Interplay of the Public and Private Sectors in the Development of Outer Space in Ukraine: Strengths and Weaknesses

Iaroslav Teleshun

Ph.D. in Political Science, Associate Professor,
Taras Shevchenko National University of Kyiv (Kyiv, Ukraine)
E-mail: teleshun.iaroslav@knu.ua
https://orcid.org/0000-0001-8059-8791

Oleg Batrymenko

Doctor of Political Sciences, Professor,
Taras Shevchenko National University of Kyiv (Kyiv, Ukraine)
E-mail: batrymenko@knu.ua
https://orcid.org/0000-0003-0211-248X

Teleshun, Iaroslav and Oleg Batrymenko (2024) Interplay of the Public and Private Sectors in the Development of Outer Space in Ukraine: Strengths and Weaknesses. *Philosophy and Cosmology*, Volume 33, 147-161. https://doi.org/10.29202/phil-cosm/33/6

The article presents the results of a study of the interaction peculiarities between the public and private sectors in the field of space exploration in Ukraine. The purpose of the study was to identify five key weaknesses and strengths of the Ukrainian space industry, which are a catalyst or inhibitor of further successful development of the industry. It is established that Ukraine has taken several necessary steps to implement a system of relations between the private and public sectors in space exploration. The authors identify five key weaknesses and strengths in the development of the Ukrainian space industry: 1) Russia's war against Ukraine; 2) lack of a systemic vision for the development of Ukraine's space industry; 3) legal unregulated interaction between the public and private sectors in space exploration; 4) the unviability of the existing model of stakeholder interaction in space exploration; 5) vested interests and the functioning of financial-political groups. It was noted that, in addition to significant shortcomings, Ukraine's domestic space industry has a few advantages. And as is often the case, strengths stem from weaknesses: 1) availability of qualified personnel; 2) existence of national space legislation; 3) investment attractiveness of the Ukrainian market; 4) Russia's war against Ukraine; 5) space brand of Ukraine. It is substantiated that understanding the strengths and weaknesses on the way to implementing an effective model of relations in the triangle "state – business – academic environment" is a prerequisite for reviving Ukraine's space potential and strengthening its competitiveness on the world scene.

Keywords: space economy, space industry, space activities, space policy, public and private sector, business, public authorities, commercialization of space, Space industry of Ukraine, vested interest, weaknesses and strengths of Ukraine space industry

Received: 3 June 2024 / Accepted: 28 June 2024 / Published: 1 October 2024

Introduction

In the 15-17th centuries, humanity dreamed of discovering new unexplored corners of the world: in Africa, America, Asia and Oceania. At the turn of the 20-21st centuries, this aspiration remained unchanged, but the object of knowledge changed. On 4 October 1957, the launch of the first artificial Earth satellite, Sputnik 1, marked the beginning of a new era of humanity – the era of the Great Space Discoveries.

Today, outer space and the benefits that mankind owes to space exploration are closer to humans than ever before. Satellite Internet, television and radio communications, navigation systems, digital photography, infrared thermometers, insulin pumps, air purification systems and basic weather forecasts are all the results of space research and an integral part of everyday life. As the English astrophysicist F. Hoyle aptly emphasised in the late 1970s: "Space is not remote at all. It's only an hour's drive away if your car could go straight upwards" (Ratcliffe, 2018).

Just as in the Age of Discovery, space exploration cannot be carried out by a single actor and requires effective interaction between all stakeholders to achieve the desired result. However, while in the Modern era, the key stakeholders in expanding living space were powerful centralised European states, the Catholic Church and the petty nobility, today they are national governments acting in close cooperation with the private sector and the academic community. According to The Guardian's Top 10 Science Stories of the Year – chosen by scientists, space discoveries have consistently been shortlisted as the greatest scientific achievements of the past five years (Guardian, 2019-2023). The private sector is no less interested in space exploration. Today, the space industry is one of the most promising sectors of the economy. According to the American multinational investment bank Morgan Stanley, in 2020, the capitalisation of the space industry reached $350 billion. By the end of this year, the industry's revenue may cross the $1 trillion mark (Morgan Stanley, 2020). And by 2035, according to McKinsey & Company, the space economy will double its turnover and cross the $1.8 trillion mark (World Economic Forum, 2024).

In such circumstances, influential states are trying to attract private investment in space exploration, and business fully supports them. According to some estimates, every dollar spent on space exploration directly or indirectly generates at least $7 to $40 in profit (McFarlane, 2019).

To strengthen their positions in the "new space race", governments are creating favourable conditions for business participation in space exploration, pursuing several goals: 1) stimulating the development of this strategic industry; 2) attracting additional investment; 3) commercialising the space industry; 4) partially shifting the "financial burden" to the private sector; 4) strengthening defence capabilities, etc. (Teleshun & Batrymenko, 2023).

Ukraine, as a state with a glorious space history, needs to implement an effective model of relations in the authorities-business-academia triangle. Further neglect of the space industry and the lack of will to implement an effective model of involving all stakeholders in space exploration can only lead to a complete loss of national space potential, weakening of the state's defense capability in the face of full-scale Russian aggression, and slowdown Ukraine's recovery from the consequences of the war and its further sustainable economic growth.

Understanding the strengths and weaknesses on the way to implementing an effective model of relations in the authorities-business-academy triangle is a prerequisite for reviving Ukraine's space potential and strengthening its competitiveness on the global stage.

General overview of the space industry in Ukraine

In 1991, with the proclamation of Ukraine's independence, a new round of development of the national space industry began. According to some estimates, the newly independent state inherited a third of the industrial space potential of the former Soviet Union (Krawec, 1995). Moreover, Ukraine has managed to preserve the full cycle of rocket and space technology production, launch spacecraft for various purposes, operate them in orbit and use the information obtained in its own national interests.

Since independence Ukraine has launched more than 150 missiles from around the world: Zenit-3SL LV from the Sea Launch platform – 34 launches, Zenit and Zenit-3SLB LV from the Baikonur Cosmodrome – 33 launches, Dnipro LV – 22 launches, Cyclone-2 LV – 13 launches, Cyclone-3 LV – 26 launches, Antares LV – 11 launches, Vega LV – 15 launches (Horbulin, 2020); launched almost 400 spacecraft into Earth orbit in the interests of governments and private companies of 25 countries, including the Mohammed-VI-B spacecraft for the government of the Kingdom of Morocco; developed a propulsion engine block for the Vega launch vehicle commissioned by the European Space Agency (ESA); developed the main structure of the first stage, which launched the Orbital Sciences Corporation rocket into orbit, and later designed a satellite for the International Space Station (ISS), which delivered the Antares spacecraft; created the EgyptSat-1 spacecraft and a series of Sich satellites, etc. According to the National Academy of Sciences of Ukraine, this has allowed the state to remain in the list of TOP-5 countries with a full cycle of rocket and space technology production for decades (NAS of Ukraine, 2019).

For a long time, the space industry has remained a budget-forming sector in Ukraine, despite systemic underfunding. The National Targeted Scientific and Technical Space Programme of Ukraine for 2013-2017 was funded by about 30% of the planned amount (UAH 347 million out of UAH 1,109 million). The draft Law of Ukraine "On Approval of the National Targeted Scientific and Technical Space Programme for 2021-2025," which provided for funding for the programme in the amount of UAH 40.78 billion (including UAH 15.76 billion from the state budget) (CMU, 2021), was never voted by the Verkhovna Rada of Ukraine due to the Russian full-scale invasion of Ukraine (VRU, 2022). Despite this, according to the Vice-President of the National Academy of Sciences of Ukraine V. Horbulin, space industry enterprises fulfilled more than 150 international contracts worth up to $450 million annually. Even with the outbreak of Russia's war against Ukraine in 2014, taxes paid to the state's budget by space industry enterprises "amounted to more than UAH 1 billion, which was 10-15 times higher than the funding received under state space programmes" (Horbulin, 2020).

However, global trends, Russian aggression against Ukraine and domestic political and socio-economic processes have significantly affected the prospects for further development of the domestic space industry. Commercialisation of space activities has had a considerable impact on the competitiveness of the Ukrainian space economy. The national space industry was forced to compete not only with states in the field of outer space exploration, but also with other influential global players – corporations. For comparison, the actual budget of the

National Targeted Scientific and Technical Space Programme of Ukraine for 2013-2017, as noted above, reached approximately UAH 347 million, which is roughly equivalent to $43 million (as of 01.01.2023 at the exchange rate of the National Bank of Ukraine (NBU, 2024)). At the same time, the relatively young American company Space Exploration Technologies Corporation (better known as SpaceX) earned at least $56.5 million in 2013 for just one launch (Belfiore, 2013). At the time, it was the most favourable offer on the space industry market. Over the past two decades, the cost of launching launch vehicles has fallen tenfold, which has naturally led to an increase in the number of launches and an expansion of the market for these services (World Economic Forum, 2024). As of June 2024, SpaceX's capitalisation has already reached approximately $200 billion (Reuters, 2024).

Ukraine has taken some steps to address the issue of attracting private capital to space exploration: in 2019, the Law of Ukraine "On Space Activities" was amended to allow the private sector to operate in the space industry. The amendments to the law came into force a year later. According to Art. 1 of the Law of Ukraine "On Space Activities", the subjects of space activities are "enterprises, institutions and organisations regardless of ownership and legal form, including international and foreign ones, which carry out space activities" (VRU, 1996). The procedure for registering a space entity is quite simple: a privately owned space entity that intends to carry out space activities must submit a declaration on conducting economic activities in the field of space activities to the central executive body that ensures the formation and implementation of state policy in the field of space activities. Space entities, regardless of their form of ownership, are controlled by the state, which issues permits for certain types of space activities, exercises state supervision (control) over compliance with the legislation on space activities in Ukraine, and bears international responsibility for their activities in outer space, etc. (VRU, 1996). According to Article 10 of the aforementioned legal act, the following types of activities of private companies require a permit from the state authorities: testing (except for computer tests) of launch vehicles, including their units/components and spacecraft; launching rockets and/or spacecraft; controlling spacecraft in Earth orbit or outer space; returning spacecraft and/or their returning components from Earth orbit or outer space to Earth (VRU, 1996).

Despite the important steps forward in the implementation of the principles of cooperation between public authorities, state-owned companies and private capital in the development of outer space, this is not enough to catch up (let alone overtake) the leading space powers. The process of space commercialisation in Western countries (primarily the U.S.) began much earlier. The commercial use of satellites is believed to have begun in 1962 with the launch of Telstar 1, which enabled the first live television image transmission between the U.S. and Europe. In 1965, the Intelsat I satellite (better known as Early Bird), developed by Hughes Aircraft Company for the Communications Satellite Corporation (COMSAT), confirmed the commercial viability of space exploration by private companies. Fifty years later, 31% of all space launches were commercial (FAA, 2010). Since the 60s of the 20th century, the National Aeronautics and Space Administration (NASA) has been actively cooperating with private aerospace companies such as Lockheed Martin Corporation, Northrop & Grumman Corporation, Boeing Company, North American Aviation, etc. (Teleshun & Batrymenko, 2023).

The European community began the process of integrating the private and public sectors in space exploration a little later. However, this happened much earlier than Ukraine began to think about this possibility. A striking example of the integration of the private and public sectors is the European Ariane programme, the world's first commercial launch service, started in 1979, which not only guarantees European countries access to outer space and the ability to launch satellites independently, but also symbolises political, technological and economic integration between European nations (Babják, 2024).

Currently, space activities are extremely attractive for private-sector investment. As noted above, space technology is an integral part of modern life. Retail, food processing, supply chains and transport infrastructure, climate change mitigation and disaster management – all these industries can benefit from space-based innovations in their respective fields. As S. Buckup, a member of the World Economic Forum's Executive Committee, noted, "Space technologies are delivering greater value to a more diverse set of stakeholders than ever before" (Khlystov & Markovitz, 2024). The expansion of the range of interest groups involved in space exploration has led to an increase in investment in the industry: according to some estimates, in 2021-2022, investments in space activities crossed the $70 billion mark. By 2035, the space tourism market will be estimated at approximately $4-6 billion, with the main source of income coming from the space stations of the Forbes World Ranking participants in orbit (Khlystov & Markovitz, 2024). At the same time, the rapid development of space activities has pushed related industries to equally rapid development: agriculture, information technology, insurance and construction, etc.

According to the authors of the report "Space: The $1.8 Trillion Opportunity for Global Economic Growth," there are four key trends in the development of outer space in the 21st century:

1. *Space will be a larger part of the global economy:* "The space economy is forecast to reach $1.8 trillion by 2035, up from $630 billion in 2023 and growing at an average of 9% per annum – well above the growth rate of global gross domestic product (GDP)."
2. *Space's impact will increasingly go beyond space itself:* "The share of the total space economy captured by incumbent space hardware and service providers will gradually decrease to the benefit of non-traditional players such as ride-hailing apps, which would never have reached the global scale they have without satellite-based technology connecting drivers and riders and providing navigation services."
3. *Space will become more about connecting people and goods:* "Five industries – supply chain and transportation; food and beverage; state-sponsored defence; retail, consumer goods and lifestyle; and digital communications – will generate more than 60% of the increase in the space economy by 2035. In addition, nine other industries will see space-related revenues reach several billion dollars – creating opportunities for traditional and non-traditional players alike."
4. *Space's return on investment will be more than financial:* "Beyond revenue generation, space will play an increasingly crucial role in mitigating world challenges, ranging from disaster warning and climate monitoring, to improved humanitarian response and more widespread prosperity" (World Economic Forum, 2024).

Given the global socio-economic and political processes, as well as Russia's war against Ukraine, Kyiv cannot miss the opportunity to take advantage of global trends. Moreover, as noted above, despite decades of difficulties for the space industry, Ukraine has retained sufficient space potential to be competitive on the world arena. Most of the related areas that are stimulated by the development of the space industry are also strategic and extremely important for Ukraine. In particular, the following six innovative industries are likely to become dominant in the coming decades: space transport and logistics; in-space manufacturing; bioproduction, which is the production of organs, tissue chips, and drug therapies under microgravity conditions as well as disease modelling; nuclear launch and propulsion, which utilizes nuclear energy to potentially substitute current fuel sources that use chemical reactions as propellants; space agriculture, as the production of food in space via controlled environment cultivation; satellite services and maintenance (Rausser et al., 2023).

Investments in the development of the space industry are extremely important not only for Ukraine's strategic goals but also for its tactical needs. It is about Ukraine's trade competitiveness in the international arena, as well as national security and defence issues. In particular, the Regulation (E.U.) 2023/1115 on deforestation-free products (EUDR) (European Commission, 2024), which will start to apply on 30 December 2024, has a direct impact on Ukraine and is closely related to space innovation. All member states of the European community are obliged to comply with Regulation 2023/1115, which requires all products and goods (cocoa, palm oil, rubber and wood) produced and exported to the Euro area to comply with E.U. policies and standards. This means confirming compliance with the principles of sustainable management of natural resources, where transparency of the origin of raw materials is a key principle. If a business entity exporting the above raw materials or goods containing them cannot prove their origin, the E.U. market will be closed to them (WWF-Ukraine, 2024). One of the most effective tools for monitoring deforestation in the E.U. is the use of video and photo data obtained from space satellites. Of course, Ukraine is not currently a member of the European Union, so it may not comply with the requirements of the EU Forest Regulation, but it risks losing the largest market for domestic exports. According to statistics from the State Customs Service, in the first quarter of 2024, Ukrainian exports to the E.U. accounted for 57% of total exports (SCS of Ukraine, 2024). According to the Ukrainian Association of Furniture Manufacturers and the Wood Industry U.A. platform, approximately 5-6% of domestic exports in 2023-2024 were wood and wood products (UAFM, 2023; Wood Industry, 2023).

The need to develop the space industry is even more critical in terms of ensuring Ukraine's national security and defence. Suffice it to recall the high-profile scandal in early 2024 regarding Russia's possible use of satellite imagery from two of the largest commercial satellite imagery companies in the U.S. to strike at Ukrainian strategic targets: Maxar Technologies Inc. and Planet Labs PBC (Wood, 2024). Despite the policies of both companies restricting the sale of satellite imagery and other materials to Russia and its companies, they have no or poorly developed mechanisms to verify the end user of the product. With the mediation of a third party, any state or company can obtain the relevant material regardless of sanctions lists and government policies. Another high-profile case was Russia's use of Starlink Internet terminals in its war against Ukraine (Grove, 2024). In the absence of similar or at least similar domestic technologies and capabilities, Ukraine is forced to continue using these services to counter the aggressor.

Given the numerous threats to national security that will not disappear with the end of the so-called "acute phase" of the war, Ukraine needs to develop its own space industry while minimising the outsourcing of its key functions. The successful development of the space industry in the 21st century, including in Ukraine, requires the involvement of all stakeholders to develop an effective space policy and implement an efficient model of coexistence between government agencies, the private sector, civil society and the expert community in the exploration of outer space. Only effective cooperation between all stakeholders can ensure the competitiveness of the national space industry and Ukraine in the global arena. M. Suffredini, CEO of Axiom Space, Inc. said: "The key enabler for the advancement of civilization is synergy between a supportive space policy framework, pioneering business models and the development of a vibrant space economy," and "The future of space is not just about the destinations we build but about the economic ecosystems we create along the way" (World Economic Forum, 2024).

Understanding the nature of public-private cooperation in space exploration, the key weaknesses and strengths of the national space industry, and Ukraine's strategic and tactical needs is the first step towards implementing an effective model of such relations.

Weaknesses of the Ukrainian space industry

Today, Ukraine faces numerous challenges and threats, both external and internal. The government's chaotic response to key problems is a forced step to preserve Ukrainian statehood. However, the successful future of the state is determined not so much by successful tactical steps as by a strategic vision that allows us to correctly prioritise the needs of the state, considering the available resources, goals and current development directions. In our opinion, the space industry is one of these priorities. The development of the space economy will partially solve the urgent problems of ensuring national security and defence of Ukraine and lay the groundwork for further sustainable development of Ukraine.

Given the attractiveness of implementing the "European" model of public-private cooperation in space exploration in Ukraine, it is worth highlighting five key strengths and weaknesses of the national space industry.

Russia's war against Ukraine. The war is the biggest challenge for the development of the national space industry. The destruction of strategic facilities and research centres, migration of highly skilled professionals, displacement of large domestic business and destruction of infrastructure are just some of the challenges caused by the war that hinder the development of Ukraine's space economy. According to the Government of Ukraine, the World Bank, the European Commission, and the United Nations, the amount of investment needed to rebuild Ukraine exceeded US$486 billion as of 31 December 2023 (W.B., 2024). Given the scale of the devastation, it is likely that priority donor aid, loans and external investments in Ukraine's recovery will be directed towards humanitarian assistance and the restoration of social infrastructure. The space industry may once again be off the table. As noted above, the National Targeted Scientific and Technical Space Programme for 2021-2025 was not approved due to Russia's war against Ukraine. The Ukraine Facility and the Ukrainian Plan for the Ukraine Facility do not have a space component (European Council, 2024; Ministry of Economy of Ukraine, 2024).

Lack of a systemic vision for the development of Ukraine's space industry. Due to subjective and objective factors, the national establishment lacks a systematic vision of the future of the Ukrainian space industry. This problem dates to the 1990s, when Ukraine declared its independence. The first space programmes of independent Ukraine did not consider the needs of an independent Ukraine and global market trends and were mainly aimed at preserving the potential inherited from the USSR: maintaining the full cycle of rocket and space technology development, launching spacecraft for various purposes, operating them in Earth orbit, etc. (Horbulin, 2020). According to O. Fedorov, Director of the Space Research Institute of the National Academy of Sciences of Ukraine, the implementation of a new competitive model of space activities is a necessary step to "restart" the national space industry, where the main goal is not "strategic pursuit in the name of leadership" but the implementation of the principles of sustainable development and customer focus (Surzhyk, 2019). The effectiveness of space programmes '...is measured not by the number of launches, but by the answers to the following questions: how much the security of the country and the region will increase, what is the benefit of disaster forecasting or emergency assessment, how to improve specific management decisions" (Surzhyk, 2019). The future of Ukraine's space industry should be focused on the realisation of the national interests of the state and meeting social needs, and not be “hostage to historically established trends” (Horbulin, 2020).

Legal unregulated interplay between the public and private sectors in space exploration. Even though Ukraine has taken certain steps to formalise public-private relations in the implementation of space policy by amending the Law of Ukraine “On Space Activities” in 2019, private investment in space activities remains minimal. The mechanism for attracting business to space activities still contains significant obstacles to the commercialisation of the industry: 1) legal regulation lags far behind and does not meet the needs of the development of space activities in Ukraine; 2) international agreements do not meet the level of national regulations of advanced countries and new global trends; 3) the space industry of Ukraine is focused mainly on not the most profitable areas of the space economy, which reduces the attractiveness for private investors; 4) there is no clear distinction between national interests and the commercial component in space activities; 5) mechanisms for reconciling private and public interests in the context of space commercialisation are either absent or highly ineffective; 6) there are no effective mechanisms for attracting foreign investment to space exploration, etc. (Teleshun & Batrymenko, 2023). The Law of Ukraine, “On State Support of Space Activities,” does not meet the current needs and interests of all space actors (VRU, 2000). The law focuses exclusively on supporting the public sector of space activities. Public funding for the space industry on the eve of the full-scale invasion was on par with some African countries: in 2016-2018, Kyiv spent approximately $320 million on space activities, while Algeria spent $278.5 million, and South Africa spent $68.3 million (Teleshun & Batrymenko, 2023). Private investment has been insignificant, as the state has failed to provide favourable conditions for private investment in the sector.

Unviability of the existing model of stakeholder interaction in space exploration. Ukraine currently lacks an effective model for involving all stakeholders in the development and implementation of space policy. It is not only about attracting business to space activities, but also about the state’s ability to effectively use the scientific achievements of the academic community to meet national interests and the needs of society. Modern competitive models of space exploration involve combining the resources and strategic vision of the public sector with profit-oriented rapid technological progress, driven by the interest of the private sector and the deep knowledge of the academic community. The new space economy is nothing more than a balancing act between public and private sector investment in the exploitation of fundamental scientific discoveries. While public investment focuses on solid and ambitious research, private sector investment promotes diversification, commercialisation and innovation in the space industry. The unsustainability of the domestic model of stakeholder interaction in space exploration leads to either the closure of space start-ups or their relocation to other countries. Suffice it to mention a number of private space initiatives that have mostly been further developed in other, more development-friendly countries: the private US-Ukrainian aerospace company Firefly Aerospace (founded by Ukrainian M. Polyakov, 2017) is one of nine private companies that sends landers under the lunar exploration programme commissioned by NASA; Space 1000 (founded by D. Rudenko) is a closed community of entrepreneurs, I.T. specialists and top managers of leading Western companies specialising in launching collectible coins and precious metals into space; Spacebit (founded by P. Tanasiuk, 2017) is a private British-Ukrainian company specialising in launching small lunar rovers; SpaceVR, specialising in space exploration using virtual reality, etc. (Teleshun & Batrymenko, 2023).

In turn, the need for coordination between the public, private and academic sectors in space activities is increasingly being discussed in the U.S. According to G. Rausser, E. Choi, and A.

Bayen, "As NASA continues to contract with private companies, the next natural step is to establish public–private research and development partnerships (PPRDPs) with the inclusion of research universities. This expanded scope for the public dimension could include the codification of significant discoveries as well as the potential for the open-sourcing of research findings. By strengthening multilateral research collaboration between NASA, research universities, and the private sector, such PPRDP can eliminate coordination failures by aligning incentives and resource integration, eliciting more capital investments that would increase basic research that generates public goods and commercialized technologies emanating from applied research" (Rausser et al., 2023). In their opinion, private companies will be interested in PPRDP not only because of the possibility of commercialising research results, but also because of access to the young intellectual resource of universities (Rausser et al., 2023).

Public-private partnerships in research and development are not new to the U.S. The foundations for effective collaboration between these entities were laid in 1980 with the passage of the Patent and Trademark Act Amendments (better known as the Bayh-Dole Act) (GovInfo, 1980), which granted universities intellectual property rights (IPR) for federally funded research. This encouraged scientist to focus their research on potential commercial applications: "Since this act, over 11,000 startups have been spun off from universities; technology firms and parks near universities have increased; and technology transfer offices have been formed to handle IPRs" (Rausser et al., 2023). The 1986 Federal Technology Transfer Act_only expanded the possibilities for this cooperation (U.S. Department of the Interior, 1986).

Vested interests and the functioning of financial-political groups. Even though Ukraine has made significant progress in fighting corruption in recent years, this problem remains a key issue today. According to Transparency International's Corruption Perceptions Index (CPI) for 2023, Ukraine received 36 points out of 100 and ranked 104th out of 180 countries (T.I., 2024). The lack of an effective and fair justice system, constant changes in the rules of interaction with government agencies, imperfect competition in the market, weak protection of investors' interests, and fierce competition between financial-political groups for the distribution of state funding and orders reduce the likelihood of private investment in the space industry both now and during Ukraine's post-war recovery (Paterson & Teleshun, 2024). The space industry, given the risky nature of rocket launches and the aggressive nature of outer space, is a high-risk area for investment, and when combined with the unstable institutional environment in Ukraine, it becomes extremely threatening to private investors.

Strengths of the Ukrainian space industry

The above list of weaknesses of the domestic space industry is not exhaustive. There are other significant factors that hinder the development of the Ukrainian space industry. Nevertheless, it is important to understand that the Ukrainian space industry has several advantages in addition to significant disadvantages. And, as is often the case, its strengths stem from its weaknesses.

Availability of qualified personnel. Despite the difficult years for Ukraine, the national space industry has consistently demonstrated its competitiveness, primarily due to the highly professional specialists in the sector. In the 1990s, there were about 600 specialised enterprises engaged in the development of rocket and space technology in Ukraine, employing more than 250,000 qualified specialists. The world-famous Ukrainian space enterprises are the Pivdenne Design Office and State Factory "Production Union Pivdennyi Machine-Building Plant named after O.M. Makarov" in Dnipro, Kharkiv's JSC "HARTRON" and SSPE "Association Kommunar", Kyiv's Kyivprylad, PJSC "Kurs" and PJSC "Elmiz", Chernihiv's PJSC "Chernihiv Plant of radio equipment" etc. Despite the deprioritisation of the space industry by the Ukrainian establishment, migration processes and unfavourable economic conditions that led to the closure of many space enterprises, the industry has retained its intellectual and human resources potential. There are at least three higher education institutions in Ukraine that train new personnel for the national space industry: National Aviation University, National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute," National Aerospace University "Kharkiv Aviation Institute" (Informator, 2023).

Existence of national space legislation. Even though Ukrainian space legislation is outdated and imperfect, its existence is to some extent an advantage for Ukraine in terms of its European aspirations. On 12 September 2023, the Cabinet of Ministers of Ukraine approved an action plan for Ukraine's integration into the European Space Agency (ESA) (CMU, 2023). The action plan provides for the preparation of the negotiation process with ESA to expand deeper cooperation, approximation of Ukrainian legislation to E.U. acquis in the field of space activities, negotiations and preparation for the conclusion of an agreement/accession to the convention.

According to the European Space Agency, in addition to Ukraine, ten other European countries, including Belgium, France and Germany, have national space legislation. The European Commission is currently working on a draft E.U. space law. According to the Commissioner for the Internal Market of the E.U., T. Breton, the aim of this draft law is to create a "true single market" for space (Desmarais, 2024).

The European Commission began to think about the need for space legislation in 2021 with the launch of its space programme, which combines various space projects: the Earth observation programme Copernicus and the European GPS navigation tool Galileo. In 2022, the European community recognised that space is a strategic area and jointly developed the E.U. Space Strategy for Security and Defence to protect the continent's interests in space until 2030. For the first time, the strategy mentions the need to develop E.U. space law.

According to information published on the European Commission's website, the law should regulate space activities in three areas: 1) safe satellite traffic to avoid "increasing risk of collisions"; 2) protecting the E.U. infrastructures against cyber-attacks; 3) building Europe's space sector as an "important enabler of services" (Stefoudi, 2024). As T. Breton noted, "[The E.U. Space Law] is also a matter of security as in the current geopolitical context, the protection of our space system from systemic security risks is a must" (Desmarais, 2024).

Ukraine's own space legislation and developed sectors of the space industry allow it to be not only a consumer but also a producer of services useful to the European community. Considering Ukraine's European aspirations, this will undoubtedly strengthen the country's ability to defend and promote its national interests at the E.U. level.

Investment attractiveness of the Ukrainian market. Despite the war, the Ukrainian market is quite attractive. It has consistently demonstrated high intellectual potential, cheap labour and minimal competition in attractive investment areas. The strong potential of the Ukrainian I.T. industry, the availability of highly qualified specialists and the glorious history of space exploration make Ukraine attractive for investment in the space industry. According to the European Business Association, only ten months after the start of the full-scale Russian invasion, Ukraine's investment attractiveness index recovered to a "covid" value (2.48 out of 5) (EBA, 2022) and continued to grow. In the first quarter of 2024, according to Dealroom, the Ukrainian startup industry was valued at €28 billion. Ukraine, along with Poland and Estonia, is one of the three largest players in Central and Eastern Europe: The 26,000 startups in the region raised over €2.1 billion in 2023, with a total value of €213 billion (Dudko, 2024).

Russia's war against Ukraine. War is both a threat and an opportunity for the national space industry. The military conflict can become a catalyst for the development of Ukraine's space industry during the war and the basis for its sustainable post-war recovery. According to the Law of Ukraine "On the State Budget of Ukraine for 2024," UAH 1 trillion 692.6 billion has been allocated for the defence and security sector, which is 22.1% of the country's GDP. Of this amount, more than UAH 100 billion is allocated for the development of the defence industry, including the space industry (VRU, 2023). According to D. Kysylevskyi, Deputy Chairman of the Committee on Economic Development: "Few people think about it, but the war for Ukraine's independence continues every second, not only at the front, but also in space. The State Space Agency of Ukraine provides a constant exchange of information with hundreds of satellites from partner countries. This allows our headquarters to make operational decisions that save the lives of thousands of people and deliver devastating blows to the occupiers. The current war demonstrates how important it is for a country to develop its own space industry. Our partner countries provide us with images of enemy positions, but this largely depends on whether their president will not change after the elections. Our partner countries also provide us with missiles with a very limited range, while there are still specialists who have not only designed but also manufactured missiles that are many times more powerful than ATACMS and Storm Shadow... The aerospace industry in Ukraine is now actively reviving. The war left the country with no other choice. It's time to catch up and eventually regain the lost ground. The state should pay sufficient attention to the development of its own rocket science and industry" (Press Service of the VRU, 2024).

Space brand of Ukraine. Ukraine is a country with a glorious history of space exploration. There is probably not a single space expert in the world who is not aware of the role that Ukrainians and Ukraine have played in the exploration of outer space. Ukrainian state-owned space enterprises are world-renowned, and the names of Ukrainians such as O. Zasyadko, M. Kibalchych, Y. Kondratyuk or S. Korolev are no less well known. The national space industry is a powerful unifying symbol for Ukrainians and a brand in the international arena. Suffice it to recall the "people's satellite" of the Finnish company ICEYE Ltd. that was purchased with voluntary contributions from citizens and still works for Ukraine's defence (Kuzmenko, 2024). And E. Musk has acknowledged that Ukraine's Zenith missiles, developed by the Pivdenne Design Bureau, are among the best in the world (ENGRE, 2022). Ukraine should use this heritage to promote its interests in the international arena and use the space industry as an engine of technological and economic development.

Conclusions

In the 21st century, space exploration is no longer an activity available only to a select few. More and more different stakeholders are involved in the expansion of new space. Business is a key player in the modern space race. Effective interaction between the public and private sectors, supported by the academic environment, is the key to a country's competitiveness in space competitions. Ukraine is no exception. Implementing an effective model of interplay between all stakeholders in the implementation of space policy is a necessary step towards strengthening national security and defence and accelerating sustainable economic growth. Understanding the strengths and weaknesses on the way to implementing an effective model of relations in the state-business-academia triangle is a prerequisite for reviving Ukraine's space potential and strengthening its competitiveness on the global stage.

🕮 References

Babják, Matúš, Kai Strycker, and Philipp Kürten (2024) Future Space: European Integration and the Future of Europe's Presence in Outer Space. *Space Generation Advisory Council*, June 7. Available online: https://spacegeneration.org/futurespace-european-integration-and-the-future-of-europes-presence-in-outer-space

Belfiore, Michael (2013) The Rocketeer. *Foreign Policy*, December 9. Available online: https://foreignpolicy.com/2013/12/09/the-rocketeer/

Desmarais, Anna (2024) The European Commission told Euronews Next that they expect to propose a European space law sometime in April. *Euronews*, April 4. Available online: https://www.euronews.com/next/2024/04/04/creating-a-true-single-market-in-orbit-what-should-we-expect-from-europes-new-space-law

Dudko, Valentyna (2024) Is spring coming soon? *Forbes*, April 1. Available online: https://forbes.ua/innovations/skoro-vesna-z-pochatku-roku-ukrainski-startapi-otrimali-shchonaymenshe-42-mln-investitsiy-yak-pochuvaetsya-venchurna-industriya-u-pershomu-kvartali-2024-go-doslidzhennya-forbes-01042024-20239

ENGRE (2022) Elon Musk Sees the Future in Ukrainian Space. *ENGRE*. Available online: https://engre.co/about/common-projects/elon-musk-sees-the-future-in-ukrainian-space/

European Council (2024) The Ukraine Facility. *European Council.* Available online: https://www.consilium.europa.eu/en/policies/ukraine-facility/

GovInfo (1980) Public Law 96-517 – DEC. 12, 1980. *GovInfo*, December 12. Available online: https://www.govinfo.gov/content/pkg/STATUTE-94/pdf/STATUTE-94-Pg3015.pdf

Grove, Thomas, Nicholas Bariyo, Micah Maidenberg, Emma Scott and Ian Lovett (2024) The Black Market That Delivers Elon Musk's Starlink to U.S. Foes. *The Wall Street Journal*, April 9. Available online: https://www.wsj.com/business/telecom/starlink-musk-ukraine-russia-sudan-satellite-communications-technology-f4fc79d9?mod=hp_lead_pos1

European Business Association (2022) Ukraine's investment attractiveness index has recovered to a 'covid' value. *European Business Association*, December 15. Available online: https://eba.com.ua/indeks-investytsijnoyi-pryvablyvosti-ukrayiny-vidnovyvsya-do-kovidnogo-znachennya/

European Commission (2024) Deforestation Regulation implementation. *European Commission*. Available online: https://green-business.ec.europa.eu/deforestation-regulation-implementation_en

Federal Aviation Administration (2010) Frequently Asked Questions. *Federal Aviation Administration, United States Department of Transportation*. Available online: https://web.archive.org/web/20180709035127/https://www.faa.gov/about/office_org/headquarters_offices/ast/faq/

Horbulin, Volodymyr (2020) Space Strategy and National Development Prospects*. Bulletin of the National Academy of Sciences of Ukraine*, Volume 3, 3-10.

Informator (2023) Where do astronauts get trained in Ukraine? *Informator*, April 13. Available online: https://if.informator.ua/2023/04/13/de-v-ukrayini-vchat-kosmonavtiv/

Krawec, Roman (1995) Ukrainian space policy – contributing to national economic development. *Space Policy*, Volume 11, Issue 2, 105-114. https://doi.org/10.1016/0265 –9646(95)00004-V

Khlystov, Nikolai and Gayle Markovitz (2024) Space is booming. Here's how to embrace the $1.8 trillion opportunity. *World Economic Forum 2024*, April 8. Available online: https://www.weforum.org/agenda/2024/04/space-economy-technology-invest-rocket-opportunity/

Kuzmenko, Yuliya (2024) The DIU's 'People's Sputnik' has taken over 4,000 images in two years. *Suspilne*, June, 26. Available online: https://suspilne.media/776945-narodnij-suputnik-gur-za-dva-roki-zrobiv-ponad-4-tisaci-znimkiv/

McFarlane, Paul (2019) Celebrating benefits of Apollo program on 50th anniversary of Moon landing. *Nevada Today*, July 18. Available online: https://www.unr.edu/nevada-today/blogs/2019/celebrating-the-benefits-of-apollo-missions

Ministry of Economy of Ukraine (2024) Plan for the Ukraine Facility. Ministry of Economy of Ukraine, March. Available online: https://www.ukrainefacility.me.gov.ua/wp-content/uploads/2024/03/plan-dlya-ukraine-facility_prezentacziya.pdf

Morgan Stanley (2020) Space: Investing in the Final Frontier. *Morgan Stanley*. Available online: https://www.morganstanley.com/ideas/investing-in-space

National Academy of Sciences of Ukraine (2019) 8 Facts about Ukrainian Cosmonautics. *National Academy of Sciences of Ukraine*, April 16. Available online: https://www.nas.gov.ua/UA/Messages/Pages/View.aspx?MessageID=4899

National Bank of Ukraine (2024) Official exchange rate of the hryvnia against foreign currencies. National *Bank of Ukraine*. Available online: https://bank.gov.ua/ua/markets/exchangerates

Paterson, Anna and Iaroslav Teleshun (2024) *The political economy of a green recovery in Ukraine*. The Policy Practice, Brief 16, February. Available online: https://www.thepolicypractice.com/web/sites/default/files/2024-02/The%20political%20economy%20of%20a%20green%20recovery%20in%20Ukraine_final%208.2.24.pdf

Press Service of the Verkhovna Rada of Ukraine (2024) Happy Rocket and Space Industry Day. Press Service of the Verkhovna Rada of Ukraine, April 12. Available online: https://www.rada.gov.ua/news/news_kom/248376.html

Ratcliffe, Susan (2018) *Oxford Essential Quotations (6 ed.)*. Oxford University Press.

Rausser, Gordon, Choi Elliot, and Bayen Alexandre (2023) Public–private partnerships in fostering outer space innovations. *Space Exploration: Economics, Technologies, and Policies*. Volume 120. No. 43. https://doi.org/10.1073/pnas.2222013120

Report of Transparency International for Corruption Perceptions Index (2024) Available online: https://cpi.ti-ukraine.org/

Report of The World Bank, the Government of Ukraine, the European Union, the United Nations (2024) Ukraine, Third Rapid Damage and Needs Assessment (RDNA3) February 2022 – December 2023. Available online: https://www.undp.org/ukraine/publications/updated-ukraine-recovery-and-reconstruction-needs-assessment

Report of World Economic Forum (2024) Space: The $1.8 Trillion Opportunity for Global Economic Growth, Insight Report. *World Economic Forum and McKinsey & Company*. Available online: https://www3.weforum.org/docs/WEF_Space_2024.pdf

Reuters (2024) SpaceX mulling tender offer at $200 billion valuation. *Reuters*, May 24. Available online: https://finance.yahoo.com/news/spacex-mulling-tender-offer-200-220934351.html

State Customs Service of Ukraine (2024) In the first quarter of 2024, Ukraine's trade turnover amounted to $26 billion. *State Customs Service of Ukraine*, April 11. Available online: https://customs.gov.ua/news/zagalne-20/post/za-pershii-kvartal-2024-roku-tovaroobig-ukrayini-sklav-26-mlrd-1559

Stefoudi, Dimitra (2024) E.U. Space Law – Three reasons against, three reasons in favour. *EJIL: Talk*, April 29. Available online: https://www.ejiltalk.org/eu-space-law-three-reasons-against-three-reasons-in-favour/

Surzhyk, Lidia (2019) Why does Ukraine need Space? *Mirror of the week*, April 12. Available online: https://zn.ua/ukr/science/navischo-ukrayini-kosmos-308410_.html

Teleshun, Iaroslav and Oleg Batrymenko (2023) Interplay of the Public and Private Sectors in the Development of Outer Space. *Philosophy and Cosmology*, Volume 31, 82-95. https://doi.org/10.29202/phil-cosm/31/7

The Cabinet of Ministers of Ukraine (2021) National Targeted Scientific and Technical Space Program of Ukraine for 2021-2025. *The Cabinet of Ministers of Ukraine*. Available online: https://www.kmu.gov.ua/bills/proekt-zakonu-pro-zatverdzhennya-zagalnoderzhavnoi-tsilovoi-naukovo-tekhnichnoi-kosmichnoi-programi-na-2021-2025-roki

The Cabinet of Ministers of Ukraine (2023) Order on Approval of the Action Plan for Ukraine's Integration into the European Space Agency. *The Cabinet of Ministers of Ukraine*. Available online: https://www.kmu.gov.ua/npas/pro-zatverdzhennia-planu-dii-shchodo-intehratsii-ukrainy-do-ievropeiskoho-kosmichnoho-ahentstva-i120923-796

The Guardian (2023) The 10 biggest science stories of 2023 – chosen by scientists. *The Guardian*, December 23. Available online: https://www.theguardian.com/science/2023/dec/23/the-10-biggest-science-stories-of-2023-chosen-by-scientists

The Guardian (2022) The 10 biggest science stories of 2022 – chosen by scientists. *The Guardian*, December 18. Available online: https://www.theguardian.com/science/2022/dec/18/the-10-biggest-science-stories-of-2022-chosen-by-scientists

The Guardian (2021) The year's top 10 science stories, chosen by scientists. *The Guardian*, December 19. Available online: https://www.theguardian.com/science/2021/dec/19/the-years-top-10-science-stories-chosen-by-scientists

The Guardian (2020) The virus-free scientific breakthroughs of 2020, chosen by scientists. *The Guardian*, December 20. Available online: https://www.theguardian.com/science/2020/dec/20/the-virus-free-scientific-breakthroughs-of-2020-chosen-by-scientists

The Guardian (2019) The science stories that shaped 2019. *The Guardian*, December 22. Available online: https://www.theguardian.com/science/2019/dec/22/the-science-stories-that-shaped-2019

Ukrainian Association of Furniture Manufacturers (2023) Dynamics of Ukrainian furniture exports in the first half of 2023. *Ukrainian Association of Furniture Manufacturers*, August 14. Available online: https://uafm.com.ua/dynamika-eksportu-ukrayinskyh-mebliv-za-i-pivrichchya-2023-roku/

U.S. Department of the Interior (1986) CRADAs – Cooperative Research & Development Agreements. U.S. Department of the Interior. Available online: https://www.doi.gov/techtransfer/crada

Verkhovna Rada of Ukraine (2022) Draft Law on Approval of the National Targeted Scientific and Technical Space Program of Ukraine for 2021-2025. *Verkhovna Rada of Ukraine*. Available online: https://itd.rada.gov.ua/billInfo/Bills/CardByRn?regNum=6129&conv=9

Verkhovna Rada of Ukraine (1996) The Law of Ukraine on Space Activities. *Verkhovna Rada of Ukraine*. Available online: https://zakon.rada.gov.ua/laws/show/502/96-%D0%B2%D1%80#Text

Verkhovna Rada of Ukraine (2000) The Law of Ukraine on state support for space activities. Verkhovna Rada of Ukraine, March 16. Available online: https://zakon.rada.gov.ua/laws/show/1559-14#Text

Verkhovna Rada of Ukraine (2024) *Law of Ukraine* on the State Budget of Ukraine for 2024. *Verkhovna Rada of Ukraine*, November 11. Available online: https://zakon.rada.gov.ua/laws/show/3460-20#Text

Wood Industry U.A. platform (2023) EUDR/EUTR: how can Ukrainian timber exporters comply with the requirements? *Wood Industry U.A. platform*, November 24. Available online: https://derevynnyk.com/eudr-eutr-yak-ukrayinskym-eksporteram-derevyny-dotrymuvatysya-vymog/

Wood, Graeme (2024) A Suspicious Pattern Alarming the Ukrainian Military. *The Atlantic*, March 18. Available online: https://www.theatlantic.com/international/archive/2024/03/american-satellites-russia-ukraine-war/677775/

WWF-Ukraine (2024) The impact of the EUDR on Ukraine: prospects and risks. *WWF-Ukraine*, March 27. Available online: https://wwf.ua/?13330391/EUDR-Forum-in-Ukraine-results-and-prospects