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Space 4.0 – a common, democratic European space, part 3

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Abstract— **Building a common, democratic European space is not only a huge economic, industrial and social undertaking. This is a very complex civilizational and political undertaking, of a global nature, but generated in our European space giga-region coordinated by ESA and strongly coupled with the American space giga-region of NASA. Policies for the implementation of common democratic space over other giga-regions are slightly different, so the globalization of the idea of space development is politically and economically highly hybrid. Various space giga-regions are more or less politically and economically susceptible to cooperation and acceptance of certain general principles as a lasting common denominator. In the NASA and ESA giga-regions we have the slogans NewSpace and Space 4.0, which we call together as OpenSpace. A very strong common basis of these giga-regions, but also of China and India, is the emphasis on developing and strengthening the private space sector. It is about the creation, strengthening and development of large companies capable of producing rockets, transport systems for people and goods, as well as numerous SME sector companies that can provide a significant variety of space infrastructure services. The development of space and satellite technologies in Europe is very uneven. Only a few countries have their own infrastructure of a self-sustaining space eco-system. The idea of Space 4.0 includes equalizing space opportunities in Europe. To become globally competitive, Europe must carefully implement its policy of equalizing the development of space technologies in its territory. A version of this paper in Polish was published in Elektronika Monthly by SEP.**

Keywords— **space policies; Space 4.0 project; European Space Agency; space democratization; space and satellite engineering**

I. Introduction

We are talking and describing in more and more detail the construction of the space potential of our civilization [1]. We define this potential as OpenSpace. Ideas such as NewSpace and Space 4.0 [2] present some innovative and socio-economic fragments of the construction of this potential [3]. The benefits and threats of building an economic space are analysed [4]. Sometimes the idea of Space 4.0 is called the Technological Space or Economic Space [6]. Large space companies [8] and the SME sector are interested in this new economic space. The processes of building economic space are studied from the technological, economic and market perspectives [7]. The OpenSpace potential is being created in many regions of the world [5], and also very intensively in the European Space 4.0 region [9], [10], [11], [12].

The Space 4.0 idea cannot be implemented without nanosatellites and microsatellites. We can say that small satellites were initially one of the serious incubators of opening up outer space and giving birth to the idea of OpenSpace, and not the other way around. They gave a strong impulse to open up space. No one could oppose too much and for too long the idea of sending nanosatellites by pupils, students, numerous interested academic communities, who did not have large funds for other forms of fun in the space. Additionally, very quickly individual nanosatellites turned into even more effective and even more eye-catching constellations. Paraphrasing Godzilla or Jurassic Park, we talk about Space 4.0 "no size but the large number counts".

In other words, the decisive factor was the large dispersed interest, the number of designed and ready-to-orbit satellites and their low costs. Of great importance were the weight and dimensions, as well as the considerable functionality of small satellites sent effectively to various LEO orbits and performing their tasks very effectively. It can be said that only in the second stage did OpenSpace become an active incubator of new technologies also in nanosatellites and their larger micro and super-micro clones. This direction of development of satellite technologies turned out to be very quickly leading and necessary with the growing demand for modern services effectively offered by small, versatile, and numerous satellite equipment.

It was hard to imagine a quarter of a century ago that the nanosatellites created at that time, as a technical standard and operating exclusively in the academic environment, would today, 25 years later, effectively serve local communities, selected limited areas of the Internet, sparsely populated areas without access to other services, provide broadband communication services with very low latency from LEO orbits. Constellations of nanosatellites and microsatellites have also proven effective in serving global IoT/IIoT systems. Such satellite systems are slowly replacing some classic solutions. In certain application areas, they are becoming irreplaceable, thanks to flexibility, low costs and rapid prototyping using non-specialized popular commercial parts. Nanosatellites are economically proven in the implementation of quick hardware and software tests, as well as low-cost performance of specialized research tasks.

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II. Open Space – incubator of new technologies and services - OpenSpaceServices

On the new, incomparably denser hardware base initiated evolutionarily by Space 4.0, a completely novel, large service sector is being built. New Space, Space 4.0 and OpenSpace create infrastructure completely different from the previous one. Let's call this new service sector OSS the OpenSpaceServices. Satellite radio channels covering a dense network of uplinks, downlinks, constellation and inter-constellation connections are subject to very strong integration with terrestrial radio, cable, and fibre optic networks. A new type of infrastructure is being created, which will be subject to virtualization in the next development stages. On such a virtual base, the OSS systems will have the possibility of development in their own, dynamically created, virtual space.

In what conditions do we currently operate before we reach this stage? The ground module of the satellite system is formed by the base stations of the backbone ground network, mobile or stationary subscriber terminals, network adapters and control stations. The terminals are equipped with transceiver antennas. Space modules depend on the type of satellite and the type of orbit. There are large differences in latency between LEO, MEO and GEO orbits ranging from a few ms to several hundred ms. The visibility of satellites in different orbits for one subscriber station is also different, e.g. for LEO satellites in the range of 10-30 minutes. The area visible by the antenna of a LEO satellite is about 4000 km. The continuity of satellite connections is ensured by appropriately distributed constellations, and in the future by virtualization of equipment and services.

Similar to terrestrial network systems, satellite systems have a simpler access or full access-backbone architecture. In the first case, the satellite is a broadband mirror for radio signals. In the second case, the satellite is an intelligent network node, also having the functionality of inter-satellite communication of the ISL (Inter Satellite Links) standard. Many currently operating telecommunications satellites have an access architecture, simpler and much cheaper than the architecture of a full intelligent access-backbone network node. The future definitely belongs to small satellites in the form of full intelligent network nodes. Access satellites will probably only be a supplement.

Until recently, such an effective massive network could not be created due to costs and other technologies used in the pre-Space 4.0 era. As a result, the group of potential subscribers of such networks was relatively narrow, completely contrary to the idea of satellite networks. The SatCom sector has so far been an elite infrastructure serving, for example, large financial and economic institutions with extensive structures of their own virtual networks. Space 4.0 completely changes this situation and for the first time breaks the accessibility barrier. However, it is not about accessibility only to satellite telecommunications networks, but to services where such networks are integrated and constitute an integrated hardware and software component. Such a system ensures the operation of an environment where various services are implemented. This creates a completely different approach to business, opening up opportunities for the SME sector.

The spectacular success of the Starlink satellite constellation and the satellite Internet access service it offers at a speed of 10 Gb/s (up to 23 Gb/s) has clearly and for the first time shown the capabilities of a constellation of small satellites consuming power below 100 W (average 50-75 W) per satellite. Currently, the Starlink constellation consists of significantly more than 5,000 of these small satellites orbiting the Earth every 90 minutes at an altitude of 340 to 1,200 km, an average of just over 500 km. This is a LEO category distance, so in terms of signal, these satellites have ultra-low latency, much lower than geostationary satellites. Over 20 Starlink satellites are currently visible over Poland. It should be emphasized that Starlink has nothing to do with CubeSat technology, but if CubeSat had not been globalized so quickly and achieved such success, there is no telling what the fate of Starlink would have been.

The small satellite sector is very diverse. Both CubeSat and Starlink of the first generation, and many other satellites with sizes categorized into pico, nano, micro, and mini belong to this sector. The categorization of the satellite is determined by weight. CubeSat is a maximum of 1.5 kg and the module size of 1U 10x10 cm, and a typical first generation Starlink weighs about 260 kg, and its dimensions are up to 2.8x1.4 m. The transport proportions of CubeSat - Starlink are about the same as a children's bicycle to a truck. The Falcon 9 rocket carried up to 60 such satellites into orbit at once. It is not surprising that within the general group of small satellites, these are completely different satellite technologies. But they have a strong common denominator, the entire small satellite sector belongs to OpenSpace, which in Europe we call Space 4.0 and in the USA NewSpace.

The OpenSpace idea is developing rapidly. The small satellite sector is changing dynamically. The largest satellites in this category are growing rapidly, crossing subsequent weight and size barriers in the small satellite group. Rapid prototyping is changing satellite equipment extremely effectively. Satellite factories are starting to emerge, fully robotic, somewhat similar to Tesla car factories, producing satellite equipment on a conveyor belt. This is what is happening in the USA and China. Such are the European plans. The requirements for the digital throughput of small satellites are increasing dynamically. Hence, a new generation of Starlinks was developed in two versions, in which these satellites have grown significantly, even beyond the category of small satellites. This is the order of things, indicating a very successful direction of evolution. OpenSpace and Space 4.0 are the growth hormones of small and large satellites.

The Starlink V2 Mini version already weighs 800 kg and measures about 7 meters. The Starlink V2 Mini is also launched into orbit by the Falcon 9 rocket, but 21 pieces at a time. Even larger full versions of the V2 will be launched by the large Starhip rocket. The Starlink V2 Mini contains a new generation of phased array antennas with a scanning beam, uses a wider band, including the E band for reverse data transmission, which increases the throughput of a single satellite transponder four times compared to the Starlink V1 version, i.e. to about 100 Gb/s. This is still an order of magnitude less than the assumed goal of 1 Tb/s of full technical profitability of building integrated satellite virtual networks.

Of course, the question arises: what is the point of a gigantic, multi-thousand Starlink satellite constellation? A constellation that is supposed to eventually have as many as 40,000 satellites or more. Given the competition in this sector, there will be many more, probably hundreds of thousands. One can quickly answer that in densely populated European areas, well served by a dense ultra-broadband fiber-optic network and 5G, it currently makes no sense. The constellation is suitable for areas where connectivity is unavailable or poorly available, for sparsely populated areas where classic satellite communications do not reach. The Starlink constellation can of course immediately serve as a replacement communication, system support for special purposes, security, during natural disasters in specific regions, health and epidemic applications. Let us remember that Starlinks strongly support communications in Ukraine. However, this is the point of view for today.

But what can we say about the future of the constellation, not such small satellites, but medium-sized and large ones? Starlinks have competitors: Meta Space, Athena PointView, OneWeb Virgin, and above all the Chinese G60 Star Link. The market for the Internet from space is hot, and it is not known whether it will not exceed a critical temperature at some point. The main battlefield is throughput. Starlink V2 Mini offers 100 Gb/s. Starlink V2 is planned for 400 Gb/s. Throughputs over Tb/s or even much higher and covering the entire sky with this type of satellite may mean significant competition in the future for cable solutions for which it is necessary to dig channels underground and place hundreds of antennas for the G6 or G7 system, which must somehow be deployed in densely populated metropolitan areas.

Nanosatellites have grown to micro and are still small satellites. Small service satellites are growing to larger and larger, which completely changes the image of OpenSpace. Tens of thousands of satellites, soon rather hundreds of thousands, and in the perspective of decades millions sent to attractive LEO/MEO orbits completely change the image of OpenSpace. Near space is becoming not so open. We have a catastrophe in the ultraviolet, i.e. in the LEO/MEO area. Just as with ultraviolet a series of scientific discoveries showed the solution, in the case of OpenSpace everything will have to be reformatted and the thinking about space will have to be changed again. Such a development image is very likely for many reasons.

The idea of open space has been forming and maturing into its current form for several decades. In different giga-regions, the idea of OpenSpace is perceived differently, which is influenced by local political systems. Without a doubt, everywhere on a global scale, there is an economic opening of space. The methods of practical implementation of this opening in giga-regions are different. In the NASA-ESA giga-area, OpenSpace achieved its first significant successes very quickly through almost instantaneous, sometimes approximate, adaptation of many classic technologies to space conditions. This speed of action, and the use of other technologies, have proven to be very beneficial and bode well for the future.

Many classic technologies, standards and sequences of building OldSpace satellites were abandoned in the construction of small OpenSpace class satellites. Moreover, some of these classic technologies became outdated and were replaced by new ones. This reduced the costs of hardware production, in many cases even by two orders of magnitude or more, and shortened the production time of space infrastructure several times. Most importantly, despite such seemingly risky moves, it was possible to maintain a sufficiently high reliability of the infrastructure, including orbital and ground hardware and software, as well as user, service, functional, operator and service interfaces. Fast, simplified OpenSpace technologies turned out to be mature, supported by industrial technologies.

Of course, this success did not come from nowhere. OpenSpace technologies have benefited substantially from Industry 4.0 procedures, and in particular from advanced methods of fast and ultrafast prototyping FP/UFP. FP currently uses not only advanced programming environments such as 3D/4D MathCAD, but is supported in design and comprehensive testing by machine learning methods, artificial intelligence and its generative version GenAI. New generations of small OpenSpace class satellites are characterized by significant flexibility of hardware and software solutions, modular design, standardization, possibility of reconfiguration, large service capacity, several orders of magnitude lower level of energy demand, use of fast prototyping and cheap ASIC systems resistant to ionizing radiation in LEO/MEO conditions, use of redundant FPGA/VHDL technologies optimized for space.

Interestingly, the technologies of large classic OldSpace satellites have now begun to switch to modern methods of rapid prototyping and deep ultrafast testing developed and tested in the construction of NewSpace/Space 4.0/OpenSpace generation satellites. OpenSpace incubates significant changes in large satellites. If large satellite technologies had not noticed these changes imposed by OpenSpace or had ignored them, the sector would have been left behind. However, this is not the case. In the large satellite sector, there is strong competition for financial efficiency, production speed, functional flexibility, which are priority attributes in NewSpace/Space 4.0, but were not the most important ones in the OldSpace era.

OpenSpace covers, or rather appropriates, increasingly larger areas of space activity. OpenSpace not only expands and modifies classic technologies and introduces new ones, but due to the specific conditions of operation of equipment and services in space, it is a strong initiator of innovation and creation of very beneficial development directions. In the case of small satellites, it seemed that they could be suppliers of micro and mini services, or serve to perform specific specialized and narrow research and development-innovation tasks. This is of course the case due to the significant market demand for such small but specialized tasks. Small satellites test many new technologies at low cost that promise wide applications and reduction of production costs of larger satellites, or development of satellite services.

In parallel, the idea of using small satellites has been extended with great benefits to satellite constellations that can perform large research tasks and very complex services, also of a distributed, observational, communication and global nature. The hardware layer of hard space technologies includes the overall maintenance of orbital and ground infrastructure by a single specialized company. Such a space hardware layer or a system or network of such layers are overlaid with services, usually provided by another specialized company. Such infrastructures and related services are offered using small satellites from LEO and MEO orbits. A significant advantage of using a constellation of small satellites is the low costs of launching into orbit and maintaining the infrastructure compared to standard large satellites. An entire smaller, several dozen-unit constellation of small satellites can be launched into orbit and deployed appropriately in space using a single orbital mission.

The development of space technologies very often uses previously developed development paths and adopted terminology in other hi-tech sectors. OpenSpace is very similar to OpenSource, OpenHardware, OpenUniversity, OpenSociety. Satellite as a Service is very similar to Software as a Service, even with the same abbreviation SaaS. Recently, in computing technologies we have Cloud and Quantum Computing as a Service CCaaS and QCaaS. In satellite technologies we have a satellite constellation as an SCaaS service, and also satellite communication as a service with the same abbreviation SCaaS. Using the same abbreviations speeds up the implementation of space technologies, because the standards and implementation and user procedures are very similar. In a similar way as with the classic service, a subscription is purchased from a satellite service provider SSP (satellite/space service provider). In the next stage of development, SCaaS type services will be subject to further development and standardization.

OpenSpace is also currently beginning to implement virtualization and abstraction techniques from the satellite and terrestrial hardware layer. The entire space hardware layer, including all its components, orbital and terrestrial, is shared and virtualized. The technique is analogous to the sharing and virtualization of fiber optic and 5G antenna telecommunications infrastructure. Dynamically variable and reconfigurable virtual service layers are applied to the virtual hardware layer (layers), which becomes invisible to the user. The technique is analogous to many well-known and stabilized Internet services such as local, private, virtual networks, IoT services, IIoT, Internet of Everything, security and cybersecurity services, supervision, monitoring, cloud computing, and many others. A special sector in this wide collection of services, for understandable reasons, and due to significant investments, is becoming the area of space security, concerning all components of the infrastructure, hardware, software, and the quality and security of the services provided.

A large part of such activity, and additionally growing, are satellites imaging the Earth, especially of the NGSO class. This results from significant progress in satellite imaging techniques, as well as data processing, correlation and presentation. Added to this is a complete change in increasingly efficient techniques for transmitting massive amounts of data between the satellite and receiving stations on Earth. Intelligent, reconfigurable antenna systems on the satellite, combined with software using artificial intelligence procedures, enable fast handling of many data streams to many simultaneously serviced clients. In terms of the massiveness of data transmission, satellites are conventionally divided into HTS and VHTS (high/very high throughput satellites). GEO satellites constitute a separate group serving this large, specific sector. The GEO satellite sector is customarily divided into GSO and NGSO. These are fundamentally different classes of satellites. The NGSO sector is served by Space 4.0 class satellites.

The area that we call here as OSS OpenSpaceServices in short and in accordance with the nomenclature used is a new gigantic business space, the dimensions of which we are not fully aware of today. We need to mature to fully develop this area. The first decade of more intensive development of OpenSpace technology only whetted our appetites, and very unevenly in different giga-regions. Not the entire Globe has woken up yet, which is understandable, but some regions have begun to seriously invest in the development of this sector. Currently, the determinant and limitation of OSS development and increasing its diversity is satellite equipment, of which there is still very little. The first decade of OpenSpace intensification has only just begun, still somewhat timidly, sending equipment to LEO orbits. Only the second decade will awaken a large stream of equipment transported non-stop to orbits. Initially, these will be tens of thousands, and then hundreds of thousands of tons of satellites. Current analyses of the costs of such transport to LEO orbits at an altitude of 500-600 km indicate a reduction within a decade to a level well below 100 Euro per kilogram. Then we will experience the OSS revolution, a foretaste of which we are already feeling today.

III. OpenSpace – Satellite UV Catastrophe – Whose Fault Is It?

What counts in space and satellite technologies: size, quantity, quality, differentiation? If in what we are currently observing as a consequence of OpenSpace we are heading towards the analogy of a cosmic catastrophe in the ultraviolet, can we analogously expect some fundamental breakthrough? Let's go back once again to the basic attributes of satellites that realize the OpenSpace era. This era caused, as mentioned, an increase in the size of satellites, starting from the pico series, through nano, micro and small. Even nano has grown because they consist of several 1U modules, and so on upwards. Modular construction has also been adopted in some solutions of higher weight categories. Starlinks are growing and will continue to grow, because the requirement is an increase in the available information throughput, and in principle together with the throughput of the satellite intelligence. The requirements will not end with the throughput of 1 Tb/s. Microsatellites are easier to pack into the cargo hold of a large rocket if they are completely flat, and such a technology of flat modular construction was quickly born.

After the question about OpenSpace, whose merit is it, which we tried to answer, the question soon arose, whose fault is it? Whose fault is it that OpenSpace is the source of so many new and difficult problems to solve. OpenSpace is the cause of the rapid growth of the average dimensions of orbited satellites, their mass, energy demand, the number of satellites sent to LEO/MEO orbits per year, the number and spatial distribution of constellations, functional diversity, the variety of services offered, etc. Along with the growth of these parameters, another question arises, adding to the problem of whose fault it is. The question concerns the number of operational satellites that can relatively safely orbit around the Earth, especially in LEO orbits. LEO orbits have a significant advantage over others, they are low-latency signal and high-resolution image. Higher orbits require larger communication and imaging equipment in order to obtain similar signal parameters, which is of course related to costs, further growth of satellite sizes and energy demand.

The question about the immediate consequences of OpenSpace can be very easily ridiculed like others in this series, whose merit, whose fault, whether we will have some cosmic breakthrough analogous to the ultraviolet catastrophe, like a quantum breakthrough. The question is not unfounded, even though we do not see such a breakthrough for now. Who can quickly predict when the millionth functional satellite will appear in orbit? The authors claim that soon, perhaps it is a decade's perspective, probably not much longer, maybe a few decades. What does a million satellites in LOE orbit mean, and then very quickly another one after that, and in a few decades we have 10 million and perhaps much more. Will quantity turn into quality? Will quality turn into a complete paradigm shift. Will the paradigm shift lead to a fundamental discovery about the properties of space, which will force us to act completely differently? A different drive, different ways of transporting crews, these are problems well beyond the fourth issue of our Space 4.0 dogma.

What does a million satellites deployed in LEO mean, let's say in ten or twenty years? Today, although there are not yet a million satellites in LEO orbits, the largest satellite operators answer this question with the necessity for some satellites to perform avoidance maneuvers, due to the very numerous, increasingly frequent satellite conjunctions, currently approaching 10 million per year. In the case of the Starlink constellation, statistics of such necessary maneuvers performed in set periods of time are publicly disclosed. Currently, these are tens of thousands of maneuvers per year. Does this mean that LEO orbits are already too dense? The answer must be simple and decisive - absolutely not, there are large spaces at disposal, at wise disposal. We return to the question of whose fault it is? Another decade, at most two, and without doing anything in the field of, for example, space traffic law in the area of low orbits, we will have a truly Wild West in the LEO orbits.

Satellite catastrophe in ultraviolet is not only a problem of introducing efficient and effective international law regulating the rules of using LEO orbits. It is also common sense and awareness that there are no unlimited resources. The settlement in a disorderly manner with a million uncoordinated satellites can hardly be called anything other than a predatory economy of the LEO area. This area is very valuable to all of humanity. We are diligently building it with NewSpace and Space 4.0 technologies. We opened it up so recently with the help of the OpenSpace idea. How wide is it currently open? Not so wide yet, because there was too little time to build the appropriate structures. However, they are being built and the opening will continue. The doors to space will open much wider than they are now. Who will prevent a legally operating, honest company from meeting the demand for various space services?

The recent third Falcon Heavy mission carried another special cargo from the Celestis space services company, which already offers various types of orbital and funeral services. Since 2019, the company has been placing capsule urns containing ashes, as well as DNA, of famous people from all over the world into orbit. In total, the company has already sent hundreds of such urns into orbit. The demand is simply enormous. It is very difficult to argue with this, such are people, such are we. The company is driving demand by planning to send capsules containing ashes of several US presidents into orbit. The company's further plans include burials of capsules containing ashes on the Moon and possibly on Mars. LEO orbits are, in a sense, satellite highways for us. Perhaps one day, looking back, we will look differently at the justification for placing the ashes of the deceased along active and densely populated highways. Surely, however, organizing burials under the regolith layer on the surface of the Moon is something different than in the free, valuable space along the densely used satellite highways. This is our path of maturing into space. Opening up space takes place in a variety of ways. Due to the low price, hundreds and thousands of capsules will be launched into orbit using Vulcan Centaur rockets built by ULA (United Launch Alliance), in which Amazon and Jeff Bezos have shares.

OpenSpace provides new development impulses, but also new problems to solve. Another problem, apart from clogging the space in LEO orbits, is the reflection of light by them and the possibility of significantly illuminating the night sky if the number of satellites increases significantly. With a million satellites and the current level of light reflection by them, the night sky will be bright. This can have very different effects on the natural environment, e.g. disrupt the natural circadian cycle, plant physiology and photosynthesis. As humanity, we have not undergone such tests on a global scale. Just in case, programs are being launched to produce satellites with the general name Darksat that reflect as little sunlight towards the Earth as possible. The solution to this problem is not obvious, it is difficult, and requires the use of new non-trivial technological solutions.

The introduction of reusable rocket stages with their controlled return to Earth is associated with the need to limit the landing zone of reusable stages, including the largest in terms of dimensions, the first stage. Such stages with spent fuel in the engines are quite poorly controllable. Various methods of controlling the return zone of rocket stages are being investigated. In some Long March rockets, a type of mesh fins was used to limit the dispersion area of the returning stage. This is another, quite difficult technological problem to solve correlated with OpenSpace.

IV. OpenSpace – Dual Applications and The Terminator of Blind Boxer

The GEO satellite sector, and in general satellite reconnaissance and image monitoring, also includes special applications, which are often performed for many reasons, mainly costs, in dual versions. This is especially true for countries that do not have, or have a small number of, their own satellites. In June 2024, the Geospatial Reconnaissance and Satellite Services Agency ARGUS was established in Poland by the Ministry of National Defense. The establishment of such an agency was inspired by the rapid growth of the role of space and satellite techniques in special and classic reconnaissance systems. In many European countries, such agencies exist or are being created. Agencies organize geo-satellite matters locally, but the most important are their own imaging satellites. The role of such satellites is huge. They contribute directly to the growth of national income and security. Countries that do not have their own reconnaissance satellites are much poorer.

A strong potential foundation for the operation and an environment facilitating the organization of such a Geospatial Reconnaissance agency is the OpenSpace idea and the procedures and open Space 4.0 technologies behind it in Europe. The establishment of this agency was preceded by the establishment of the Image Reconnaissance Center in Białobrzegi OROB by the Ministry of National Defense in 2017. The operation of this Center was and still is dependent on external sources obtained from cooperating organizations. The Center is not yet fully independent in terms of information, but it is an important point on the map, creating a network node. This Space 4.0 class satellite monitoring network will be developed and the OROB center is being converted into an active and independent node. Poland will soon, we hope, join the group of countries with its own reconnaissance satellites. We are diligently making up for significant backlogs in the national space sector in the country.

The aim of OROB was to include our country in the global network of special and dual satellite services and to adapt, develop and master the technology of satellite geospatial reconnaissance in the country. The creation of ARGUS and the acquisition of reconnaissance satellites by Poland is to change this situation for the better. A centre such as OROB, and perhaps others will be created, will also contribute to the common pool with its own valuable source satellite information. Poland will thus become a full-fledged participant in the European and global satellite monitoring network. Without its own, completely own, satellite reconnaissance capabilities in special systems, the important long-range safety and kill chains are incomplete.

And in dual systems of satellite geo-monitoring, without a full observation and decision chain, we do not use the potential of space imaging in agriculture, geology, environmental protection, management and spatial management, losing very specific billions of zlotys annually. The epidemic of fires in large waste and garbage dumps, in many cases clever illegal procedures of scattering harmful waste and immediately covering it with a thin layer of earth on remote, unmonitored agricultural wastelands would not have occurred if such an efficient decision chain of satellite monitoring had been in operation. Such imaging is invaluable at every level of spatial management, not only centrally at the national level but even more so at the local commune and county level.

The imaging resolution of the best GEO satellites currently in use from LEO orbits is 30 cm, and some even less, close to 10 cm. Environmental pollution on a mass scale would be impossible. And this pollution is due to high profitability. The ratio of the costs of professional disposal of harmful waste to its illegal hiding in agricultural land can be as high as 1000:1. No drones, even MALE (medium-altitude, long-endurance) or other advanced ones, will protect us from such harmful and nasty procedures, as long as they are profitable and as long as they go unpunished. Efficient, own, dual, high-resolution satellite monitoring of the LEO Space 4.0 class is necessary.

We do not have our own space industry capable of producing medium-sized Space 4.0 class satellites. Such an industry is being diligently built, and in a somewhat dispersed manner. Any delay in Poland having its own LEO and also GEO Space 4.0 satellites is a specific loss. The global demand for such satellites is enormous, caused of course by the OpenSpace ideas. Despite the almost assembly line technology of producing such satellites by several major manufacturers, the waiting time for the construction of infrastructure and launching into orbit is significant. In the case of Poland, in 2022, two S950 VHR Pleiades Neo observation satellites were ordered in France together with the ground infrastructure. These satellites will be launched into orbit in 2027. In the meantime, between the signed agreement and the launch of the observation system, Poland has guaranteed access to some contractual data from French observation satellites. This is of course good, but it is definitely not enough for our country. The domestic space sector requires rethinking.

An example of building a space industry in the SME sector in the country is the development of Creotech Instruments. There are several such companies, but Creotech's plans are impressive. The company will have to pass the first exams in 2024 and 2025. In parallel to the plans to place two Pleiades satellites, which is being implemented under a separate intergovernmental agreement, Creotech instruments is working on an alternative and faster solution to provide the country with satellite independence in the area of high-resolution geo-observation using microsatellites. The Polish Imaging Satellites PIAST program assumes sending three microsatellites into LEO orbit in 2025. The next MikroGlob program assumes orbiting four microsatellites that will operate in separated VIS-RGB and NIR spectral bands. In addition to Creotech, several other innovative hi-tech companies from the SME sector in Poland have satellite ambitions. Space engineering experience is starting to build

OpenSpace is reaching us in the country in the GEO sector from LEO orbits with a delay, but fortunately it is reaching us. Of course, it is about a completely own system of high-resolution, time- and space-wise geo-observation of the Earth. In the special sector, let us hope that the shameful era of long-range illusion and blind boxer will fortunately end, also with the departure to the eternal reserve of Su-22 class equipment. OpenSpace reached us a little earlier in the SME sector. But SME hi-tech has been developing in the country almost from the beginning, so the small capital strength of the sector, even despite the number, technological advancement, extraordinary activity and business acumen of the established companies, could not immediately cause a technological and investment revolution and be reflected in the form of specific, massive orbital successes, as happened in several other satellite-advanced countries. Slowly, at our own pace, fortunately increasingly faster, we are moving as a country and as a society towards using our rightful place in orbits around the Earth. The small satellite revolution that is currently taking place and the beautifully defined era of Space 4.0 give us a chance.

The not very precisely defined class of small satellites, in terms of dimensions and weight, including objects weighing about 1.5 tons, is also revolutionizing special and dual applications. Some space gigaregions, there is no doubt about it, are starting to build constellations of small satellites for special purposes. In the American press, one can find discussions on the future of satellite systems for security, remote sensing, early warning, etc. Such systems as the space branch of NORAD are based on large satellites. A few remote sensing satellites are more vulnerable in terms of safe operation than a very large constellation of small satellites. Such very large special constellations, using the rapidly increasing functionality of small satellites, willingly or unwillingly contribute to the development and reinforcement of the dominant NewSpace and OpenSpace technologies. Opponents in such discussions on the special applications of small satellites argue for the use of constellations of large satellites with appropriate energetic laser systems. Is it possible to stop such directions of development of space technologies?

At the interface of special technologies and the OpenSpace area, we can currently observe an interesting situation caused by a significant acceleration of activities in the area of dual applications. This is due to the rapid increase in production in some giga-regions of various types of small satellites with very advanced communication and imaging functionalities. This increase is so rapid that it has caused concern in various areas of the industry. Conservative special applications based so far on large satellites as if they had initially overlooked the avalanche of small, highly functional satellites sent en masse to various types of orbits. What has worried the satellite special area is not only the number of small satellites but also their diversity, high specialization and universal functionalities. Such a mass of various small satellites, by the way not so small at all, because up to about 1.5 tons, begins to significantly exceed the functionality of large classic satellites.

In the group of the largest satellites belonging to the class of small satellites, i.e. in the area of approximately 500-1500 kg, two large subgroups of satellites can be distinguished. The first, most numerous subgroup, are highly standardized modular satellites increasingly produced in robotic factories of the Tesla type. Examples are the American and Chinese Starlinks. They are starting to build gigantic constellations. The second subgroup are specialized satellites produced individually, and increasingly often in short constellation series. The gigantic increase in the number of SMEs producing highly functional small satellites is astonishing. There are currently thousands of such companies and their number is growing. Each already produces or declares plans to produce a total of tens of thousands of small, technologically advanced satellites.

This situation is starting to completely change the image of the space industry in the world and fill our ideas about OpenSpace and its regional implementations such as NewSpace, Space 4.0 or the different ChinaSpace and IndiaSpace with facts. Let's imagine that the area of special and dual applications will not react to this situation? And will continue to build large satellites in the old style. Large satellites, but made in new technologies, also belong to the OpenSpace era, but their role is different, no less important. The ambitions in the space industry sector of our country should include all categories of satellites.

V. OpenSpace – Investments and Space Economy in different Super-Regions

The OpenSpace idea is being actively implemented all over the world. The most important activities are conducted in several giga-regions. Giga-regions compete with each other politically, economically, technologically, socially, but also cooperate. OpenSpace is also an area of big politics, gigantic finances, investments, and consequently the construction of global, open service opportunities. In total, there are currently thousands of projects and tens of thousands of different smaller and larger events and activities carried out all over the Earth. This explosion of space activity results not only from the ambitions of individual countries and giga-regions, but mainly from the need and understanding of the significant economic benefits that can be brought locally and globally by coupling the manufacturing economy and services with space. To implement such numerous space ventures, and especially to maintain their results, specialized staff is necessary. This makes the OpenSpace idea, let us hope, the beginning of a great process of reorientation of our civilization, and not just a simple supplementation of the economy with a full-fledged space sector.

It is impossible to present all these interesting OpenSpace activities globally in a short article, which are all the more interesting because they sometimes differ significantly between regions. The outline of activities in some geographical areas is presented here rather only as a kind of contrast and a slightly broader background for the activities in our European giga-region, under the Space 4.0 flag. This is by no means an analysis of the situation in the world. Contrast is necessary to create appropriate conditions for commenting on the situation in Poland and Europe. The development of the space sector in the world is so dynamic that analyses and comments from just a few years ago have lost much of their relevance and sharpness of vision, and some even border on ridiculousness. We have underestimated the dynamics of OpenSpace processes. It is important that we appreciate the importance of these development processes in the country and do not miss our chance.

In some regions, the term NewSpace is not used at all. In some other regions, the term NewSpace has even been adopted for national space economic programs. In the case of the Indian subcontinent, NSIL NewSpace India Limited, established in 2019, is a government program and public venture coordinated by a separate Ministry of Space. NSIL is responsible, together with an industrial consortium, for the production and integration of rockets and satellites. NSIL's mission, in line with the NewSpace ideology, is to significantly increase private sector participation in public space programs.

Official documents assign the following tasks to NSIL: mass production of small satellites in cooperation with the private sector, transfer of small satellite technology to industry, construction of rockets and launch pads for small satellites to carry satellites up to 500 kg to LEO orbits up to 500 km and Sun-synchronous orbits - SSLV rocket (small satellite launch vehicle), support for university teams incubating space and satellite technologies, cooperation with the Indian Institute of

Space Science and Technology, marketing of space technologies, etc. Under one of the contracts, NSIL sent a constellation of over 100 small satellites into orbit, including for Eutelsat OneWeb. NSIL cooperates with the Indian Space Research Organization (ISRO). ISRO has its own rockets to carry large, multi-ton satellites to geostationary orbits, e.g. LVM3. ISRO is a research and development arm and NSIL is a kind of implementation arm of the Ministry of Space, operating in a public-private partnership. India is slowly emerging as one of the super-leaders of space technologies, consistently building a private space sector economy.

China, in terms of space activity on the scale of large satellite actions, as well as on the scale of the OpenSpace class, belongs to a narrow group of super-leaders, equal to the scope of activities in the USA and Europe. In certain areas of space technologies, they have become leaders. They were the first to test a full satellite quantum communication system. In 2024, they were be the first to exceed 100 satellite orbital launches per year. Thirty of these launches are commercial and are carried out by private companies. They have numerous constellations of GEO class remote sensing satellites operating in GEO, MEO and LEO orbits. In May 2004 year, the high-resolution Beijing constellation supervised by 21AT was supplemented to 7 satellites with another 4 NewSpace class satellites, using the Long March-2D rocket, placed in circular sun-synchronous orbits at an altitude of 600 km. The panchromatic resolution is 0.5 m, and the multispectral resolution is 2 m. China's largest GEO remote sensing constellation, supervised by CGST, currently has over 100 satellites active in orbit and is being replenished to 300 in 2005. China has a relatively wide range of rockets to launch small and large satellites into the LEO/MEO region and beyond. For example, the Kuaizhou-11 rockets of commercial companies Expace and Ceres-1 of Galactic Energy launched a total of several dozen service satellites into LEO orbits in 2024 and are launching more in 2025.

It is worth recalling that China's five-satellite, 53-day lunar sample collection and return mission Chang'e-6 from the dark side returned to Earth on the day 2.06.24 with a 2-kilogram sample of lunar material drilled in the Apollo crater. The mission involved the Queqiao-2 relay satellite orbiting the Moon since March 2024 and the small lunar satellites Tiandu-1 and Tiandu-2. The success of the Chang'e-6 mission initiated plans to build the Queqiao multi-satellite constellation in a lunar orbit favorable for continuous communication with Earth, and preparations for the subsequent Chang'e-7 and Chang'e-8 missions. The Queqiao constellation is a step in the construction of a three-stage network of communications, navigation, observation and remote sensing for distant missions, as well as the construction of infrastructure for the International Lunar Research Station (ILRS). A dozen countries from the global south giga-region have signed the ILRS agreement. China's plans include involving more than 50 countries in the ILRS project. These plans are very realistic.

The first 18 satellites of the G60 Starlink mega-constellation, supervised by SSST (Shanghai Spacecom Satellite Technology), planned for 12,000 satellites were launched into LEO orbit using the Long March 6A rocket in early August 2024. By the end of 2024, approximately 110 G60 Starlink satellites were launched. G60 satellites are made in a new, low-cost, reliable, modular construction technology of flat panels. The constellation is to provide global access to the Internet and be a kind of competition for American and European projects, including SpaceX's Starlink. In addition, an important role of the very quickly built constellation, in a dedicated factory in Shanghai, is to reserve a significant number of physical places in LEO orbits as well as frequency bands for Internet transmission and secure data systems. The factory in Shanghai is capable of producing one satellite per day. The plans include the expansion of the factory to 600 satellites per year, launched into orbit by 50 missions. The assembly line production has reduced the production costs of one modular flat-panel satellite by almost 40% compared to classic production.

Another developing Chinese mega-constellation, Guowang SatNet, is being developed by a separate industrial consortium CSNG (China Satellite Network Group) and is to contain 13,000 satellites. Test satellites from this constellation operate in LEO orbits. The planned increase in the number of missions to well over 100 per year has resulted in the commencement of construction of a new spaceport on Hainan Island. The port began operations in 2024. It is also becoming necessary to increase the payload capacity of the rockets and change their design. To this end, the Long March 5B rocket is being supplemented with the Yuansheng-2 upper stage, and the scalable Long March 8 rocket is being optimized for mass production. China's satellite plans for both large missions, but above all for activities in the LEO/MEO area, are so significant that they have a major impact on activities in other giga-regions. It even seems that in some areas of OpenSpace, China is setting the pace of change. It is worth noting, however, that China does not use the space names NewSpace, Space 4.0 or OpenSpace in any of its actions and economic initiatives.

China's goal is to build a commercial space ecosystem that is reliable, but cheaper and more efficient than those offered by other giga-regions. Action in this direction involves significantly increasing the production capacity of satellites and orbiting vehicles, and to a large extent automating such production. Action in this direction also involves reserving physical space and frequency bands already now through the mass launch of active satellites into LEO/MEO orbits. China, with such a pace of development, will probably soon offer very cheap services such as Satellite as a SaaS Service and Constellation as a SCaaS service.

It is also worth adding that China is dynamically expanding its constellation of ultra-high-resolution spy satellites operating in LEO orbits. In July 2024, the CHEOS constellation supervised by CASC (China Aerospace Science and Technology Corporation) was joined by the fifth satellite, Gaofen-11, optical observation of the Earth's surface, launched into orbit by the Long March 4B rocket from the TSLC (Taiyuan Satellite Launch Center) satellite port located in northern China. The CHEOS constellation is located in a quasi-polar orbit at an altitude of 500 km and is in the process of being expanded with more new satellites with increasing imaging capabilities. In 2024, the constellation was expanded to 8 satellites. The observation optics with an aperture of 1.5 m located on the Gaofen-11 satellites have a resolution of about 10 cm. The constellation images in optical, multispectral, hyperspectral, and synthetic aperture radar modes.

The Russian Federation is creating a separate space giga-region. Significant historical achievements are currently largely slowed down and suspended in many technical areas. Despite this, published plans, e.g. the construction of an independent, large, orbital space station arouse respect. However, in the current geopolitical situation, in addition to respect, they raise justified serious doubts about the possibility of implementing a gigantic project, without major international participation, including, for example, Chinese assistance, by 2030, with a serious stage ending in 2027. Incomparably more likely plans concern the construction of somewhat competitive and more real infrastructures by the Chinese giga-region. These plans concern, as already mentioned, the construction of a station in orbit around the Moon and a research inhabited station on the surface of the Moon. Chinese plans to gather at least 50 consortium members from other countries around these projects seem realistic. In Europe, we have the beautiful idea of MoonVillage-Moon 4.0, and in China the international ILRS project. In the US and China we have serial production of hundreds and soon thousands of satellites in standardized modular solutions. In Europe we have the Space 4.0 ideology. There is no hiding the fact that there is and will be a powerful, hopefully constructive, global competition in the space area.

It is worth showing two hard examples from two giga-regions to present the scale of the difficulties we are overcoming in space technologies, with rapid development. The private Chinese company Space Pionier is conducting static thrust tests of reusable rocket engines and rocket stages at the new commercial spaceport Gongyi/Henan. Such a test of the first stage of the Tianlong-3 vehicle containing 9 engines was carried out on June 30, 2024 and ended with an uncontrolled ascent of the stage and a disaster - the explosion of the falling stage full of fuel. Tianlong-3 is a reusable vehicle comparable to Space X Falcon 9 with a planned thrust of about a thousand tons. A similar event took place in the USA in 2020, when it exploded during static tests of the Space X Starship.

Another example is the problems with Boeing's flagship CST-100 Starliner spacecraft docked in July 2024 with the International Space Station ISS. Worse still, a small helium leak was noticed before launch but ignored. Compressed helium is used as an inertial gas to feed fuel to several of Starliner's propulsion and maneuvering engines. During the journey to the ISS, the leak deepened, causing some of the small maneuvering engines to fail. After docking, the faults were located in the engines and eliminated, but there is a risk of recurrence of failure in other engines. The problem is related to maintaining a very strictly defined angle of attack during atmospheric entry in order to ensure minimal friction and heating of the vehicle. An inappropriate entry angle can lead to overheating of the ship and disaster. Starliner is equipped with redundant engines, but the initial explanation for the cause of the failure in the form of damage to the seals after thermal impact of fuel and helium does not allow for a major reconstruction of the power system in orbit.

At NASA's WSTF (White Sands Test Facility), Boeing conducted tests in July and August 2024 to fire the thrusters and replicate the fuel supply emergency that occurred in orbit at a critical moment when Starliner docked with the ISS. As a result, two US astronauts are trapped on the ISS waiting to decide whether to return on Boeing's Starliner or another ship, such as Space X's Dragon-2, docked parallel to the ISS or specially sent in addition. This is the first manned test mission in preparation for Starliner's manned commercial missions (there have been several unmanned test missions), while Dragon has completed 30 cargo transports to the ISS and a ninth Space X mission with astronauts was prepared for late August 2024. There is currently a 9-person crew on the ISS and two of them should return to Earth as soon as possible.

VI. OpenSpace – Is Space 4.0 a TGV/EuroStar Service or a Pan-European network?

The first place in terms of the number of active satellites in Europe, excluding Russia, is occupied by Great Britain, followed by Germany, France and Italy. With the launch of programs to build constellations of small satellites in Space 4.0 technology, this situation is changing dynamically. Soon, the number of active European satellites will be significantly increased, i.e. several times. The pace of increase will rise. However, there are satellite blank spots in Europe, which we are diligently eliminating, of course with the help of Space 4.0. However, it must be remembered that Space 4.0 is an ideology and not a large structural, flagship European, innovative and economic development program. Perhaps we lack such a solidarity development program in the Space 4.0 giga-region. Such a European program could have fast tracks, levelling the status and supporting the development of space technologies in interested and well-motivated regions of Europe. The production of launch vehicles and satellites must completely change, also in Europe, in accordance with the rules of Industry 4.0. However, it is necessary to distinguish and not confuse commercial ventures in the style of Space 4.0 with research missions. It is necessary to remember that serious research missions are currently being prepared for over a decade, but such timing will probably also slowly have to change in the near future. The processes of preparing the largest missions will probably not change.

Let's take a closer look, for contrast, at how our European giga-region operates under the Space 4.0 flag. And also at what the situation is in Poland. In Europe, the TGV and EuroStar networks operate efficiently, but this is not a pan-European network. In Europe, the Space 4.0 idea has started to operate efficiently, but it is not a large structural development program. Is it possible to buy a cheap SaaS service with the European Space 4.0 emblem? Is such a possibility planned? What significant two-satellite constellation with infrastructure is Poland buying? The Pleiades Neo satellites from Airbus Defence and Space are French, and their delivery time from the contract is over 5 years, and they are not cheap. The contract amounts to over 500 million euros. They are probably not manufactured in series, as in China, despite being compact satellites. Five years is a long time especially in the Space 4.0 ecosystem. Could such timing show the truth about European production capabilities, and therefore about the possibility of the Space 4.0 implementation pace? Will two high-resolution observation satellites equipped with the Naomi optical system be enough for us? Probably not, but we have to start somewhere.

A larger number of satellites in the constellation allows for more frequent imaging, which means a very important higher time resolution. The amount mentioned above has nothing to do with the costs of small Space 4.0 satellites, where the cost of even advanced nanosatellites, including orbiting, does not exceed 1 million euros, and the more advanced microsatellites 10 million euros. It must be remembered that Pleiades are special satellites. The Pleiades constellation operated by Airbus consists of a dozen or so satellites, including old and new generations, and other satellites. Pleiades Neo are orbited using an Arianespace Vega rocket from the spaceport in French Guiana. The constellation cooperates with Airbus's EDRS (Airbus SpaceDataHighway) geostationary satellites, creating a fast network for the exchange of dynamic, precise imaging data.

It is necessary to ask such questions about our situation in Europe. If we do not develop our own satellite technologies, we will be left behind. Our own part of this industry must have capital and intellect. Two development legs are necessary, public and private, strengthened by PPP cooperation and strong, reliable and fair international cooperation. Two interacting pillars are necessary, international and strictly national. It is necessary to create a basic massive public, government-supported production platform for LEO orbiting vehicles and various types of small satellites, as the first leg. The second leg being developed, i.e. domestic space SMEs, are excellent, but they have little capital, the development of which will take a long time without state support. Poland and Europe must do something about this problem so that Space 4.0 does not remain just a flagship slogan. A slogan for the development of space technologies only in a small area of Europe, as EuroStar operates. Is the expansion of the EuroStar network to a larger part of Europe still a political or economic and business problem? Many European countries, including Poland, are concerned with this problem in a very significant, even existential way.

In the development of the OpenSpace idea, multi-billionaires such as Elon Musk (SpaceX), Jeff Bezos (Blue Origin), Richard Branson (Virgin), and others, as well as their companies and participation in numerous space ventures, play an important role. However, they mostly belong to the NewSpace giga-area, and only a few to other giga-areas, including Space 4.0. These are people with significant investment opportunities and the projects inspired by them have a significant impact on the entire picture and directions of development of satellite and space technologies. In a sense, they create a separate giga-region in terms of activity, number of projects, scope, level of financing and global significance. The projects concern both the development of large space technologies and many initiatives related to the development of the OpenSpace idea, including in particular the development of space services. It is estimated that the aggregated initiatives of this unique investment sector in OpenSpace technologies in the last dozen or so years exceed $ 100 billion, which can be comparable to the projects of just a few giga-regions.

OpenSpace investments in giga-regions are growing very quickly. Where is our Space 4.0 in this context? Annual US spending on government, public space projects approached $100 billion in 2024 and will probably exceed this amount in 2025. The total space technology market in the US in 2024 was about $500 billion. The value of this market will double in a decade and exceed $1 trillion. Annual government spending by China on such projects is approaching $20 billion in 2024. In a very short period of time, this amount will reach $50 billion. In addition, there is private investment, at least in the same amount. These two countries are the absolute leaders in investment in space technologies. The Russian Federation invests over $5 billion annually. Japan, Great Britain and India have similar levels of investment, and Canada is only slightly lower.

The European Union invests over 10 billion Euros per year, including France around 3 billion, Germany and Italy around 2 billion. The investments of the aforementioned leaders in the Space 4.0 area are growing rapidly. Investments of the remaining EU countries are rather not very large, at the level of tens of millions of euros and only in a few cases several hundred million. Joint European government investments are coordinated by ESA. France is the main payer and dominator in ESA, through its CNES agency, at the level of 25% of its total budget. Given its potential, Germany has a surprisingly low space budget. In principle, the same can be said about the entire European Union. The annual EU space budget of around 10 billion euros is surprisingly low given its capabilities and probably ambitions. Since the British space agency UKSA is a member of ESA, in principle the budget can be counted together and increased to around 15 billion euros, which is still an amount significantly lower than the level of Chinese investments, not to mention American ones.

In Europe, ESA is a powerful dominator, similar to NASA in the US. However, there are significant differences between the two space markets. In the US, the private space market, including large companies such as Boeing and the SME sector, is powerful. In Europe, there are also several large companies, but almost exclusively in close design and contracting cooperation with governments, especially in the security and defence sector. It seems that in Europe such large companies are less likely to subcontract critical tasks to the hi-tech SME sector. On the other hand, or precisely because of this, the European SME space sector is not as developed as in the US. Overall, the European space market is much smaller and less diverse than in the US. ESA, as the author of the Space 4.0 slogan, is of course actively working for a significant expansion of the private space sector in Europe, but it has too little of its own funds, collected from the governments of the Member States, to propose and sustain multi-billion development projects. The currently required level of hundreds of billions of euros is not available to ESA for now.

The European space budget is composed of the ESA part, which consists of the member states, and the combined or separate program budgets of individual countries. National budgets include public and private parts. Some countries, leaders in space technology in Europe, such as France, England, Germany, Italy, etc., recover most of the funds paid in contracts. Therefore, these funds cannot be counted twice and separately as a contribution to ESA, the ESA budget and the recovery in ESA contracts. In any case, the total European space budget is currently much lower than the space budgets of the American and Chinese giga-regions separately. ESA, in cooperation with the EU, should undertake new initiatives in this area. In particular, cooperation between the EU and ESA should probably be arranged differently.

This may also be due to the fact that in Europe we are used to the fact that flagship programs, such as brain, cancer, quantum, infrastructure, are in the order of one billion Euros. The gigantic space sector described in the proud and ambitious Space 4.0 documents will not be quickly awakened by a programmatic injection of a single billion euros and that within a decade. The amounts at disposal should be at least ten times larger, and better a hundred times larger. Perhaps something in the Space 4.0 documents was formulated too cautiously and conservatively in terms of finances and the assumed pace of development? However, it is difficult to accept this as a certainty, because Space 4.0 has been in a sense programmatically coupled with a strong, important future industrial development trend of Industry 4.0. It is difficult to imagine that the Space 4.0 project, containing a significant innovative industrial load, but of a sectoral nature, and not global like Industry 4.0, would be some kind of alternative or third way to Industry 4.0 and not simply its important sectoral part.

As a kind of muster example of national activities in Europe, we can mention the situation of the space sector in Italy, a country that is one of the pioneers in the development of these technologies. The coordinator of the public activities of this sector is the Italian Space Agency ASI (Agenzia Spaziale Italiana). Italy launched its first satellite in 1964, the third country to do so. The Italian aerospace industry is the designer of many ISS components, such as the Leonardo module (Alenia Spazio S.p.A.), the Cupola module, the Cygnus cargo spacecraft delivering goods to the ISS, and others. ASI manages the Cosmo-SkyMed constellation of several satellites in polar orbits that monitor the Mediterranean basin with high resolution. Italy regularly takes an active part in the most important large ESA missions, such as BepiColombo, the Rosetta mission to the Churyumov-Gerasimenko comet, the Mars reconnaissance orbiter MRO, and many others. Italy currently has around 50 active satellites in orbit, and is one of the few countries with a full space industrial ecosystem. This ecosystem includes its own commercial satellite orbiting system with its own Vega-C, Vega-E and Vega-Light rockets. The IRIDE constellation will be orbited using this system at the turn of 2025/26. The Italian government's IRIDE Earth observation project is worth over 1 billion euros. Such an advanced level results from the fact that the Italians have been diligently building this sector for decades. A similar level and development dynamics of the space sector are demonstrated by all European economic leaders, such as Germany, France and England, but also Spain, Greece and others. These countries are currently the largest European beneficiaries of the OpenSpace idea, but in a very profitable way the idea is spreading to all countries of the Space 4.0 region and globally. OpenSpace has swept the globe like wildfire. More and more countries that can afford it, that understand the role of the space sector and have ambitions to develop it, are building their ecosystems for small satellites. It is worth mentioning here some of the countries building their systems, such as: Arab countries, Singapore, Israel, Australia, Indonesia, the Philippines, Vietnam, Brazil and others.

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