is to establish a just or decent basic institution, and once it is established, this saving behavior stops. At the same time, according to Rawls, the establishment of such an institution does not require a large amount of wealth, but depends on the history and the view of justice specific to a society.

Rawls argues that the duty of assistance in the Law of Peoples is very similar to the principle of just savings at the domestic level, and that both aim to achieve and maintain a just or decent system. A society must eventually have a political culture that can sustain the system. To this end, Rawls stresses that the key factors are the political virtue of a society, the industriousness and innovation of its members, as well as their population policy and human rights situation. In Rawls's view, these factors play a more critical role than wealth in establishing just or decent institutions. As long as the well-ordered peoples help burden societies to establish the fair or decent system, burden societies incorporated into the peoples' society to become well-ordered, the purpose of assistance has reached, and assistance can stop. Even if they are still in a state of poverty, rich societies have no obligation to take further economic redistribution as Rawls believes that there is no need to achieve equal wealth among peoples and a fair or acceptable

system ensures a burdened society's economic development. In this regard, the ultimate goal of the assistance obligation is only moral equality among different societies.

The duty of assistance constitutes an important part of Rawls's international justice theory. Rawls insists that inequality is not necessarily unjust and when it is unjust, just because inequality has an unjust impact on the basic structure of peoples's society, and on the relationship between the people and its members. However, once the duty of assistance is fulfilled, this will not happen, so there is no need to focus on inequality. Rawls highlights three reasons: First, by the time the purpose of the assistance to burdened societies is achieved, all the peoples have an effective liberal or decent government. In such cases, there is no need to narrow the gap between different peoples in wealth possession because this kind of government can take effective measures to ensure that their people live valuable lives. Second, once the assistance obligation is completed, every people has its own liberal or decent government within it, the citizens of which will not feel inferior only because other societies are richer than the one they belong to. At this time, each person can adjust the significance of their own social wealth, so there is no reason to feel inferior. Third, in Rawls's view, justice in the Law of Peoples refers not only to formal equality, but also to a just procedure. Since the representatives of peoples choose the basic principles equally in the original position, this process is a just procedure, and the result of the application of this procedure is just.

In short, for Rawls, as long as the principle of assistance is carefully followed, every society can be responsible for itself after establishing a just or decent system and eventually lead its people to a happy life, which makes any redistribution or assistance unnecessary.

In my opinion, Rawls's arguments for the principle of assistance are not convincing. Why do some countries in the world are prosperous while others are in crisis? This has been one of the hot issues for the economists for centuries. Rawls feels no need to explore the principles of resource redistribution because "the crucial element in how a country fares is its political culture—its members' political and civic virtues – and not the level of its resources, the arbitrariness of the distribution of natural resources causes no difficulty" (Rawls, 1999). Clearly, Rawls here cites David Landes's view on the wealth and poverty of nations. However, Landes's research does not show any single-cause theory of national wealth and poverty. Landers does recognize the important influence of a country's political culture in her economic development, but he does not take it as the only decisive factor (David Landes, 1998).

I do not intent to deny Rawls's point of view. In fact, many economists support his assertion. Andrew Hurrel points out that "the problems of inequality and underdevelopment lie within domestic societies rather than with the international system" (Hurrell, 2001). However, Hurrel also reminds us that "this view clearly underplays the vulnerability of developing societies to global markets. (…) It neglects the degree to which the emergence over time of the 'unfavorable conditions' that afflict poor societies has as much to do with external and global factors as with internal ones" what is more, we cannot ignore the influence of geographical environment, climate, population, natural resources and the international environment on the national economic development. In fact, Rawls also admits that an important role of the people's government is to be the representative and effective agent of the people, responsible for maintaining its territory and the integrity of the environment and the population size. Rawls goes on to say, "unless a definite agent is given responsibility for maintaining an asset and bears the loss for not doing so, that asset tends to deteriorate. In this case the asset is the peoples territory and its capacity to support them in perpetuity; and the agent is the people themselves as politically organized" (Rawls, 1999). Obviously, it is from the perspective of resources that Rawls talks about the

management of territory and the environment. Rawls may have aimed to show that natural resources and other factors can exert influence on a country's development mainly through the role of political culture, but unfortunately, he has not fully demonstrated this. Moreover, there is still a problem. Even if a country has established a liberal or decent system, it is still relatively short of resources. Is it willing to obtain more resources according to a redistribution principle to promote its economic development? The answer seems to be yes, but Rawls will give a negative answer. Why is that?

Leif Wenar attempts to provide a defense for Rawls's seemingly inconsistent position. He points out that the key is that the fundamental interests of domestic citizens and peoples are different. The former pursues more wealth and income, while peoples do not. Peoples only pay attention to a certain level of wealth that can ensure the maintenance of their just political order. Beyond this level, their concern for wealth disappears. Therefore, there is no need to redistribute to maintain background justice, as people are indifferent to what will be distributed (Leif Wenar, 2006). However, in the second level of the international original position, as representatives of liberal or decent peoples, the parties do not know the territorial size and population size of the people they represent, nor do they know the amount of their natural resources, let alone the level of their economic development or other related information. So, behind the veil of ignorance, all parties may only be aware of their political and cultural information, not knowing how much resources and wealth are needed to establish and maintain their just or decent system. In this case, it is unconvincing to think that peoples are indifferent to the pursuit of more resources and wealth.

Hsuan-Hsiang Lin argues that from a practical point of view, Rawls is obviously a bit naive to think that peoples are not interested in maximizing their wealth. Nonetheless, he adds that even if the interests of wealth are considered in the international original position, they must be coordinated with the fundamental interest of people's self-respect. The law of peoples must allow ample space for peoples to choose their conception of distributive justice, and formulate distributive policies accordingly. When this political and economic autonomy is not allowed, people's self-respect will get hurt (Lin, 2006). However, if the basic needs to maintain people's livelihoods and health are not met, what is the point of talking about self-respect? As Peter Singer points out sharply, "tens of millions of people have died from poverty-related illnesses in countries that have yet to gain liberal or decent institutions and become "well-ordered." The issue of how the rich countries and their citizens are to respond to the needs of the hundreds of millions of people in extreme poverty has an urgency that overrides the longer-term goal of changing the culture of societies that are not effectively regulated by a public conception of justice. But that issue is not one to which the author of *A Theory of Justice* ever gave serious attention" (Singer, 2016). This exactly shows the indifference of "peoples" and no respect for the principle of human rights. Charles Beitz doubts the basis of Rawls's argument, saying that diversified factors, including natural resources, technology or human behavior, affect economic development. It is difficult to decide which is more important because it varies from one society to another (Beitz, 2000).

From Rawls' arguments we can see that he does not prioritize the issue of equality, but believes that a just or decent institutional culture is enough to secure the relative equality between countries. However, Rawls underestimates the importance of equality at the international level. In the context of globalization, the inequality between countries will gradually lead to an increasingly serious inequality, as strong or rich countries are likely to make use of their dominance to manipulate international political and economic relations, and eventually, there

will be only a few great powers or rich countries in the world that possess or control most of the world's wealth, whereas most poor countries are getting poorer and poorer. If things continue like this, serious instability will even occur in the domestic politics of just or decent countries. To maintain their rule, these governments are highly likely to deviate from well-ordered societies and become outlaw states in pursuit of power and self-interest.

Conclusions

From domestic justice to international justice, Rawls dramatically abandons moral individualism and chooses to construct the Law of Peoples with peoples as the main subjects. In *A Theory of Justice*, individuals are always in the core position in the process of choosing the principles of justice, but it is peoples that choose the basic principles under the original position at the international level. This significant change subjects Rawls' theory of international justice to a lot of criticism. Perhaps Rawls thinks more about the practicability of his theory. In the beginning of *The Law of Peoples*, Rawls highlights the concept of "realistic utopia" in the hope that the Law of Peoples as a "realistic utopia" is reasonable and necessary. As long as all societies establish a just or decent system, tragedies of unjust wars, religious persecution, genocide and famine can be eventually eliminated. Yet a close scrutiny of the Law of Peoples enables us to find that despite liberal peoples tolerate decent hierarchical peoples and incorporate them into the society of peoples, decent peoples who had no say during the course are placed only in a subordinate position. In order to incorporate outlaw states and burdened societies into well-ordered societies, peoples can even abandon the principles of independence, equality, non-interference and respect for human rights that constitute the basis of the Law of Peoples. All these greatly hinder its justice and practicability and make it eventually fall into a dilemma.

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The Effect of Space Launches on Climate: A Legal and Policy Perspective

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Energy production, transportation, and industrial operations, which have higher carbon footprints, are frequently the focus of climate change mitigation measures. It is important to keep in mind that the processes involved in outer space launch operations, such as manufacturing, shipping and infrastructure construction have environmental impacts as well. It is critical to take into account the possible effects of space launches on the Earth's climate from a legal and regulatory perspective as the space industry is expanded rapidly. When rocket propellants burn, carbon dioxide (CO2) and harmful gases are released into the atmosphere, which contributes to greenhouse gas emissions from space launches. This research paper in Part II elaborates on human rights perspective to climate change. Part III investigates the influence of outer space activities on climate. In Part IV, the evaluation of the disproportionate effects of space launch emissions on marginalised and vulnerable populations is discussed, with an emphasis on the concepts of climate justice and equity. Part V conducts a study of national laws, international environmental treaties, space law and policy procedures asserting liability and determining compensation for potential climate damage resulting from space launch activities. Part VI proposes establishment of specific liability frameworks and policy considerations through international cooperation for space launch operations liable for any negative climate repercussions along with incentivizing sustainable propulsion technologies and supporting green infrastructure.

Keywords: outer space, climate change, policy, sustainable space technology

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Introduction

Humanity has set out on an incredible voyage of exploration and discovery across the infinite outer space, going beyond the boundaries of our planet to solve the enigmas of the universe. Outer space launch operations are essential to this journey of discovery as it constitute large-scale projects that launch spacecraft into orbit, allowing human scientific research and technology advancement to reach new dimensions. The environmental effects of space launch operations,

however, are a serious issue that demands consideration in the midst of the breathtaking space exploration that involves rocket launches and space missions.

The relationship between environmental sustainability and space exploration is a fundamental paradox that combines the need to protect the fragile balance of our planet's ecosystems with the limitless possibilities for human growth. Although space launches represent enormous strides forward for humanity, they also have a noticeable negative impact on the environment. Bringing with them ecological fallout requires consideration and reflection on our part.

This study delves into the complex and confusing world of space launch operations, analysing the environmental implications and revealing the complex network of causal links that underlie the effects of space launches on the surrounding ecosystem. Each thread of this complex tapestry provides a glimpse into the ecological consequences, ranging from the pollution released during rocket launches to the destruction of terrestrial ecosystems and the growth of space junk in Earth's orbit.

Statement of problem

The number of space launches has increased dramatically in recent years due to both growing commercial interest and new developments in technology. Although these launches are essential for communication, scientific research, earth observation, remote sensing and national security, their effects on the environment likewise constitute a cause for concern. Among the most important environmental problems connected to space launches are the release of contaminants, harm to ecosystems and production of space debris. A thorough understanding of the environmental consequences, scope, reasons, and possible mitigation techniques is necessary to address them. Therefore, evaluating the effects of space launch operations on the environment and identifying practical mitigation strategies and policies are the main goals of this research.

Literature Review

- Tanja Masson-Zwaan and Roberto Cassar, the Peaceful Uses of Outer Space (2019)
  The chapter depicts space negotiations as a consequence of the USSR and US government working together at UNCOPUOS to guarantee the peaceful use and exploration of space, space law was created. The Outer Space Treaty discussions demonstrated how these two global giants put aside their political differences to come to a mutually beneficial legal agreement. The chapter questions the continued applicability of UNCOPUOS and international space law in offering a framework for the peaceful use and exploration of space.
- Michael Byers and Aaron Boley, Mega-constellations and International Law (2023)
  In the framework of international law, this chapter addresses the difficulties brought about by the rapid expansion of mega-constellations, with a focus on satellite collision and subsequent accountability. It draws attention to the fact how difficult it is to prove causality in knock-on collisions, in which spacecraft are struck by debris from an earlier collision. Determining what constitutes appropriate behaviour and negligence is difficult since there are no legally enforceable international standards for the construction and operation of satellites.
- Steve Mirmina and Caryn Schenewerk, International Space Law and Space Laws of the United States (2022)

The book highlights the significance of international collaboration by giving a brief history of space exploration and the evolution of space law throughout the first 50 years. The United States' domestic laws governing space-related operations are covered in great detail in the second part of the book. To meet its international duties under the Outer Space Treaties, the United States has established domestic laws and regulations to incorporate its legally binding commitments into its domestic legal system. As required by Article VI of the Outer Space Treaty, these domestic rules and regulations pertaining to space-related activities are intended to authorize and supervise the actions of U.S. nationals in outer space.

- Alla Pozdnakova, Pollution of the Marine Environment by Spaceflights, (2023)
  The chapter (Book – The Environmental Rule of Law for Oceans) discusses the need for an effective environmental legal regime in the space sector and the use of general environmental laws and multilateral environmental agreements to address pollution caused by spaceflights. Due to the release of hazardous materials into the atmosphere and the discarding of space launch vehicle and deorbiting spacecraft components, spaceflights have the potential to pollute the Earth's ecology, especially its marine environment. This pollution source has not received much worldwide attention, despite the fact that it could potentially be substantial. The applicable environmental law provisions are drawn from general environmental laws and multilateral environmental accords like the UN Convention on the Law of the Sea in the lack of particular environmental provisions in the international law of outer space. The author states that prior to establishing any significant regulations, primarily focus should be on building the international institutional framework and acquiring scientific data regarding the effects of spaceflights on the maritime environment.
- H. A. Simpson, Regulating Science Fiction: The Regulatory Deficiencies in a Rapidly Growing Commercial Space Industry (2015)

The paper addresses how the emergence of satellite mega-constellations has led to inadequacies in the legal system controlling commercial space. It outlines the pertinent legal framework and the urgent issues surrounding space exploration. It also notes that the industry is mostly in charge of regulating satellite constellations. It does not, however, get into specifics about the legal ramifications of satellite constellations.

Along with other literatures analysed, the gap identified is related to discussion with respect to different stages and phases of space launches. Whenever, a space object is launched beyond the Earth it involves manufacturing, launching, orbiting and final disposal. These stages have diverse implications, including on climate, which are still not addresses and governed.

Research Objective

1. To examine the impacts on the environmental implications of outer space operations.
2. To evaluate the scope and scale of environmental effects related to various space launch operations phases, such as rocket construction, fuelling, launch and spacecraft dismantlement.
3. To assess current practices and mitigation strategies, along with regulatory compliance for reducing the environmental impact of space launches.
4. To suggest recommendations for minimising environmental footprint of outer space operations and ensure space sustainability.

Research Methodology

This study adopt doctrinal method of research focuses on secondary data including legal texts, international instruments, statutes, regulations, and academic literature to analyse legal ideas, theories, and frameworks, in contrast to empirical research, which is dependent on primary data gathering and analysis.

Human Rights Perspective to Climate Change

Climate factors, such as humidity, temperature, rainfall, wind patterns and the changing seasons, have a significant impact on ecological interactions and processes as well as the distribution, prosperity and conduct of plant and animal species. Variations in the climate can cause disturbances to these relationships, resulting in changes to the ecosystems, diversity of species and fluctuations in population dynamics (Robinson, 2009). Climate change constitutes a human rights crisis as well rather than just an environmental problem.

Many human rights are violated by the negative consequences of climate change, including the rights to food, water, shelter, health, life and self-determination (Posner & Sunstein, 2007). These rights are seriously threatened by climate change, which can result in severe weather, disrupted monsoon patterns, elevated sea levels, food and water insecurity. The fundamental base to the human rights perspective on climate change is the recognition of the right to a healthy environment (Mboya, 2020). The acknowledgement of the right to a healthy environment is fundamental to the human rights viewpoint on climate change. With the devastating ecosystems, contaminating the air and water making ecological hazards more prevalent, climate change threatens this right. Consequently, preserving and improving the environment is crucial to ensuring the health and welfare of people. Achieving the Sustainable Development Goals (SDGs) is hampered by climate change, which presents serious obstacles to sustainable development (Nguyen & Nguyen, 2022). Extreme weather and natural disasters are two effects of climate change that can thwart development efforts, worsen poverty, and widen economic disparities. Climate-related relocating and loss of livelihoods violate people's rights to dignity and self-determination.

Although the effects of climate change are seen globally, it disproportionately harms the vulnerable populations, aggravating already-existing disparities and jeopardizing the exercise of basic human rights. Those that are already at a higher risk of adaptation – such as women, children, individuals with impairments, and indigenous peoples – are disproportionately impacted. It is crucial that pressing issue of climate change is approached from a human rights perspective, giving equal emphasis to the defence and advancement of human rights.

Climate change is not just a consequence of individual or isolated actions but is deeply intertwined with systemic issues and structural inequities, including financial inequality, social injustice and political inactivity. While approaching climate change from a human rights perspective means acknowledging and redressing the structural inequities that underlie it (Limon, 2009). This involves somehow admitting that wealthy countries and companies have historically and currently contributed to climate change, disproportionately burdening developing nations and underprivileged groups. The nations lagging behind in technical revolution are burdened with the aftermath of growing economies. Drawing an analogy with the outer space sector, the space-faring nations are ahead in the race to frontier beyond the planet Earth. The expansion of space technology and satellite utilization is ahead in these nations compared to many other nations worldwide. Outer space despite being a common heritage of mankind (Nnadozie & Sule,

2022), is accessible only to few nations (now, commercial entities as well). The application of outer space industry is growing in modern affairs of human existence, such as navigation, remote sensing, and earth observation. Space-faring nations have initiated operations and somehow polluted outer space with orbital trash and debris, which might disrupt further exploration in the future and also have the potential to drastically affect the climate on Earth. The environmental implications of outer space activities are discussed in the following section.

Environmental Implications of Outer Space Operations

For many years, the fascination of space travel has captured the interest of individuals, encouraging governments, businesses and private organizations to explore the frontier beyond Earth in pursuit of possibilities, resources and information. The spectrum and dimension of space operations have increased substantially in recent decades, changing the cosmic landscape and the balance of environmental equilibria, ranging from satellite deployments and space tourism to interplanetary projects and space junk multiplication. The phases in outer space missions-commencing from the manufacturing of the parts of the satellite, launch, during operational life and disposal stage have implications that are visible.

Large amounts of energy, resources from the Earth, and materials such as metals, composites, electronics, and propellants are needed in the production of space assets. Significant quantities of energy and non-renewable resources are used in the extraction, processing and shipping of space asset production and operations. This can result in the loss of ecological diversity and environmental damage, especially in regions with extensive mining and manufacturing activity.

The release of contaminants during rocket launches constitutes significantly prominent impact on the Earth due to space launch operations. Liquid oxygen and hydrogen are examples of propellant fuels that rocket engines burn to produce the thrust required to launch spacecraft into orbit. When these fuels burn, a number of pollutants are released into the atmosphere, such as particulate matter, water vapor, carbon dioxide (CO2), and nitrogen oxides (NOx) (Ryan et al., 2022). These emissions have a negative impact on the atmospheric composition and climate, and also having the potential to undermine the progress made by Montreal Protocol with respect to ozone depletion (Ryan et al., 2022).

Space activities have a direct impact on terrestrial ecosystems and wildlife habitats, especially in the proximity of the space launch locations, in addition to orbiting trash and rocket propellant emissions. Outer space station establishment and missions have the potential to damage nearby ecosystems, impede the migration of species, intensify the dispersion and depletion of habitat. The space tourism sector is expanding at a rapid rate, which poses the question of whether it is sustainable to launch several commercial satellites into orbit given the energy, resources and emissions involved in each mission.

The rise of space debris forms a blanket of retired satellites, discarded rocket stages, and spacecraft components that orbit Earth at speeds surpassing thousands of kilometers per hour is one of the most critical environmental issues resulting from space operations (Akers, 2011). This expanding debris field threatens to cause catastrophic collisions and cascading effects (Kessler syndrome) (Kessler & Cour-Palais, 1978) posing a serious risk to functioning satellites, spacecraft and possibly the International Space Station. The accumulation of space junk is nevertheless a recurring and growing environmental problem, even with worldwide attempts to manage it (Chen, 2011). Satellite dumping into the ocean may release toxins and dangerous elements that endanger marine life, ecological systems and the quality of water. Batteries, propellants, and

electrical systems are not only a few of the parts that make up a satellite; some of these parts can contain dangerous or poisonous materials that could leak into the ocean upon landing.

The purposeful or inadvertent return of defunct or deactivated satellites into Earth are dumped into high seas at the end of their operational life (von Rebay, 2022). The potential hazards involved with the dumping of space debris in marine ecosystems give rise to issues over the ecology, safety and regulations surrounding the practice (von Rebay, 2022). Satellite elements that don't biodegrade easily, such metal pieces, thermal insulation, and composite materials, can linger in marine environments for long periods of time. This can affect marine ecosystems and habitats and expose marine creatures to the risk of becoming engulfed.

In order to establish liability and accountability for a nation, international law, in general, mandates that the negative consequence must be a result of action or omission of the nation, provided it has jurisdiction or control over it. While this standard of proof might be easily demonstrated in the case of transboundary river pollution due to space operations, however, it is far more challenging to prove in the case of global greenhouse gas emissions, where the consequences are the result of numerous State and non-State actors acting cumulatively across numerous jurisdictions (Lewis, 2018).

When it comes to the development and use of space assets, especially constellations of satellites and ground-based space infrastructure, light pollution is also a major environmental problem (Yakushina, 2023). Light pollution is the exorbitant or misdirected artificial light caused by human activity that interferes with the natural light patterns and has an adverse effect on ecological systems and astronomical observations (Koller et al., 2020).

Despite the common misconception that space is a serene and undisturbed place, human activity and presence there might have unavoidable environmental effects that compromise the sustainability and integrity of celestial bodies (Schafer, 1988). During landing or surface operations which includes robotic devices, landers and humans – may unintentionally spread microbial organisms, compounds and terrestrial organisms to the surfaces of celestial bodies. This contamination, referred to as "forward contamination," which might pollute samples, obstruct astrobiological study, and make it more difficult to discover things and jeopardize the scientific integrity of extraterrestrial settings. The expansion of operations considering space mining raises concerns. Mining activities have the potential to disrupt celestial bodies' natural regolith, surface materials and geological formations. Outer space is indefinite and still unexplored by human beings, and the nature and reaction of activities are unpredictable, with few or no precedents. The phases of space missions, including the disposal of satellites have huge implications on systems existing on and beyond Earth.

Disproportionate Impact of Outer Space Operations

Space tourism, mining of resources, navigation, communication via satellite, Earth observation, and scientific research are just a few of the many operations that constitute the space sector. Despite outer space being common heritage of mankind, it is clear that there is an unequal distribution of resources and advantages among the various actors participating in space exploration, exploitation, and usage (Venkatesan et al., 2020). This phenomenon is a reflection of variations in the space industry's investment, involvement, and impact, which are frequently influenced by technological, geopolitical, and economic reasons. Geopolitical factors have an impact on the space sector; major spacefaring nations, like the United States, Russia, China, and the European Union, have a considerable effect on space policies, laws, and operations.

These nations frequently give national security concerns, scientific development, and strategic goals prominence in their space programs, which results in disparities in transfer of technology, accessibility to space resources, environmental concerns and global partnerships.

The space industry is substantially shaped with advancements in technology, which in turn encourage innovation in satellite systems, orbital infrastructure and the exploration of space (Vicas, 1980). However, proficient spacefaring countries and commercial space enterprises tend to have exclusive access to cutting-edge technology and professional expertise, which creates gaps in technological capability and competitiveness among various industry players. Smaller nations and beginners in the space industry may find it challenging to keep up with the swift improvements in technology and may encounter problems in obtaining and utilizing space technology to achieve economic and social growth. Additionally, this can lead to obstacles for entry and inadequate chances for significant participation in the global space economy for emerging space powers and underdeveloped nations.

The environmental cost of human operations outside Earth's atmosphere is still largely hidden and underestimated, while the glories of space entice us with prospects of discovery and advancement. In reality, the unexpected repercussions of our cosmic goals are brought to light by the disproportionate impacts of space operations. Globally, space faring nations somewhat achieved advance facilities of navigation, communication, remote sensing, among others. The impact of space operations is global; however, the benefits are limited to a few privileged.

The space industry's resource allocation is impacted by conflicting priorities, market demand and regulatory aspirations. Different segments of the space industry (communication, navigation, earth observation, research etc.) confront variations in resource allocation due to competing interests for capital funding, commitments, agreements and research opportunities provided by government space agencies, private space corporations, academic institutions, and international organizations (McDougal & Lipson, 1958) Furthermore, the allocation of resources and investment decisions for space projects are often influenced by political agendas, budgetary restrictions, commercial interests, international relations and changing policy objectives. This might exacerbate the differences in financing and support for space endeavours. Nations ailing for basic human rights such as water, food and shelter will not make budgetary commitments for space industry to flourish. Nevertheless, these nations are not aloof from the impact of excessive outer space activities.

Numerous advantages are provided by the space industry, such as novel scientific findings, technology developments, business prospects and collective benefits (Reinstein, 1999). However, various stakeholders often enjoy unequal access to these advantages. Certain industries, regions and communities benefit more than others. Developed nations with advanced space capabilities have the potential to derive higher economic rewards from commercial space endeavours, but poor nations are likely to experience difficulties in harnessing space technology for long-term growth (Wihlborg & Wijkman, 1981).

The excessive and ungoverned space operations by few concentrated stakeholders to fulfil their interests will jeopardize the interests of non-space faring nations and future generations. The mitigation strategies at this point can only curb the further deterioration of the space environment, but the space junk already created is a sign of future hinderance and compromise of inter-generational equity. In order to insure equitable access and utilization pf space resources, opportunities for all stakeholders collectively benefiting mankind should be a priority (Kostenko, 2023).

Climate change and Outer space: Legal and Policy Analysis

Integrating perspectives regarding impact evaluation, environmental sustainability and holistic thinking provide an insightful examination of the space industry, shedding light on its intricate relationships with the environment and orienting efforts toward environmentally sustainable endeavours in outer space.

International environmental jurisprudence comprises a broad spectrum of legal doctrines, agreements and court rulings intended to resolve environmental concerns on a global level. Over the past few decades, this area of law has seen tremendous transformation in in response to mounting environmental issues such as pollution, ecological disbalance, global warming and climate change. Customary law, international treaties and soft law instruments regulate the legal and policy regime concerning environment. To address particular environmental challenges, nations negotiated multilateral environmental accords. These treaties address a wide variety of issues, such as maritime pollution ('International Convention for the Prevention of Pollution from Ships'), biodiversity protection ('Convention on Biological Diversity'), and climate change (Schipper, 2006) ('The United Nations Framework Convention on Climate Change'). These treaties give participating nations legally commitments and offer a framework for coordination and collaboration in dealing with environmental concerns. However, these lack imposing any kind of obligation specifically to outer space activities.

The Convention on Climate Change (UNFCCC) and the subsequent protocols, namely the Kyoto Protocol (Kyoto Protocol, 1998) and the Paris Agreement, create broad guidelines for international climate action, defining goals for reducing emissions, encouraging collaboration among nations and streamlining procedures for providing funding and transferring technology to developing nations (Kuyper et al., 2018). The UNFCCC can be considered to have implications for space operations owing to potential environmental effects of space activities on Earth's climate system, even though its primary focus is on terrestrial sources of greenhouse gas emissions and related climate measures. Countries with active space programs may help mitigate climate change and promote sustainable space resource use in line with UNFCCC commitments by incorporating climate change concerns into space policy and planning. Apart from comprehensive treaties, environment protection is dealt specifically with respect to outer space operations in international instruments. The provisions seek to guarantee that space operations are carried out in a way that avoids damage to the environment and encourages the sustainable use of resources in space.

The fundamental agreement that regulates operations in space is the Outer Space Treaty, 1967. Article IX of the treaty requires nations carrying out operations in space to prevent detrimental pollution of ecosystems and celestial bodies (Taubenfeld, 1973). A broad idea of protecting the environment in space is reflected in this clause. The notion of absolute culpability for harm caused by space objects, irrespective of fault, is established by the Liability Convention, 1972 (Dennerley, 2018). Liability for environmental harm resulting from space objects, including satellite collisions or the re-entry of space trash, is included. The treaty places a strong emphasis on protecting the environment and making space-faring countries responsible for any harm on 'Earth's surface or aircraft in flight' due to their space operations (Art. II).

States are required under the Registration Convention, 1975 to register space objects that are launched and submit details regarding their orbital characteristics (von der Dunk, 2003). The treaty's main goal is to streamline space object monitoring and recognition easier, but it also indirectly aids environmental conservation by encouraging responsibility, accountability

and transparency in space operations. The Moon Agreement, 1979 encompasses measures to safeguard the environment as well as the usage and exploitation of lunar resources (Bini, 2008). The agreement in Art. VII emphasizes the significance of environmental preservation in space exploration on and beyond Earth while establishing guidelines for the sustainable development of the Moon and other celestial bodies.

International law encompasses not only legally binding treaties but also non-binding guidelines, declarations and principles that set standards and norms for nations and other relevant parties. Soft law instruments are complimentary in determining global governance and encouraging international collaboration. International efforts have been undertaken specifically to create standards and mitigating techniques to address the problem of space debris. To reduce the chance of accidents with debris, space agencies and satellite operators, for instance, use collision prevention techniques. In order to minimize the production of debris, programs like the Space Debris Mitigation Guidelines 2007 (Inter-Agency, 2002) published by the United Nations Office for Outer Space Affairs (UNOOSA) offer guidelines for spacecraft design, operation, and end-of-life disposal. The spread of space debris, however, continues to be a chronic and growing environmental problem that calls for constant attention and cooperative action from the international space community. Member states and respective entities ought to voluntarily take measures to guarantee that guidelines are followed through methods and debris mitigation techniques, using their own appropriate means. There are no legally enforceable regulations requiring any entity to adhere to debris minimization criteria (Rajapaksa & Wijerathna, 2017). Due to the multiplicity of varying standards by different organizations and member states based on UN treaty rules and principles, it has led to ambiguity in the space exploration community concerning debris mitigation (Rajapaksa & Wijerathna, 2017).

Since the precautionary principle has garnered sufficient international acceptance, at least since the 1990s, to be considered as legal principle or, more importantly, a customary norm of international law (Mcinerney-Lankford et al., 2011), it would appear logical to recognize its applicability to the current space debris crisis. Hence, it is asserted that, insofar as the legal obligation to reduce the creation of space debris is concerned, Outer Space Law is complete. While applying with the precautionary principle, Launching States are required to take economical steps to control the increasing amount of space debris produced in order to safeguard the environment beyond Earth (de O. Bittencourt Neto, 2013).

The idea that states have a shared obligation to protect and restore the environment is encapsulated in the common but differentiated responsibilities and respective capacities (CBDRC) principle (Brunnée & Streck, 2013). The scope and magnitude of each state's individual responsibility may vary depending on their unique national circumstances (Brunnée & Streck, 2013). This idea has influenced way the climate regime has developed and has been crucial in encouraging cooperation and compromise. Similarly, this can be extended to outer space industry and it will be relevant for years to come.

Conclusions

A thorough and perceptive analysis of the space business is provided by integrating viewpoints from impact assessment, sustainable development, and holistic perspectives. The intricate relationships that the space industry has with the environment, society and economy must be highlighted in governance. Together, all of these perspectives help to better comprehend the environmental possibilities and problems related to space operations. It will also help in

formulating the sustainable future directions for the space sector. The space industry is massive and requires governance to keep both public and private sectors in a positive line of action, considering the interests of all mankind.

A critical assessment needs to emphasize on how urgent it is to implement comprehensive strategies that prioritize fairness, justice, and meaningful engagement in order to successfully combat climate change and protect 'everyone's right to human rights.' In 2010, during the IAM's 30th session in Geneva, Switzerland, leaders from the participating organizations decided to release a special report detailing ways UN agencies employ space-based technology to combat climate change. The report provides an overview of several operations, such as data collecting and distribution, standard creation, research and output generation, in addition to Earth observations for mitigating climate disturbances. Space technology when used in appropriate manner can be effective instrument to fight climate change instead of being a contribute to negative environment implications. The sustainable use of space resources and the mitigation of climate change may both be aided among nations by the sharing of space technology and experience as well as cooperative efforts to create cleaner propulsion systems and reduce space trash.

In contrast to conventional rocket engines, nations must develop biofuels, reusable launch vehicles and electric propulsion systems that emit less emissions and contaminants. The environmental impact of space launches may also be reduced by taking steps like launching rockets from isolated or unpopulated places and putting emission reduction technology into practice.

The precautionary principle, the concept of common but differentiated responsibilities, and the principle of intergenerational equity are examples of international environmental law principles that serve as fundamental guidelines for interpreting and carrying out international climate change provisions. These guidelines place a strong emphasis on the necessity of considering preventative action in the face of scientific uncertainty, acknowledging past emissions differences between countries, and taking future generations into account when making climate-related decisions.

Numerous nations have implemented legislative and regulatory measures in their jurisdiction to tackle the issue of climate change. These regulations should establish goals for reducing emissions, encourage the growth of renewable energy sources, impose carbon pricing schemes and create guidelines for energy efficiency and greenhouse gas emissions from the space sector. Sustainable space practices aim to reduce the consumption of resources, minimize the environmental impact of space operations, and mitigate waste formation and pollution. The space industry could accelerate space exploration and technological progress while addressing worldwide efforts to resolve climate change, declining biodiversity, and other ecological issues by adopting sustainability norms. With paradigm shift in outer space industry from closed government-oriented operations to commercialisation, makes it need of an hour.

When assessing the possible effects that space missions, satellite launches and the development of space infrastructure may have on the environment and society, environmental impact assessments (EIAs) and social impact assessments (SIAs) are crucial instruments. The assessment of impact aids in identifying possible hazards, deficiencies and trade-offs related to space operations, such as pollution, habitat damage, uprooting indigenous groups, and socioeconomic disparities. Stakeholders may minimize the negative effects of space industry operations while maximizing the good effects by carrying out thorough impact studies that help drive choices and mitigation strategies. It is recommended that SIAs or EIAs, be carried out in order to examine the possible environmental consequences of planned space launch operations

and determine the most effective way to minimize any negative effects. Furthermore, measures like conservation and habitat restoration should be designed in order to lessen the negative effects that space station have on nearby ecosystems and wildlife habitats.

Establishment of specific liability frameworks and policy deliberations through international cooperation complimenting the current regime will be considerate step towards streaming procedures in the space industry. Also, nations should set up mechanism for commercial entities defining their liability for any negative climate repercussions due to their operation. Also, commercial space entities should be encouraged by providing them funds and incentives to develop sustainable propulsion technologies and supporting green infrastructure.

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Legal Nature of Remote Sensing of the Earth from Space

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To ensure the proper functioning of Ukraine as a space nation, one of the important factors is the development of domestic legal opinion and legislation on the outlined issue. And if the topic of the formation of space law in Ukraine appears to be more researched, then its direction, such as remote sensing of the Earth from space, requires a more detailed legal analysis and legislative regulation. Evidence of this is the draft Law of Ukraine "On State Regulation in the Field of Earth Remote Sensing," proposed in 2014, which has not yet been adopted, although its adoption is part of Ukraine's obligations under the Ukraine-EU Association Agreement. In such a case, the issue of researching the legal basis of remote sensing of the Earth from space becomes relevant, where the legal nature of this phenomenon is of primary importance.

In the course of the conducted scientific research, the following legal features of remote sensing of the Earth from space were proposed: 1) it is a type of information collection based on the method of observation, which is part of such a management function as monitoring; 2) it is the activity on special space systems or their separate elements operation, as well as the accumulation, processing, integration and distribution of relevant data about the Earth; 3) it is a set of space and informational means that are functionally and organizationally interconnected and ensure proper remote sensing of the Earth from space; 4) the main technical means of remote sensing of the Earth are: radars, lidars, laser altimeters, spectrometers, radiometers, accelerometers, rangefinders, echo sounders, scatter meters, etc.; 5) it is a set of legal relations, the object of which is information necessary for the development of many spheres of human activity: meteorology, ecology, nature management, seismology, prevention of emergency situations of natural and man-made origin, agroforestry improvement activities, in the field of security and defense of the country, etc. The subjects of such legal relations are defined as operators, primary subjects of service provision, secondary subjects of service provision, consumers, as well as a set of authorized controlling authorities. The reasons for the emergence of such legal relations, to which the author includes international and domestic normative acts dedicated to the legal regulation of remote sensing of the Earth, are also revealed; 6) it is a comprehensive institution of space law; 7) is an interdisciplinary science that combines scientific developments in the specifics of space meteorology, geodesy, geology, hydrology, oceanology, earth science, etc.

Based on the selected features, the author's definition of the concept of remote sensing of the Earth from space is formulated in the work.

Keywords: remote sensing of the Earth, legal signs, space law, institute of law, interdisciplinary science.

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Introduction

The technology of remote sensing of the Earth (hereinafter – RSE) has recently become widespread due to a number of factors: rapid development of international relations; deepening of knowledge about the environment and its individual components, as well as military conflicts in the world.

Remote sensing itself originated back in 1858, when the Earth was filmed from a parachute for the first time, and it was already widely used during the First World War in the form of aerial photography for reconnaissance. During the Second World War, the types of such sensing already included: radars, sonar and infrared enemy detection systems (The origin, 2022).

However, the actual scientific use of RSE began with the launch in 1972 of the first American artificial satellite under the Landsat program.

Since then, the Earth observation satellite market has developed rapidly. Today, more than two dozen countries of the world carry out RSE activities. According to BIS Research, the global market for Earth observation satellite data and services is expected to reach USD 15.90 bln in 2032 (Satellite, 2022).

Such events become the basis for a comprehensive analysis of this phenomenon within the framework of legal science.

The most researched issues in this area include, in particular, the issue of the international legal regime of activities related to RSE, compliance with the principles and norms of international law and the sovereign rights of states when carrying out such activities, historical, economic, and informational aspects of the development of RSE, as well as a comprehensive scientific study of the legal foundations RSE has not yet been conducted in domestic jurisprudence.

In this regard, the purpose of this study will be the legal nature of RSE as a fundamental component of the legal foundations of RSE.

Discussion

According to DSTU 4220-2003 "Remote sensing of the Earth from space. Terms and definitions of concepts" RSE should be understood as receiving data about the Earth from space using the properties of electromagnetic waves emitted, reflected, absorbed, or scattered by sounding objects.

At the same international level, RSE is considered as the observation and measurement of the energy and polarization characteristics of the own and reflected radiation of elements of the land, ocean and atmosphere of the Earth in various ranges of electromagnetic waves, which contribute to the determination of the location, description of the nature and variability of natural parameters and phenomena, the natural resources of the Earth, the environment, as well as anthropogenic objects and formations (Article 1 of the Convention on the Transfer and Use of Data of the Remote Sensing of the Earth from Outer Space dated 19/05/1978).

In the "Principles relating to remote sensing of the Earth from outer space," approved by UN General Assembly Resolution 41/65 dated 03/12/1986, RSE means sensing the Earth's surface

from space using the properties of electromagnetic waves emitted, reflected or scattered by probed objects, with the aim of better management of natural resources, improvement of land use and environmental protection (Principle I).

In the scientific literature, RSE is considered as a type of observation carried out from space using the properties of electromagnetic waves emitted or scattered by probed objects, with the aim of improving the management of natural resources, increasing the efficiency of land use and environmental protection (Malysheva, 2014).

The following questions arise: to which type of activity does the RSE belong, does it act as an independent legal phenomenon, and what is its place in the legal system of law?

In modern understanding, remote sensing of the Earth is considered through a set of measures aimed at obtaining information about any object or process without direct contact with it (Dovhyi et al., 2019), i.e., at a distance (Gibson, 2000).

Based on the given provision, the RSE is a type of information collection.

A feature of RSE that distinguishes it from other types of information collection is that it is conducted by using the method of observation from space, with the automatic satellites or from aboard spacecraft and manned orbital stations for various components of the Earth's environment.

The method of observation serves as the basis of such a legal means of gathering information as monitoring, which is a system of constant observation of phenomena and processes that occur in the environment, society for the purpose of their assessment, control and forecasting, the results of which serve to justify management decisions to ensure security people and objects/subjects, and which can be carried out with the help of electronic and other technical means from land, sea and space stations (Shemshuchenko, 2001).

According to the Preamble of UN General Assembly Resolution 41/65 dated 03/12/1986, its principles relate to the monitoring of the entire surface of the Earth, and therefore may include various types and directions of such monitoring, in particular: ecological (On the approval, 1998); emergency situations (Civil, 2012); fishing vessels (On the creation, 2004); military (On the implementation, 2023) etc.

Hence, RSE from space in its general form is the observation of the Earth, carried out from the most advantageous positions in outer space using the properties of electromagnetic waves that are emitted, reflected or scattered by probed objects (Malysheva, 2014).

Cameras placed on automatic RSE satellites and on board spacecraft and orbital space stations receive high-resolution images of the Earth's surface, the World Ocean, and the Earth's atmosphere. Herewith, energy, polarization and other physical characteristics of own, reflected and scattered radiation of observation objects are measured and fixed (Malysheva, 2019).

Considering the fact that the use of special devices for observation is the basis of the RSE, it can also be treated as the activity of operating the RSE systems or its individual elements, as well as the accumulation, processing, integration and distribution of relevant data, where the RSE system should be understood as a set of space and ground technical and informational means, which are functionally and organizationally interconnected and provide RSE. That is, it is a set of activities that help characterize the nature and/or conditions of phenomena on, above, or below the Earth's surface using observations and measurements from space platforms.

According to Principle I of the UN General Assembly Resolution 41/65 dated 03/12/1986, the "RSE activity" is the operation of space remote sensing systems for the processing, interpretation and distribution of the processed data.

Currently, such measures depend on the emission and reflection of electromagnetic radiation from the surface of the object being studied (In Search, 2024).

Depending on the source of the signal, there are two types of RSE – active and passive (Kohut, 2023).

A feature of the active RSE of the Earth's surface is that the sensors of the devices direct the signal and only after that analyse its intensity. They fully function regardless of the time of day. The following devices are used for this type of RSE:

- radar – a device employing the radar signals to measure the range, with the help of which the distance to the object under study is determined due to their reflection through the emission of radio waves;
- lidar – a device determining the distance to the object under study using light pulses and measuring the intensity of the returned signal, calculated by multiplying the required time by the speed of light;
- laser altimeter – a device that measures height using a lidar;
- range finders – a device that determines the distance using one or two identical devices on different platforms that transmit signals to each other;
- echo sounder – a device that studies weather conditions vertically by emitting pulses;
- scatterometer (reflectometer) – a device used to analyse returned (scattered) radiation.

This type of RSE is actively used in agriculture and forestry, during search and rescue operations, weather forecasting, etc.

In turn, passive RSE devices do not have their own source of energy, which would be directed to the research object or the Earth's surface, so their effectiveness is completely dependent on sunlight.

Such instruments include multi-spectral or hyper-spectral sensors that measure signal intensity using combinations of visible, near, thermal infra-red, and microwave channels.

These include a spectrometer, radiometer, spectroradiometer, hyperspectral radiometer, echo sounder and accelerometer.

One of the most widespread examples of passive RSE is recognized by the Landsat Program, with the help of which for more than 40 years satellites have been collecting and recording data about the planet that are in the public domain and include information that can be used in various industries: geology, cartography, ecology, forestry and agriculture, oceanology, meteorology, etc. (Ridwan et al., 2018).

RSE is widely used in the military sphere as well. Today, the RSE, in particular, allows monitoring of compliance with international agreements on the limitation of strategic weapons, solving other tasks of defence and security of states.

All data received by the satellite are instantly transmitted to receiving ground stations and can be accumulated for further transmission. Such receiving ground stations are located in different places and on different continents.

The information itself, which is obtained as a result of RSE, is defined as "digital files" containing data based on the geographical characteristics of the area.

Such information is processed in various ways, for example, receiving data; preliminary processing; data storage; distribution; analysis of information and use. In the first four cases, the initial stage with the participation of satellites that collect and then transmit information using telemetry, photographs or magnetic recording is discussed. In others, it is about the processing and analysis of received information by special subjects (Report, 1996).

Such subjects of RSE include operators (providers of satellite data), primary subjects of service provision (those that convert satellite data into various types of images), secondary subjects of service provision (those that receive information from primary subjects and make it according to the needs of end users), as well as consumers of RSE information (Malysheva & Hurova, 2020).

The activities of such subjects of space exploration are controlled by specially authorized authorities, represented at the international level by the United Nations Committee on the Peaceful Uses of Outer Space (International, 1959), and at the state level by the State Space Agency of Ukraine (On the approval, 2015).

The experience of advanced countries of the world shows that the use of data received from the RSE is mainly regulated by their domestic legislation.

An example of a special remote sensing management regime is the Canadian Remote Sensing Space Systems Act (2005). The legislation covers space-based remote sensing activities using one or more remote sensing satellites and their operational and data transmission facilities. Compared to the International Principles of Remote Sensing, this regulatory system applies to satellites operating both outside and under Canadian jurisdiction. This mode is aimed at protecting the final data for the creation of which remote sensing was carried out. Although this is an excellent regime for promoting commercial participation in remote sensing, it is somewhat inconsistent with the principles of international cooperation and open data sharing (Smith & Doldirina, 2017).

In turn, the US Land Remote-Sensing Commercialization Act (1984) establishes a closer reflection of these principles, "requiring private remote sensing operators to provide data to all potential users on the same terms."

The German Satellitendatensicherheitsgesetz (en. Satellite Data Security Act) (2007) (SatDSiG) defines general requirements and regulations for satellite operators and data providers in the primary interests of national security as well as commercial security for sensing data. This structure facilitates large-scale commercial activity. Compared to the United States system, which aims for the "public good" when it comes to the dissemination of data in the national legal system, the German system is more focused on the protection of confidential data, regardless of its public or private funding (Schmidt-Tedd & Kroymann, 2008).

Consequently, the compared systems demonstrate the lack of a uniform international framework for managing information derived from RSE, which creates obstacles to the effective commercial use of data and adversely affects the reliability and authenticity of data for other purposes, such as evidence in court, climate change monitoring and timely response to disasters.

As noted in foreign literature, national regimes often do not exist to promote the goals of international principles, but rather focus on promoting national interests and protecting states from liability (Lee, 2020).

Despite the lack of a unified approach to the use of data obtained through RSE, it can be concluded that RSE is also a set of legal relationships that have a clearly defined purpose, subjects and objects.

The legal basis for the emergence of legal relations with space exploration at the international level is the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 1967, according to which all space activities are carried out for the good and in the interests of all countries, regardless of their level of economic or scientific development. Space activity is carried out by all states without any discrimination, on the basis of equality, with free access to all areas of the celestial bodies.

The member states of this Treaty may carry out such activities according to international law, including with the UN Charter. It is states that bear international responsibility for all activities in outer space, including RSE, regardless of whether it is carried out by governmental or non-governmental legal entities. However, the 1979 Convention on the Transfer and Use of Data of the Remote Sensing of the Earth from Outer Space and the "Principles Relating to Remote Sensing of the Earth from Outer Space" approved by UN General Assembly Resolution 41/65 dated 03/12/1986 are recognized as special acts related to satellite remote sensing.

In Ukraine, there is still no special legal act that would regulate the field of remote sensing of the Earth. As a separate coordination and control authority of a specially authorized central authority in the field of space activity, the RSE is defined in the Law of Ukraine "On Space Activity." The Law of Ukraine "On the National Infrastructure of Geospatial Data" dated April 13, 2020 defines the procedure for the creation, functioning and development of geospatial data, which are collected, including, with the help of RSE.

The draft Law of Ukraine "On State Regulation in the Field of Remote Sensing of the Earth" was approved by Decree of the Cabinet of Ministers of Ukraine No. 657-r dated 28/08/2013, but it has not been approved by the Parliament to this day. In 2021, the Government of Ukraine planned to give impetus to the development of domestic space activities by approving the Concept of the National Targeted Space Program of Ukraine for 2021-2025, however, due to the full-scale invasion of the Russian Federation on the territory of Ukraine, the implementation of this Concept is delayed. In this regard, the current regulations in the field of RSE on the territory of Ukraine are, in particular: DSTU 4220-2003 "Remote sensing of the Earth from space. Terms and definitions of concepts," DSTU 4758-2007 "Remote sensing of the Earth from space. Data processing. Terms and definitions of concepts," as well as DSTU 7894-2015 "Remote sensing of the Earth from space. Methodology of data processing. Procedure for development."

According to the provisions of the UN General Assembly Resolution 41/65 dated 03/12/1986, activities related to environmental protection should be carried out in several areas – management of natural resources; improvement of land use; environmental protection, as well as to promote: protection of the Earth's natural environment and protection of humanity from natural disasters (Principle X and Principle XI). However, today this activity is not limited only to these areas, but also includes applications in the field of meteorology, geodesy, geology, hydrology, oceanology, earth science and other areas, which gave an impetus to the development of such scientific areas as: space meteorology, space geodesy, space hydrology, space oceanology, space geology, etc. (Zabara, 2018).

Therefore, remote sensing can be considered as an interdisciplinary science, which contains a set of certain scientific knowledge, concepts, ideas about the features of remote sensing in various spheres of public needs.

Within the legal field, RSE is another type of space activity, which is regulated by international "soft law" instruments, as well as some national instruments, in connection with which legal relations regarding RSE constitute a comprehensive institution of space law (Hurova, 2022; Curriculum, 2011).

Conclusion

Having analysed the above, we can draw a general conclusion that remote sensing of the Earth from space is an institution of space law, which consists of a set of legal norms that regulate social relations related to the use of special technologies on space vehicles, with the

help of which observation and collection of information from space about social, ecological and man-made phenomena and processes on Earth in order to substantiate management decisions to ensure international and national security.

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Space and National Security: Points of Interaction, Opportunities and Issue of Priority

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The article reveals the importance of space for national security. The points of interaction between space activities and national security are identified, which reflect the growing importance of outer space for ensuring the security of States and emergency management, the growth of international cooperation in the field of space technologies. The newest possibilities of space to ensure national security (warning and military intelligence systems; communication systems and means of coordination; systems of space monitoring of the environment and resource management; systems of border and maritime surveillance; development of other technologies; development of global cooperation) are revealed. The problems of ensuring the priority of national security in the use of space resources have been formed, with the formation of a global strategy that geopolitical stability and prevention of the militarization of space should become key aspects for ensuring the national security of any State.

Keywords: military intelligence, geopolitical stability, state, space resources, space technology, space, international cooperation, national security, surveillance, satellites.

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Introduction

The modern world is characterized by the dynamic development of technologies and scientific research, among which the space industry occupies one of the leading places. Space is becoming an increasingly important factor affecting the national security of States, creating new opportunities and challenges. The interaction of space technologies with national security determines the need for an integrated approach to the study of this topic, taking into account both technical aspects and legal, administrative and geopolitical issues.

Above all, space technology plays a key role in ensuring national security through the development of satellite communication, navigation and surveillance systems. Satellite communication systems provide stable and uninterrupted transmission of information, which is critically important for military and civilian structures during crisis situations. Navigational satellites, such as GPS, provide the ability to accurately determine location, which is essential for both military operations and the operation of critical infrastructure. Satellite observation allows monitoring of the earth's surface, which is important for reconnaissance, emergency forecasting and environmental monitoring.

Space is increasingly recognized as a critical area for national security and global stability. Thus, failure to adopt space technologies poses significant risks, from strategic disadvantage and global isolation to increased vulnerability and economic stagnation. In addressing these challenges, countries must balance the development of local capacity with active participation in international space cooperation and governance. The future of national security is inextricably linked to space, and only by recognizing and acting on the imperative of space technology can countries ensure their security, prosperity and place in the international community (Staveris-Polykalas, 2024).

However, along with opportunities, space technologies also create new threats to national security. Spacecraft can become the target of attacks, which can lead to misinformation or disruption of critical infrastructure. In addition, space activity is becoming an arena of geopolitical competition, which requires the development of new approaches to international cooperation and legal regulation.

In this context, it is important to study the priority of the development of space technologies within the framework of the national security strategy. This includes examining issues of funding, legislative support and international cooperation. It is necessary to determine the optimal ways of integrating space programs into the general system of national security, taking into account both internal opportunities and external challenges.

Thus, the study of the interaction of space and national security is an extremely relevant and multifaceted task that requires an integrated approach and includes technical, legal, administrative and geopolitical aspects. This will not only ensure reliable protection of national interests, but will also contribute to the development of international cooperation and sustainable development of space activities.

The importance of space for national security

Security has been humanity's top priority throughout history, and national security is still a major concern for modern nations. In the past, security mainly meant protecting nations from

military attacks. As a rule, wars were fought between regular armies, but in the 21st century it became clear that not only regular armies could be a threat, but also disorganized, unpredictable, uncontrollable criminals (Özyildirim, 2023).

Threats can be classified as man-made and natural hazards, intentional or unintentional. Unexpected threats always arise for countries. Therefore, countries should continue to monitor not only the borders, but also be prepared for possible threats coming from within the country. In this context, security issues seem to be most relevant to the air, land and sea domains, but continuous surveillance from space brings benefits and complements other domains (Özyildirim, 2023).

Historically, national security has meant protection against external military threats, particularly attacks by regular armies. Modern threats can come not only from state armies, but also from irregular private military formations or criminal groups that can operate within countries. In addition to the above, security challenges include not only traditional military threats, but also man-made and natural disasters, which can be both intentional and accidental. Because of this, States must be prepared for such threats that may arise from outside, as well as from within the country. Thus, effective monitoring and control of internal and external threats become critically important.

One of the most important aspects of modern security is the integration of surveillance technologies. Traditionally, countries have focused on security in the air, land and sea spheres. However, in modern conditions, the importance of space technologies is growing. Continuous surveillance from space provides an opportunity to receive detailed and timely information about potential threats, which significantly complements traditional methods of ensuring national security.

A new space ecosystem is emerging, which has serious implications for global security and economic development. The speed at which commercial space companies are launching thousands and soon tens of thousands of satellites into orbit creates unique challenges for space security as well as military deployments. Also, according to experts, congestion in certain orbits is increasing, competition for communication bandwidth is increasing, new types of space operations are appearing, all this leads to a change in the paradigm of threats. Competition in this changing environment will require States to make significant changes in the processes of creating or acquiring modern means to strengthen their defense capabilities, adopted investment strategies, as well as in the regulatory environment of commercial space (Eftimiades, 2022).

Space technologies help countries control their borders both on land and at sea, monitor the environment, and respond in a timely manner to various crisis situations. Space-based vehicles with Earth monitoring services provide critical information for early warning, response and mitigation actions (Özyildirim, 2023). Therefore, it can be argued that countries that do not develop their own space capabilities often find themselves dependent on other countries or commercial organizations. This dependence can jeopardize national sovereignty, as access to data and services can be limited by the geopolitical interests of the provider. In addition, such trust exposes countries to the risk of espionage and manipulation, as control over the flow and integrity of information remains with an external organization (Özyildirim, 2024).

Neglecting space technologies not only affects military and strategic potential, but also hinders economic and technological development. The space industry drives innovation in many sectors, including telecommunications, navigation and Earth observation, making a significant contribution to the national economy. Failure to invest in space technology means missing out on the benefits of this fast-growing sector, including job creation, technological advancement and economic diversification (Özyildirim, 2024).

Therefore, space plays an extremely important role in ensuring national security, integrating technological achievements and strategic capabilities of the State in the modern world. One of the key aspects is the ability of the space infrastructure to provide surveillance of borders and maritime spaces. This is critical for preventing external threats and detecting illegal activities such as smuggling or illegal border crossing. Thanks to modern satellite technologies, states can quickly monitor the movements of potentially dangerous objects and respond to any challenges related to national security.

Satellite environmental monitoring systems also play an important role in rapid response to emergency situations. For example, during natural disasters such as earthquakes, hurricanes or floods, satellites provide operational information that helps organize effective rescue operations and humanitarian aid. This allows to reduce the loss of human lives and material damage, which ultimately strengthens national security and the state's resilience to emergency situations. In this regard, there is a need to manage outer space and ensure its safety against possible threats, such as the collision of satellites or intentional interference with their work.

Space technology is also an important driver of economic and technological development, which has a direct impact on national security. Innovations in the field of telecommunications, navigation and Earth observation contribute to the development of the economy and the creation of new jobs. The lack of investment in space technologies can lead to the loss of competitive advantages and a decrease in the state's technological potential. Thus, the development of space capabilities is an important component of the strategy of ensuring national security and sustainable development of the state.

Points of interaction between space activities and national security

The use of space technology for intelligence gathering and surveillance dates back to the Cold War era. The space race between the United States and the Soviet Union led to the development of satellite technology. That made it possible to monitor military activity and the early warning system. Since then, the development of satellite and sensor technologies has made the collection of space information and observation increasingly efficient. And one of the interesting things is that these technologies are designed for military use. But over time, they become available to the general public (Singh, 2023).

In the 21st century, as the concepts of threat and security change with the development of technology, the use of integrated space communication/navigation/surveillance technology and infrastructure is becoming more common for forecasting and early detection of emergencies and public warning. As expected, thanks to communication technologies such as 5G, the world is becoming more connected (Özyildirim, 2023). Therefore, countries should continue to improve their domestic space potential and international cooperation. States should soon be ready to agree on a common security and defense policy to deal with new threats to space security. All countries must agree on the peaceful uses of outer space and must develop a common approach to fill existing gaps in international agreements (Soroka, 2023). Specific links between space, security and defense are vital to the security of nations. Undoubtedly, space technology will continue to provide enormous opportunities to combat security threats on a large scale (Özyildirim, 2023).

International norms and agreements remain the main instrument for regulating space activities, which play a crucial role in ensuring that space remains a safe and sustainable environment for all. By engaging in diplomatic efforts to promote responsible behavior in space,

countries can contribute to global stability and security even as they work to develop their own space capabilities (Staveris-Polykalas, 2024).

Therefore, the interaction between space activities and national security is characterised by a number of trends that reflect the growing importance of outer space for ensuring the security of States. The trend toward integration of space technologies with other security systems is one key feature of the interaction between space activities and national security. In particular, the combination of satellite communication systems with terrestrial networks, such as 5G, allows creating reliable and high-speed data transmission channels. This ensures effective communication and coordination during emergencies and military operations. Integration also applies to navigation systems used not only for military purposes but also for civilian applications such as aviation and navigation. The innovativeness and high technological level of space systems should be highlighted separately. Modern satellites are equipped with advanced sensors and instruments that allow obtaining detailed images and data in real-time. This is crucial for gathering intelligence, monitoring military facilities, and predicting potential threats. The use of high-precision satellite images allows detecting even minor changes on the earth's surface, which facilitates timely response to potential threats. In general, space technologies have become an integral part of modern security systems, providing wide opportunities for monitoring, communication, navigation and forecasting.

Also, an important point of interaction between space activities and national security is the growth of international cooperation in the field of space technologies. States realize that effective use of space is possible only with joint efforts and concerted actions. International cooperation also promotes the exchange of technology and knowledge, which allows countries to increase their space potential and ensure national security at the highest level.

Another important trend is the expansion of space technologies for forecasting and emergency management. Weather satellites, equipped with modern sensors, make it possible to accurately predict weather conditions and natural disasters such as hurricanes, floods, or earthquakes. This makes it possible to warn the population in advance and take measures to minimize losses. Satellite monitoring also helps detect and quickly respond to fires, leaks of hazardous substances and other emergency events.

After all, space technologies contribute to increasing the level of global security and stability. Thanks to advanced data collection and monitoring technologies, states have the opportunity to detect and respond to threats in time, ensuring the protection of their citizens and territories. The integration of space systems with other security systems and international cooperation makes it possible to create a more reliable and effective defense system that meets modern challenges and threats. Thus, space technologies play a critical role in ensuring national and global security.

Opportunities of space to ensure national security

In an era where the last frontier has become the next frontier in global military dynamics, the strategic importance of space technology for national security and defense cannot be overstated. As countries increasingly rely on space to enhance their military and strategic capabilities, those who do not know how to use space technology face multifaceted dangers (Staveris-Polykalas, 2024).

Space-based capabilities such as satellite communications, intelligence, and warning systems offer unparalleled advantages in terms of information dominance, situational awareness, and global reach. Without these capabilities, countries are not only blind to the actions of potential

adversaries, but also to the dynamics of global crises that may affect national security. As alliances and partnerships increasingly depend on shared space capabilities and data, countries lacking space technology find themselves excluded from critical security coalitions. This isolation undermines their ability to influence international security policies and participate in collective defense mechanisms, making them vulnerable to external threats (Staveris-Polykalas, 2024).

When it comes to real-time defense decision-making, space intelligence is a tool that stands out, allowing decision-makers to see, understand and anticipate changes as they happen. Global trends underscore the need for rapid intelligence and swift action, as regional conflicts become global threats, timely situational awareness is critical. Therefore, Governments are increasing spending on intelligence, surveillance and reconnaissance (ISR) assets for activities within and beyond their borders (Space-based, 2024). Military and strategic intelligence are two of the most important uses of space assets for intelligence gathering and surveillance. Satellites and sensors can track military activity, such as troop movements and missile launches, providing critical information for military operations. Early warning systems can also be configured to detect missile launches and warn countries of future attacks. And at best we can intercept these missiles in the sky so they do not harm any person or structure (Singh, 2023)

It should be noted that satellites have become the main space resource used not only for intelligence gathering and surveillance, but also for obtaining various monitoring data and images of the Earth (Singh, 2023). Indeed, satellites have become an integral part of society around the world: from telecommunications to global navigation systems, they are used for both commercial and scientific purposes. However, satellites also have non-peaceful uses. Since the Cold War, military satellites have been used to provide secure communication links, for the maneuverability and coordination of military forces (i.e., the Global Positioning System (GPS)), and even for missile targeting. However, there is another use of satellites that is not directly related to military operations: the so-called ISR (Intelligence, Surveillance, Reconnaissance) (Danilo, 2023).

But it should be noted that Earth observation satellites are capable of tracking the movement of troops and equipment, space radars are used to track aircraft and sea vessels, for example, US satellites to study the sources of X-ray radiation and solar activity, such as the SOLRAD (Solar Radiation) series are capable of intercepting radio waves. Scientific and commercial satellites can sell their services to the military, thus providing them with data without being under direct military control (Danilo, 2023).

In all these applications, satellites indirectly become instruments of war. However, they are not used as military platforms, as this would be a violation of the current international consensus against the militarization of outer space. Although the provisions of the 1967 Outer Space Treaty, which expressly prohibit the deployment of weapons of mass destruction and the construction of military facilities, do not provide for the use of satellites as "indirect" instruments of war. Therefore, any attempt to regulate their use in military operations must take into account the dual nature of satellite data (Danilo, 2023; Treaty, 1966).

As such, space systems provide the most up-to-date information on current events, troop movements and evolving scenarios, and play a key role in improving situational awareness and strategic decision-making in a wide range of applications. This real-time awareness transforms the reactive process into a proactive, anticipatory one, providing an unprecedented advantage in the face of dynamic threats (Space-based, 2024).

As it is already clear from the above, space technologies can be used to collect intelligence information and surveillance in the military sphere without violating space legislation, namely by carrying out:

- Monitoring of the environment and natural resources;
- Border and maritime surveillance (Singh, 2023).

In addition, it should be noted that the rockets used to launch a satellite into space may also carry a nuclear warhead or other offensive military device. To prevent the proliferation of this technology, an attempt to create international regulation for missiles was implemented through the Missile Technology Control Regime (MTCR), proposed by the G7 in 1987. However, it has a significant limitation that is important to note in order to understand how difficult it would be to implement such a solution for satellites. RKRT is not legally binding and is not a contract. It's actually an informal agreement that could be useful in persuading countries that don't have space launch capabilities, rather than avoiding countries that build rockets for military purposes, to sell them. Compliance with the RKRT depends on the State (Danilo, 2023).

Since it will be impossible to prevent a state that has space launch vehicles and satellites from using them without its approval, the best solution is to work on two levels. If a state wants to "blind" its adversary, it will target its satellites. Anti-satellite weapons will affect other satellites of States that are not parties to the conflict. Thus, a first step could be to create "soft law" and principles that would make it unacceptable to destroy satellites because of the potential collateral damage caused by space debris. If this principle is accepted, it will be easier to gradually extend satellite protection to other forms of non-kinetic attacks (Danilo, 2023).

Therefore, space provides unique opportunities for ensuring national security, which makes it a strategically important area for any country. The use of space technologies allows countries not only to improve their defence capabilities, but also to respond more effectively to modern threats.

Among the main capabilities of space to ensure national security and defence, the following can be distinguished:

1. Warning and military intelligence systems. Satellites play a key role in early warning systems that are capable of detecting missile launches, troop movements, and other potential threats. This allows military forces to respond to threats in a timely manner and make informed decisions, which significantly increases the effectiveness of defence operations.
2. Communication systems and means of coordination. Space technologies provide reliable and secure communication between various military units, which is critical for the coordination of military operations. Communication satellites allow data to be transmitted in real-time, which significantly improves the maneuverability and efficiency of military operations. In addition, global navigation systems such as GPS provide precise positioning and routing, which is indispensable for military logistics and operational planning.
3. Space-based environmental monitoring and resource management systems can provide important information about climate change, natural disasters, and other natural phenomena. This allows us to provide protection against natural disasters and manage natural resources such as water and minerals more efficiently. Timely information about weather conditions is also important for planning operations, as it allows you to avoid adverse conditions and reduce risks.
4. Border and maritime surveillance systems provide law enforcement agencies with the opportunity to respond to violations in a timely manner and increase the security of the country. Satellites can also provide continuous surveillance of strategically important sea lanes, which is critical for ensuring economic security and stability.

5. The use of space technologies promotes the development of scientific research and innovation, which positively impacts national security.
6. The development of global cooperation can significantly increase the efficiency of the use of space resources. Joint programs and data sharing between countries allow for the creation of global surveillance and response systems that contribute to global security.

Thus, space provides unprecedented opportunities for national security, combining technological innovation, international cooperation and strategic advantages that can significantly increase the defence capability and stability of any country.

The issue of priority of national security in the use of space resources

Despite the advantages of space-based intelligence gathering and surveillance, there are several challenges and risks. Dependence on space assets is a significant risk because countries rely on these assets to obtain critical information. Space debris and collisions can also pose a risk as the amount of space debris in orbit continues to increase. Finally, geopolitical tensions and the militarization of space are growing concerns as countries seek to gain an edge in space technology (Singh, 2023).

As private actors become increasingly relevant to space activities, it would be useful to prevent satellite firms and operators from sharing data with states that might use it in a way that violates the UN charter. For this, it is possible to proceed from the existing consensus regarding the criminal liability of persons involved in the commission of international crimes. Private space companies should avoid doing business with states that may use satellite data for war crimes or other violations of humanitarian law. The sooner a consensus is reached on the use of satellites for non-peaceful purposes, the better it will be for all countries and for peaceful activities in space (Danilo, 2023).

Cyber security threats are another concern as space systems can be vulnerable to hacking and cyber attacks (Singh, 2023). Thanks to modern digital technologies, worldwide communication and information networks have fundamentally changed the models of international trade, finance and global communication in general. These patterns affect not only economic relations, but also political and social relations. Because of the interdependencies created by these new models, even authoritarian regimes cannot sustain the closed autarkic economies of the past (Derek, 2012: 3).

In its short history, individuals and companies have used space and cyberspace to create new industries, a vibrant social space, and a new realm of economics that are intertwined with our daily lives. At the same time, individuals, subnational groups, and governments use cyberspace to advance interests through malicious activities. Terrorist groups recruit, train and target over the Internet, organized crime enterprises use financial data to generate profits that exceed drug trafficking, and intelligence agencies steal secrets. Today, people tend to pose the greatest threat in cyberspace, but non-State actors, intelligence agencies, and the military are increasingly penetrating information technology networks for espionage and influence. This is likely to continue in the future as governments seek new ways and means to protect their interests in cyberspace and develop their own offensive capabilities to compete in cyberspace (Derek, 2012: 3).

In general, in our opinion, the priority of national security in the use of space resources is a conditional concept that forms a strategic approach to ensuring state stability and protecting national interests through the effective management of space activities, as well as the development

of own space programs and international cooperation to prevent the militarization of space and support of geopolitical stability.

Each state forms its own terms of national security priority when using space resources. However, in this area, it is important to maintain a balance, on the one hand, security is the greatest value of the state, therefore, any state seeks to protect itself, regardless of threats. This happens, and theoretically, it can happen when using space resources. That is, the state puts its own interests first if it is concerned with issues of its own security. Such activity, in the sphere of the use of space resources, can protect the state and, at the same time, create inevitable consequences for the planet. Accordingly, geopolitical stability and prevention of the militarization of space should become key aspects for ensuring the national security of any state. In the context of geopolitical competition, space resources are becoming important, and the use of space for military purposes can lead to increased tensions between states. It is necessary to develop international law and agreements aimed at preventing the militarization of space, including measures to prohibit the placement of weapons in space and establish mechanisms to control the use of space resources.

Conclusions

Space technologies play a critical role in ensuring national security, providing unique capabilities for monitoring, intelligence and prompt response to threats. Thanks to satellite systems, states can effectively control their borders, monitor maritime spaces and detect illegal activities, which provides an additional level of protection against external threats and strengthens the country's security infrastructure.

However, along with opportunities, space technology creates new threats, including the possibility of cyberattacks and attacks on spacecraft, which can lead to disinformation and disruption of critical infrastructure. Growing geopolitical competition in outer space requires the development of new approaches to international cooperation and global legal regulation.

Accordingly, the development of space technologies affects the models that ensure the national security of each country. To ensure national security when using space resources, a comprehensive approach is required, which includes proper and legal intelligence, cyber security, preventing the militarization of space, and development of national space programs. Currently, it is important to form a global approach to the conditional priority of national security of each state, which, first of all, should be built on the principles of geopolitical stability and prevention of the militarization of space.

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