THE STORY OF SPACE ACTIVITIES I.

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Cite: Idézés: Rezsneki, Zsombor (2025): The Story of Space Activities I. *Lélektan és hadviselés – interdiszciplináris folyóirat*, VII. évf. 2025/1. szám. 63-86.
Doi: https://www.doi.org/10.35404/LH.2025.1.63

EP / EE: Ethics Permission / Etikai engedély: KFS/2025/LH0004

Reviewers: Lektorok:
Public Reviewers / Nyilvános Lektorok:
1. Síposné Kecskeméthy Klára (Prof. Dr.), Nemzeti Közszolgálati Egyetem
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Anonymous reviewers / Anonim lektorok:
3. Anonymous reviewer (Ph.D.) / Anonim lektor (Ph.D.)
4. Anonymous reviewer (Ph.D.) / Anonim lektor (Ph.D.)

Abstract

For all countries, achieving technical excellence is a fundamental condition of space exploration. At the beginning of the space era, this was only a rivalry between the US and the Soviet Union. Today, many countries have the technical maturity to be able to develop an independent space programme. Until the end of the 20th century, only a very small number of countries, and mostly alongside the major space powers, developed their own space policies. In this consisting of two parts paper, I focus on examining the main stages that enabled main country's space capabilities. My primary analysis will focus on the geopolitical theories that have provided the theoretical basis for the great power plans, as well as on the rocket capabilities of the main space-capable countries, satellite capabilities and, of course, the path to the Moon landing. Space exploration became feasible in the last decades of the 19th century and the first decades of the 20th century.

The earlier eras provided a solid foundation for putting a man on the Moon today and for the continuing human interest in space over the centuries.
Keywords: Moon landing, rockets, satellites, outer space capability, geopolitics
Disciplines: military sciences, social sciences, engineering sciences

Absztrakt

AZ ŰRTEVÉKENYSÉGEK TÖRTÉNETE I.

Minden ország számára a világűr kutatásának alapvető feltétele a műszaki fejlettség elérése. Az űrkorszak kezdetekor ez még csak az US és a Szovjetunió versengésében jelent meg. Számos ország rendelkezik ma olyan műszaki fejlettséggel, amely arra mutat, hogy önálló űrprogramot képesek létrehozni, de az egyes országok a 20. század végéig csak nagyon kis számban és leginkább a fő űrhatalmak mellett alakították az űrpolitikájukat. Jelen, 2 részből álló publikációmban arra helyezem a hangsúlyt, hogy megvizsgáljam az egyes országok űrképességeit lehetővé tevő főbb állomásokat. Elsődlegesen elemzés alá veszem azokat a geopolitikai elméleteket, amelyek az elméleti alapját is szolgáltatták a nagyhatalmi terveknek, valamint elemzem a főbb űrképes országok rakétaképességét, a műholdképességeket és természetesen a Holdraszálláshoz vezető utat. Az űrkutatás a 19. század utolsó és a 20. század első évtizedeiben vált megvalósíthatóvá. A korábbi korok szilárd alapot adtak arra, hogy ma embert juttassunk a Holdra és az elmúlt évszázadok során az ember folyamatosan érdeklődjön a világűr iránt.

Kulcsszavak: Holdraszállás. rakéták, műholdak, űrképesség, geopolitika,
Diszciplinák: hadtudomány, társadalomtudomány, műszaki tudomány

„No one has been more alone in the world since Adam than Michael Collins...”
– NASA (I1)

Preface

I have based the contents of the present publication on my thesis entitled The Influence of Outer Space in 21st Century Geopolitics, defended in 2024. I have evaluated the materials revealed in the course of my research independently and in context together.

My research methodology is unique, with the specificity of a systematic geopolitical analysis developed by Ioannis Mazis, in addition to qualitative and quantitative methods (Mazis, 2014). I combined the systematic geopolitical analysis with quantitative, qualitative and comparative methodologies, and used a sub-chapter by sub-chapter induction method to arrive at the conclusions. The central element is a comparison of the US, Europe, Russia and China. I have used the systematic geopolitical analysis method to delineate the systems and subsystems through which I have examined space as a supra-system. The systems are remarked by countries or, as in the case of Europe, by regions based on territorial size or fragmentation. I have used the designation Europe or EU (including EFTA) or European Space Agency (hereinafter referred to as ESA) throughout the study, but for space activities they overlap and I mean the same region. The systems are linked by the subsystems where the specific space activity is carried out, such as launch stations, professional organisations or orbiting space stations.

The specificity of the systemic geopolitical analysis is given by the final element of the methodology, the „Supra-system”. The difference of the „Supra-system” can be found in its name, which is separated from the „Super-system” by a faint line. The designation „super” means something on top of something and also gives a physical expression to the word association with it. The term „supra”, however, refers more of a phenomenal term. This suggests a method of analysis that is more pervasive and more penetrating to the point. Thus, the main element of systemic geopolitical analysis is space activity, which permeates and embraces the specific activities of the countries of the world at a given place and time, which are related to the domain nature of space. I have also identified geopolitical factors (military, economic, political, social), which I have analysed in terms of space activities through a number of indicators such as the size of the military, the political establishment, Gross Domestic Product (hereinafter referred to as GDP), legal regulation, economic line, mineral resources, technology, social preparedness, etc.

Classical geopolitical theories

Before stepping into a historical analysis of the space age, I will analyse the classical geopolitical theories that were associated with technological developments that overcame humanity's spatial barriers prior to the Cold War. In the present study, I have examined the social geopolitical factor, using as indicators the historical foundations that preceded and followed space exploration and the space activities that resulted from the conquest of the Moon and the achievements of rocket and satellite capabilities.

The creator of German geopolitics was Friedrich Ratzel (1844-1904), who defined a state as a living organism and studied the environmental factors affecting populations in the context of migration (Churchill, 1911). He later combined this element of Socialdarwinism with the theory of naval power, as promoted by the American Alfred Thayer Mahan, and advocated the development of German naval power (Cohen, 2015). Friedrich Ratzel's main guiding principle was one state one land, according to which each state was regarded as a small group of mankind and he believed that man could not be imagined without land, nor could the living state. Man lives in a constant desire to acquire land, which he can only pursue at the expense of other living organisms (Fifield & Pearcy, 1997). In his view, the acquisition and maintenance of colonies is essential for a great power

(Ashworth, 2014). His most influential theory is the Lebensraum theory, according to which the state, as a living organism, is constantly shaping its internal and external appearance. According to this theory, states are moving closer and closer together as the surface of the land is no longer sufficient due to the spread of the seas. This foreshadows the way in which a state behaves today in order to own space (Szilágyi, 2013). In 1976, in the Bogota Declaration (signatory states: Colombia, Ecuador, Uganda, Brazil, Indonesia, Kenya, Republic of the Congo, Democratic Republic of the Congo) extended their territorial boundaries beyond the atmosphere, including the mineral resources of outer space (I2). At the same time, the territorial expansion in compliance with the outer space of each state were already included in the Outer Space Treaty and the Moon Agreement.

The word geopolitics was coined by the Swedish scientist Rudolf Kjellén (1864-1922) at the turn of the 19th and 20th centuries. He also placed the concept of the state at the centre, but separated the group of people who make up a nation from the state, which is well defined geographically (Cohen, 2015). In his theory, the state is the rational consequence of a group of people living together as a geographical organism and spatial phenomenon, acting autonomously to acquire resources (Ashworth, 2014). In Kjellén's case, the state already appears as an unit of power and econom. In his view, a country can only be a great power if it has all the necessary resources (Szilágyi, 2013). To this end, he considered expansion and self-sufficiency to be the main objectives of great power status. In his view, a clash of great powers was inevitable (Ashworth, 2014). In the case of space exploration, such an expansionist ambition could be based on space mining, which would ensure that the state carrying out the extraction would be independent of other states, thereby creating its own economy, political system and geopolitical influence on other countries at will.

Alfred Thayer Mahan (1840-1914), an American naval scientist, was more of a realist than the above-mentioned scientists. Despite his naval background, he still maintained the primacy of land power. In his view, sea power must have a land base on which to rely, but he believed that an island nation surrounded by sea could defend itself much better than a power bordered by sea on even one side. On the basis of his principles, he successfully influenced US foreign policy, arguing clearly in favour of securing a naval position and prioritising a policy of openness over isolation (Szilágyi, 2013). The position of the US as a world power was of fundamental interest. Since the expansion of other countries (e.g. Russia) into the seas would sooner or later have threatened its interests as a great power or even its economic interests (Cohen, 2015). At the same time, sea power has many advantages over land power. In terms of maritime routes, alliances, economics, the larger the area a country controls, the greater the extent to which it can access certain resources and obtain any information (Ashworth, 2014). With the help of satellites launched into space, this information acquisition has become deeper and more widespread.

According to Sir Halford John Mackinder (1861-1947), the Anglo-Saxon geopolitician, the world is in constant motion and is a closed system based on equilibrium. In his view, the status of power could be achieved by any state or empire with the characteristics of a state organisation, provided the necessary economic and geographical conditions, i.e. that it had the right size of territory, population and resources. Mackinder feared the decline of the British system and a German-Russian alliance, which he saw as something to be avoided at all costs (Dugin, 1997). However, he did not count on the US, which he saw as an Eastern power. He continued to see the position of great power as a land power, preferring the expansion of Russia on land to the colonialist British sea power conquering the coastlines of the continents (Szilágyi, 2013). Mackinder had a keen insight into the basic conditions for the growth of states and the conditions necessary to sustain imperial ambitions, but his theories were disproved by the second half of the 20th century and by space activity. Achieving imperial status is still considered in a similar way today, but great power status means something different. It takes an ever deeper knowledge of the foundations and context of human knowledge to be taken seriously. Today, space exploration is essential to retain the status of a great power, and ignoring it implies only strong military or economic influence, and supposing 'only' a strong regional power.

Mackinder's most influential work is the Heartland Theory (Ashworth, 2014). He envisaged a pivot area, corresponding to Eurasia - led by modern Russia as the largest territorial state - and a non-cresent area, consisting of an outer crescent (UK, South Africa, Australia, Canada, Japan and the US) and an inner crescent (Germany, Austria, Turkey, India and China). He later added to this by naming the Eurasian part and Central and Eastern Europe together as the core area, while the Eurasian and African continents were referred to as the World Island (Cohen, 2015). His famous sentence (from which he later dropped the first part, referring to Eastern Europe): „He who rules the Heartland rules the World Island, He who rules the World Island, rules the World"(Fifield & Pearcy, 1944. p.14).

Karl Ernst Haushofer (1869-1946) was the founder of the German school of geopolitics. He embraces the concept of the organic state and the theory of Lebensraum. In his theory of pan-regionalism, he recognises the conquest of large states and studies the concept of maritime and land powers. He advocates the need to build both along the lines of the Mahan principles. His theory is clearly in favour of the expansion of the German Lebensraum, according to which Germany and other countries of similar size and population density will only become great powers if they have a larger territory, population and seaport (Szilágyi, 2013). This requires territorial conquest. He believes that four major pan-regions should be created (PanEurAfrica, Pan-America, Pan-Russia, Pan-Asia)(Cohen, 2015).

Nicholas J. Spykman (1893-1943) was an American scientist and a champion of the policy of containment in the US. His theory was that alliances should be formed by all states. However, not to support each other, but to maintain a balance of power against other groups. He did not consider winning a war as the end of the struggle for power, as the defeated would constantly rebel against the victor. He feared European integration and favoured maintaining the Russian-European balance (Szilágyi, 2013). Spykman foresaw the geopolitical theory later used by Henry Kissinger to keep the Soviet Union and China apart, in the framework of triangular diplomacy (Kissinger, 1994). Like Mackinder, he divided the world into a Heartland, a Rimland and Offshore Islands and Continents. Here the power of the Rimland, that the US has the same power as the Core Area, is already apparent (Cohen, 2015). In concept, the periphery becomes the key zone (Ashworth, 2014).

At the dawn of aviation, during the First World War, the concept of the airforce supremacy was born. The italian General Giulio Douhet developed the tools for a strategic approach to air transport, laying the foundations for the new rules of future warfare (I3: Top War, 2023). At the same time, he introduced the concept of „strategic bombing", in which a powerful bombing raid is carried out against strategic targets located deep behind enemy lines. Douhet believed that increasing air supremacy provided the opportunity to decisively determine the outcome of a war by attacking the enemy's state and economic centres. In his view, land forces and navies could achieve military success independently of each other, since land forces could have naval assets and navies could have land troops. On this basis, he considered that both land forces and the navy could have their own airforces, but that there was still a case for the creation of a separate air force capable of carrying out military operations on its own (Douhet, 1998). Subsequently, the use of air power reached the level envisaged by Douhet in the Second World War, at the same time as Douhet's theses were confirmed. In 1941, the aircraft was already seen as a potential means of attack against which no effective defence could be expected in the foreseeable future and which could break the enemy's social morale by bombing population centres (Warner, 1973).

An announcement of the primacy of the airforce was also published on the Russian side in the person of Alexander de Seversky, a Georgian-Russian-born aeronautical engineer. Despite his heroic participation in the First World War, he settled in the US after the Bolshevik Revolution of 1917. As an outside expert, he argued that war supremacy - without the participation of warships - could be achieved by aerial bombardment alone (I4). He opened his american aircraft factory in the 1920s and lived in the US for the rest of his life, during which time he became the author of many books and a prominent figure on television (I5). He began his engineering work during the First World War, during which time he registered several patents, such as a device for guiding bombs and a ski for landing aircraft on ice. But his work was completed in the US with the development of the gyroscopic bomb guide and the ability to transfer fuel from one aircraft to another in the air (Meilinger, 1997).

The missile systems

The development of rocket systems can certainly be seen as the beginning of modern space activities. Although the fact of space activities dates back to antiquity, they only became accessible to mankind at a certain stage of technological development, during the development of rocket science. It has come a long way from the emergence of religious theories of sky-gazing in antiquity, through Chinese fireworks, to the development of today's rocket systems. In ancient times, the planets Mercury, Venus, Mars, Jupiter and Saturn were known from the Babylonians, through Greek and Roman beliefs, to Japanese and Chinese cultures. The most widely known mention of outer space is certainly found in passages of the Bible, such as Job 26:7 „He stretched out the north over the wilderness, He spreads out the northern skies over empty space; he suspends the earth over nothing." or Isaiah 40:22. It is he that sitteth upon the globe of the earth, and the inhabitants thereof are as locusts: he that stretcheth out the heavens as nothing, and spreadeth them out as a tent to dwell in or „Ephesians 1:10 to be put into effect when the times reach their fulfillment—to bring unity to all things in heaven and on earth under Christ" (I6). Nearly 2,500 years ago, the ancient Greek atomistic philosopher Democritus (460-370 BC) made a connection that remains an eternal truth: „man is a universe in little microcosmos" (Sipos, 2021, p. 429).

Although the ring of Saturn was only identified in 1655 by the Dutch mathematician Christian Huygens - using his 79 mm diameter telescope - the planets were already recognised by the naked eye in ancient times (I7). Despite the round shape of the celestial bodies, many scientific debates in antiquity were sparked by the flatness of the Earth and its central role in the world. Aristotle, the greatest scientist of the age, already claimed that the Earth was round. It took more than 2,000 years before the calculations and evidence of Galileo Galilei, Giordano Bruno or Johannes Kepler also proved that the Earth was round, moving and not at the centre of the world.

According to Sir Isaac Newton's third law (of motion), described in his Principia - based on the theoretical research of the italian astronomer Galileo Galilei and the French philosopher René Descartes at the turn of the 16th and 17th centuries (I8) - the obstacle to scientific realisation was removed, thus enabling the rocket to be used as a new technical achievement (Newton, 1946).

First developed by British Colonel William Congreve during the Indian colonial wars against the British, the Indian (rocket) device was successfully used in 1812 (I9). An essential ingredient in rocket technology is black powder, which was discovered in China in the 7th century BC. It was fought with by the Arabs in the 1200s and introduced to Europe in the 13th century (Lukács, 2008). Among other experiments by many European inventors, the Hungarian-born Lajos Martin developed a new invention of the spinning war rocket in 1856 (Tulogdy, 1941). In the second half of the 19th century, French publishers published Jules Verne's lifelike space travels, which were later similarly realised, but finally, on the Russian side, decades ahead of his time, the aeronautical engineer Konstantin Eduardovich Tsiolkovsky wrote his work on rocket science in 1903, in which he imagined interplanetary travel by rocket means (I10).

The theory only became a reality in the 1920s, following the work of American scientists Robbert H. Goddard and German scientist Hermann Oberth (Deborah, 2008). Then, in the late 1920s, in the world's first rocket programme, the german Fritz von Opel and the austrian Max Valier, in the framework of OPEL-RAK, produced in Germany the first rocket-powered man-driven cars and aeroplanes, based on earlier plans (I11). It was also on the basis of these plans and after consultation with the above scientists that the aeronautical engineer Wernher von Braun, a dedicated member of the National Socialist German Workers' Party and its military and defence organisation, the SS, began to develop his new rocket system. The research reached its climax in 1944, when the V-2 rocket was used by the Nazis against the Allies. In Paris on 6 September 1944 and against the United Kingdom from 8 September 1944 to 27 March 1945 (I12). Even the new engineering miracle could not turn the tide of Second World War and the Nazi Party's developments were implemented in the US and the Soviet Union after the lost war, together with the Nazi scientists they had taken over. Events followed in quick succession. Having obtained the designs of the V-2 missiles that the Nazis were experimenting with, development began in the US and the Soviet Union (I11). In fact, it was the competition between these two great powers that led to the perfection of the missile system. It is difficult to say which of these two states started the race to explore space, and whether the political objective was really to explore space or whether it was seen as a more sophisticated solution to the millennia-old struggle of mankind. In sum, the role of the German V-2 missile and the sound-speed-above-range capability of the US Air Force X-1 aircraft in 1947 (Benett & Cribb, 2008) made it clear that air defenses and missiles capable of destroying each other could be used indirectly to weaken, observe and launch a specific attack on the other.

The second half of the 1940s and the first half of the 1950s were mostly about building nuclear power, and the breakthrough in rocket science came in 1957. Although the first man-made object, the V2 rocket, was launched by the Germans on 20 June 1944, after two attempts, and sent into space at an altitude of 175 km (I12). The first man-made object specifically for space travel was launched by the US on 24 February 1949, the Bumper-Wac two-stage rocket system under the Hermes Programme (I13). In 1955, the US announced that it would launch a satellite into space during the newly formed and convened International Geophysical Year (1957-1958). Four days later the Soviets announced the same (I14). On 4 October 1957, following the development of the Intercontinental Ballistic Missile (hereinafter referred to as ICBM), the Soviets launched Sputnik 1, the world's first artificial moon (Mező, 20239. Less than a month later, the first living creature - Lajka the dog - had already walked through space aboard Sputnik-2. The Soviets had not planned a re-entry module for the satellite, and unfortunately „man's best friend” did not survive the experiment (I15). Belka and Strelka, however, are the first living beings to have survived a space voyage aboard the Soviet Sputnik-2 on 19 August 1960 (I16).

After that, the Soviets and the Americans came up with new missions in parallel, but the Soviets were first in almost everything. It was the Soviets who took the prestigious steps towards society. The first satellite and the first living creature were followed by the first space shuttle, which left the Earth's gravitational field on 2 January 1959. The first aircraft on the lunar surface was Luna-2 on 14 September 1959. The first man in space was Yuri Gagarin on board Vostok-1 on 12 April 1961. The first woman in space, Valentina Vladimirovna Tyereskova, on board Vostok-6 on 16 June 1963. The first spacewalk was carried out by the Soviets on 18 March 1965.

Naturally, the above would have been important for the US from a media point of view, since there was not only an arms race between the US and the Soviet Union, but the two camps would have tried to convince their allies whether capitalist or communist ideology was the long-term solution for all of humanity. In the meantime, however, the Americans were also making steady progress in space science thanks to their rockets. On 31 January 1958, Explorer-1 was the first satellite to make scientific measurements, followed by Vanguard-1 on 17 March 1958, making the first measurements of the Earth's shape and magnetic field. Vanguard-2 as the first camera in space on 17 February 1959. Then, on 1 April 1960, the US launches the first weather satellite and two weeks later the first navigation satellite.

However, the Soviet successes not only filled the population on the Western side with fear, but also worried the US political leadership, which saw the continued development of the Soviet forces and the huge sacrifice of its own military budget. By the mid-1960s, the Soviet missile system exceeded US capacity, with some 1,400 intercontinental ballistic missiles compared to 1,000 in the US. Moreover, the Soviet SS-18, the most advanced missile of the time, had twice the range of the US Titan-II, and was also highly accurate, and the arsenal included the entire SS series, such as the SS-11, SS-13, SS-19, etc (Phal, 1987). Later, in the 1970s, the US technical design system became increasingly dominant, and the Cold War competition ended with the economic and then political collapse of the Soviet Union.

Countries with missile systems

One of the biggest challenges in engineering is to get a rocket beyond the atmosphere. By overcoming the physical forces of nature, space travel could begin in Earth orbit. Any country that can do this can autonomously launch spacecraft into orbit around the Earth and autonomously carry out interplanetary space travel. A launch vehicle is typically a rocket-powered unit that transports the desired payload from the Earth's surface into space. The rocket system consists of two or three stages. The first stage, the most powerful stage, lifts the rocket system from the Earth's surface, the second stage carries the payload into space and the final stage is used to place it into orbit around the Earth. The rocket system runs on propellant, which can be liquid, solid or hybrid, a chemical mixture of fuel and oxidizer. This mixture provides enough propulsion to power the system (I17).

Currently, 10 countries and one intergovernmental organisation, ESA, are capable of independently implementing this technology and crossing the outermost layer of the atmosphere (Table1), while placing the spacecraft in orbit around the Earth (2022) (I18):

Table 1: GDP of countries with a rocket system in 2022, population and year of first space orbit. Source: I19.

	GDP (billion dollar)(I20)	Population in 1 000)	First orbital position (I21)
US	26 850	339 996	1958
Russian Federation	2 060	144 444	1957 (Soviet Union)
France (ESA) Italy (ESA) United Kingdom (ESA)	2 920 2 170 3 160	64 756 58 870 67 736	1965 1971
Japan	4 410	123 294	1970
China	19 370	1 425 671	1970
India	3 740	1 428 627	1980
Israel	539	9 174	1988
Ukraine	148,7	36 744	1991
Iran	367	89 172	2009
North–Korea(I22)	app. 30 (2021)	26 160	2012
South–Korea	1 720	51 784	2022

Table 2: Countries' most powerful missile systems, with maximum payload capability in Earth orbit. Source: I24

	Launching system (I25, I26)	Payload to LEO -Low Earth Orbit(in kg)
US	SLS Falcon Heavy	95 000 63 800
Russian Federation	Proton	23 700
France (ESA)	Ariane–5	16 000
China	Long March 5B	25 000
India	LVM3	10 000
Italy (ESA)	Vega C	1 430
North–Korea	Unha	200
South–Korea	KSLV–2 (Nuri)	3 300
Israel	Shavit 2	800
Ukraine	Zenit	13 700
Japan	H3	4 – 8 000
Iran	Qaem 100	80

Of the countries in Table 1, however, only seven countries or regions have the capacity to launch satellites over 1 tonne (I23). Many countries are developing rocket systems, but currently only these countries have the capability to launch their own space assets into space. Dozens of countries have various types of space launchers which, with further development, could reach the threshold of space activities. The development of these sounding rockets will give each of these emerging countries a wealth of experience in the use of operators, launch stations and other scientific advances for a future space mission (Table2). From Table 2, it is clear that countries have varying rocket capabilities. At the same time, several developments are underway that will likely increase the number of rocket systems suitable for space travel. For understanding this chapter, it is important to highlight that the three space superpowers (US, Russia, and China) are continuously developing and testing their super-heavy launch systems, which are capable of sending payloads over 100 tons into space. Until today, only the US has successfully operated a super-heavy rocket system into space, with which it also accomplished the Moon landing. The SATURN-V, as part of the Apollo/Skylab project, was capable of sending 140 tons of payload into space. The Soviet Union's Energia rocket system was able to transport 100 tons of payload into space; however, it is currently out of service and only experienced two successful launches.

Table 3: Super-heavy rocket systems under test with country of origin and maximum payload in orbit around the Earth. Source: composed by the author

Countries	Super–heavy rocket system	Payload to LEO (kg)
US	SLS Starship (two types)	130 000 150 000 és 250 000
Russian Federation	Don	130 000
China	Long March 9	150 000

Among the countries listed in Table 3, the US is still continuously experimenting with the launch of the Starship, while Russia and China are promising that their rocket systems will be ready by the end of this decade. At the same time, alongside their super-heavy rockets, these countries are also constantly developing smaller, yet more advanced rocket systems than the current ones available today. Russia is working on the Yenisei rocket, which, at 103 tons of payload capacity, is smaller than the Don, while China is developing the Long March 10 rocket, which has a payload capacity of "only" 70 tons. In addition to the currently tested super-heavy rocket systems, the US is also testing significant new tools. The Space Launch System (hereinafter referred to as SLS) will develop two additional rockets by the end of the decade, capable of sending 105 tons and 130 tons of payload beyond the atmosphere.

US and Russia (Soviet Union) Masterizing the Moon

The most powerful rocket system of all time was the SATURN-V, which assisted the American Moon landing on July 20, 1969 (I26). The Soviet Union began its Luna program in 1959, which aimed to accomplish several tasks, such as flybys of the Moon, tracking its orbit, and performing a landing. The first man-made object to touch (impact) the surface of the Moon was the Soviet Luna-2, on 13 September 1959. In parallel with the Luna program, the Soviet Zond program was initiated, though it had fewer launches and was quickly terminated. Its primary goal was to take photographic images of the Moon's surface in preparation for a later crewed landing. The Luna program continued until 1976, terminating with the Luna-24 mission. The first satellite to orbit the Moon was deployed during the Luna-10 mission in 1966. At this point, the US had already started the Pioneer program in 1958, but despite seven attempts, it could not succeed with its Moon goals (I27). In the Soviet Luna-9 program, the first successful landing on the celestial body occurred in February 1966 (I28). The US, however, successfully completed its Moon landing in June of the same year, and between then and 1968, it made five more successful landings under the Surveyor program (I29). For a time, it seemed that the Soviet Union might compete with the US in the Moon race. On November 17, 1970, as part of the Luna-21 program, the Soviet Union became the first to build and successfully deploy a lunar rover (Lunokhod). However, due to a lack of funds and rocket systems, the entire Moon program was abandoned in 1977 (I30). Demonstrating its technological prowess by then, the Soviet Union successfully returned lunar rocks to Earth three times under the Luna program, bringing back about 300 grams of lunar samples between 1970 and 1976 (I31). However, when comparing the overall achievements, this was far less than the American performance, as the US returned approximately 380 kg of lunar rocks between 1969 and 1972 as part of the six successful crewed Apollo missions (I32). During these missions, a dozen Americans walked on the Moon.

The most symbolic difference in the competition and technological demonstration between the two countries occurred on the day of the Moon landing. On 21 July 1969, as American astronauts Neil Armstrong and Buzz Aldrin completed the first human walk on the Moon, the Soviet spacecraft from the Luna-15 program crashed into the Moon's surface, thus burying and covering the Soviet Union's dream of being the first to bring back lunar samples (I33). The US was left without a competitor, and after 1972, there were no further attempts at crewed Moon landings. However, political initiatives were made on several occasions. In the early 1980s, many scientists focused on repeating the Moon landing, but the preference increasingly shifted towards establishing a Moon base and crewed missions to Mars. In 1989, US President George H. W. Bush's Space Exploration Initiative was canceled during his successor Bill Clinton's administration, primarily due to budgetary concerns (the 1969 landing cost $25 billion) (I34). Meanwhile, the parallel construction of a space station also faced significant political opposition. The return to the Moon was announced in 2004 by US President George W. Bush under the Vision for Space Exploration program, but it was canceled in 2010 during the Obama administration (I35). Today, the stance on returning to the Moon appears more unified, and the technological challenge is expanding with the involvement of several countries.

Why the Moon? In 1865 and 1870, the french writer Jules Verne published two works (From the Earth to the Moon and Round the Moon) that dealt with the theme of lunar travel. The books explore the possibility of creating a cannon capable of sending a cannonball to the Moon's surface. A bit later, but still of similar significance, came H. G. Wells' novel *The First Men in the Moon* (1901), which also captured public interest (I36). Of course, one can trace the history back even further — on scientific grounds — to the time of Galileo Galilei, when the italian physicist used his telescope to study the lunar surface. It can even be traced to the 2nd century AD, with Claudius Ptolemy's *Almagest*, in which he attempted to define the movement and position of the planets and other celestial bodies, including the Moon, through spherical trigonometry (sine, cosine, tangent, cotangent formulas), which was based on Aristotelian and Platonic principles that emerged in the Hellenistic period. The Ptolemaic model of the universe remained influential until the 17th century. Before this, the roots of celestial studies can be traced to ancient Egypt and Babylon, as well as to prehistory, with monuments like Stonehenge, where the positions of the Moon and stars were analyzed (I37). Overall, we can say that the phenomenon of celestial bodies has always fascinated certain members of humanity, even if, in the beginning, society saw religious elements in them. In the early 20th century, lunar travel became a popular topic in some Western countries, inspired by Jules Verne's aforementioned works. Verne influenced American rocket scientist Robert H. Goddard as well. In Russia, Konstantin Eduardovich Tsiolkovsky, also inspired by Verne and the shape of the Eiffel Tower being built at the time, developed the flight formula in 1898 for sending a rocket into space (I38). Later, in 1903, he established the technical formula for modern spacecraft and the multi-stage rocket powered by liquid oxygen and liquid hydrogen fuel (I39). Tsiolkovsky is still regarded as one of the fathers of rocket science, alongside German scientists Hermann Oberth and Fritz von Opel, American Robert H. Goddard, and Frenchman Robert Esnault-Pelterie. Afterward, rocket science took different paths in various countries, with Germany making significant strides with the development of the V-2 rocket during Second World War.

Returning to the Moon, the 1920s were mainly focused on rocket experiments. However, parallel to that, various civil organizations dealing with interplanetary travel were established (russian-soviet, german, american, british), whose primary goal was to connect rocket science with space travel. Between 1937 and 1939, from a scientific perspective, the British Interplanetary Society (BIS) — led by science fiction writers Arthur C. Clarke and H. G. Wells — was the first to explore the possibility of making lunar travel a reality (I40).

In 1919, Robert H. Goddard presented the idea to the public, attracting both confusion and ridicule. However, in theory, every rocket scientist had asked the question of whether lunar travel was possible. His presentations were publicly discredited, and even the *New York Times* harshly criticized him, claiming that his theory demonstrated his ignorance of basic physics learned in elementary school (I41). The BIS, however, advanced much further. They began studying the materials science of space vehicles and proposed concrete suggestions for designing space-suits to be worn on the Moon. They also analyzed atmospheric obstacles from a physical standpoint, creating a technical committee for this purpose (I42). This all took place before the Second World War. Therefore, the idea of lunar travel goes back much earlier than its realization in 1969. However, from the mid-1950s onward, the two superpowers, the US and the Soviet Union, deliberately began preparing for a crewed lunar landing through their rocket programs. Based on the above, in the beginning, only distant study of the Moon was feasible, but the launch of *Sputnik-1* in 1957 was followed by other satellites and tests.

undeniable central figure of the Soviet space program was rocket engineer Sergey Pavlovich Korolev. In the 1930s, he began his work with liquid-fuel rocket systems. However, due to disagreements with his superiors and despite Stalin's recommendation to pursue solid propellant research he focused on liquid fuel, he fell victim to the Great Purge of 1937-1938, along with many other brilliant engineers (I43). He was imprisoned in various Soviet prisons, where thousands died daily from inadequate food, clothing, or brutal treatment. After a few years of captivity, during the early years of Second World War, he was transferred to a special prison for engineers and scientists, where he could continue his work. After the war, following the Soviet acquisition of the German V-2 rocket type, Korolev joined the Soviet Experimental and Design Bureau (опытно–конструкторское бюро, Opytno Konstruktorskoye Byuro, OKB). His talents were recognized, and he was appointed head of the Soviet rocket program (I44). Under his leadership, the R-7 rocket family was developed, as well as the N-1 rocket — the foundation for the later Proton rocket — which was left unfinished due to Korolev's death but was likely intended to be used for a lunar landing (I45).

The R-7 rocket helped the Soviet Union to send the first satellite, the first living creature, and the first human into space as part of the Vostok spacecraft and program (I46). This was followed in 1964 by the Voskhod spacecraft and program, where in 1965, Aleksei Arkhipovich Leonov performed the first spacewalk. Around this time, the development of the Soyuz spacecraft began, alongside the aforementioned N-1 rocket, which was planned to be used for the lunar landing as well. Unfortunately, Korolev's health was severely affected by his years in prison, and he passed away in 1966.

Soviet engineer Yuriy Vasilyevich Kondratyuk also explored the possibility of lunar travel as part of the Lunar Orbit Rendezvous (LOR) program (I47). However, like many others, he was imprisoned. Learning from Korolev's example, he did not push for recognition of his scientific work. Later, the United States—later acknowledged by Neil Armstrong—used his findings in the Apollo program (I48). Kondratyuk disappeared during Second World War in 1942. Many scientists focused on economics faced a similar fate. Vasily

Vasilyevich Leontyev, a Russian-born economist who would later win the Nobel Prize, studied the interaction between different economic sectors (industries) in the US based on the Soviet planned economy. However, for his stand on behalf of freedom and the scientific community (against scientific censorship) (Gardfield & Leintif, 1986), the Stalinist regime „rewarded" him with either starve or imprisonment (I49).

To this day, the US is the only country that has put a man on the Moon. Founded in 1958, NASA - whose main mission is to make space flight a reality - carried out several successful moon landings between 1968 and 1972 as part of the Apollo programme. In the early 1960s, the Mercury programme was completed and the transition was made to a multi-person spacecraft (Mercury carried US astronaut Alan B. Shepard into Earth orbit on 5 May 1961) (I50).

The Apollo programme was designed for three astronauts and was tested from the 1960s onwards under the Gemini programme, with the two-crew type (I51). The Apollo programme was more than just a landing on the moon. Instruments were designed and developed that later contributed to other space activities. These included Skylab, which created the hardware for an Earth-orbiting space station in 1973-1974 (I52), and the Apollo-Soyuz programme in 1975, when the joint US-Soviet space programme began as the Cold War eased.

Europe

After Second World War, Europe was weakened. However, the American-Soviet confrontation analyzed above was based on European technological achievements. This is the strange rise of the US and the USSR as great powers, resting on scientific research that was founded by Germany, which had started Second World War and then suffered a complete defeat.

Germany, the United Kingdom and France were busy balancing each other's power, while receiving security guarantees from the US and the USSR. At the same time, Europe's intellectual potential gained new strength like a phoenix. In 1957, it created the European Economic Community and then turned to space activities, among many other areas.

European space activity began with the establishment of two main organisations: the European Launcher Development Organisation (ELDO) and the European Space Research Organisation (ESRO). ELDO operated between 1960 and 1974 and was intended to develop European missile capabilities to replace the British Blue Streak medium-range ballistic missile system. ESRO was established in 1964 and was tasked with ensuring scientific research in outer space. The two organisations merged in 1975 to form ESA (I53). Today, it has 22 members: Austria, Belgium, the Czech Republic, Denmark, Estonia, Finland, Germany, France, Italy, Greece, Ireland, Hungary, Luxembourg, the Netherlands, Norway, Poland, Switzerland, Portugal, Spain, Romania, Sweden and the United Kingdom. The organization has an associate member Canada and cooperating partners Bulgaria, Cyprus, Latvia, Lithuania, Malta and Slovakia. It has strategic partnership agreements with the US, Russia and China, and maintains relations with organizations in Japan, India, Argentina, Brazil, Israel, South Korea and Australia.

Before the formation of ESA, ELDO was already working on a three-stage rocket system capable of placing satellites into orbit around the Earth. The British government had already felt the need to develop similar rocket systems in the 1950s, similar to those developed by the US and the Soviet Union. However, the cost burden forced the United Kingdom to continue the development together with other European countries. As a result of the division of labor, the British built the first stage, the French the second and the Germans the third stage (I54). The telemetry equipment was developed by the Netherlands and Belgium. The project did not achieve the desired effect due to internal problems within ELDO and mixed success. In 1973, France, in consultation with the United Kingdom and Germany, who had lost interest in continuing the project, decided to carry out the development of the rocket system alone (I55). France carried out the task with Airbus and Arianespace and established the European launch base in its overseas department of French Guiana. The result was one of the most important rocket families in the world (Ariane), which made ESA a leader in commercial space launches in the 1990s. Europe became independent in carrying out space activities (I56). Ariane-5 retired in 2023 and one of its last tasks was to put the world's most advanced James Webb Space Telescope (JWST) - a joint venture between the US and ESA - into orbit (I57). The new Ariane-6 heavy launcher is still being tested today, with its first launch tests taking place in 2023 and 2024.

Based on the GDP data in Table 1, Russia cannot compete with much smaller and less well-off countries today, but its role in space exploration continues to place it among the developed countries. In terms of its economic strength, we can further compare Russia's GDP with the GDP of the BENELUX (Belgium, Netherlands, Luxembourg, Belgium, Netherlands, Luxembourg, hereinafter referred to as BENELUX) countries (in 2022 Belgium 578 billion 604 million dollars, Netherlands 991 billion 114 million dollars, Luxembourg 82 billion 274 million dollars), which totals approximately 1,650 billion dollars, or with the GDP of the Northern European countries (in 2022 Sweden 585 billion 939 million dollars, Norway 579 billion 267 million dollars, Finland 280 billion 825 million dollars, Iceland 27 billion 841 million dollars, Denmark 395 billion 403 million dollars), which totals approximately 1,900 billion dollars. The GDP of Great Britain and France is 50% larger than Russia's GDP, and Italy also exceeds it. Japan and Germany have GDPs that are almost 2-2.5 times larger than Russia's. Furthermore, the economies of the countries that form the basis of European space exploration exceed the size of China's economy. At the same time, the Soviet Union was the second largest economy – after the US and in close competition with Japan – when it collapsed in 1990, and yet it was unable to complete its space program (I58).

China

The second and third steps of China's space activities are directly linked to the Soviet Union. It launched its first satellite in 1970 with its own rocket system. Soviet-Chinese relations were strong before the border dispute in 1969, but after that there was only minimal cooperation until the end of the Cold War. Following the competition between the major space powers, China decided to send a man into space by 1973, under the Project-714 program (I59). However, the program was canceled in 1972 for political and economic reasons and was revived again in the 1990s under the Project-921 program - together with plans for a space station (I60). The Soviet Union not only made the ballistic missile system available to China, but also undertook the training of astronauts and provided the necessary technical conditions (spacesuits)(I61). China sent a man into space in 2003 with the Shenzhou-5 spacecraft, which is a structural copy of the Russian Soyuz (I62).

In 2014, Russia and China strengthened their former space alliance under Western sanctions, and Russia provided significant assistance to the development of the Chinese satellite system BeiDou. The cooperation between the Russian GLONASS satellite system and the BeiDou satellite system created a much more accurate positioning system, and data sharing between the two countries became continuous (I63). In 2018, Russia authorized the sale of the RD-180 rocket, which was the basis of Russia's space activities, to China. The US also purchased the RD-180 rocket for its Atlas missile system in the early 2000s, but after the annexation of Crimea in 2014, the US withdrew it as a political decision and did not purchase any more (I64).

Russia grew closer to China in the 1990s after the end of the Cold War, but after China's manned spaceflight, it decided to reduce its support for China, fearing the primacy of the US-Russia alliance in space activities. In 2006, Russia believed that China was 30 years behind it, but realizing this reality, it banned the transfer of space equipment, including the RD-180 rocket (Qisong & Nishan, 2021), (I65), Today, cooperation is closer, based on the freer flow of Russian high-tech and Chinese chips between the two countries.

However, if we go back in time and examine China's first steps in space from the time before space activities, we come to the direction of the US. After the suppression of the Boxer Rebellion in China in the late 19th century, China had to pay reparations. However, the US established a Boxer Indemnity Scholarship (hereinafter referred to as the Boxer Indemnity Scholarship) program, in which the Chinese reparations were recycled and Chinese students were given the opportunity to study at American universities (I66). Many Chinese scientists graduated in the US and returned to China to do scientific work. Qian Xuesen, known as the father of Chinese space exploration, earned a scientific degree and taught at the Massachusetts Institute of Technology (hereinafter referred to as MIT) and the California Institute of Technology (hereinafter referred to as CalTech) in the 1930s, after studying at Peking University, also working under the supervision of Hungarian-born physicist Tódor Kármán (I67). After years of house arrest in the 1950s for his support for communist China, he returned to China (I68). He became a member of Chinese academia and played a pioneering role in the development of ballistic missiles, based on experience gained at NASA's JPL (I69). Communist China then found a new partner in the Soviet Union.

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