

Space 4.0 – a common, democratic European space

Ryszard S. Romaniuk, and Piotr Orleański

Abstract—Regardless of differences in political views on the scope and depth of the European integration, there are so many areas of possible and very beneficial integration that it is difficult to include them all in the area of controversy. One such area of necessary and extremely profitable European integration is, among others, space. Unless we go back a few decades and consider space, even today, to be the pride only of those nations that have overcome the space barrier. This would be an absurdity difficult to imagine in today's Europe. Space 4.0 is, in its shortest definition and in relation to European context, a great, long-term effort by our entire community to democratize space over Europe. It was high time for ESA to make this decision in 2016. Space 4.0 is a large sector project with general social ambitions, contributing to the Industry 4.0 project and the idea of European Society 4.0. Europe was maturing for this decision on many levels: political, social, but mainly economic and competitive. We will soon celebrate the 10th anniversary of this decision, so we would like to remind again where we direct our European space dreams, and maybe it is time for a slightly earlier summary of activities during this period of almost a decade, especially from our Polish, perhaps slightly subjective perspective. The Polish version of this article is published concurrently in *Elektronika* journal by SEP - Assoc.Pol.El.Eng.

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I. INTRODUCTION

THE idea and name of the concept Space 4.0 [1,2], first used officially in 2016, comes from the slightly earlier defined term Industry 4.0 defining the new European direction of economic policy and practice. The same 4.0 numbering of both components was intended to emphasize their strong mutual entanglement and anchoring of space technologies in a diversified, new type of economic, industrial and service platform. The ambitious direction of intelligent civilization development and a new style of economic activities was defined in a number of extensive documents, initially by dedicated technical working groups in 2013, and then in subsequent years by relevant agencies of the European Space Agency. Industry 4.0 is one of the components of a broader system of deep social reconstruction, not only industrial, but broader, dreamed and planned by the European Union. Space 4.0 is an element of this kaleidoscope of civilization, redefined and aimed at optimal, sustainable social development in various areas, including space. This space is to be completely different from the previous

one [3], democratic and common, economic and social, friendly and accessible. Space 4.0 has a chance to end, at least in Europe, the approach to space as an individual, closely guarded, national prestige [4].

II. SPACE 4.0 – SPACE AS AN AREA OF RICH RESOURCES AND SOCIAL DEVELOPMENT

We all remember the catchy marketing slogans of the new policy that appeared some time ago, and not only on European banners, indicating potential directions of the future development of society and civilization. The main slogan was, and still is, that we are building an intelligent society, or a society permanently based on knowledge. In other words, with the help of various components, including Industry 4.0, Education 4.0, Space 4.0 and many others, intertwined with each other, we are starting to build, for now only in Europe, the Society 4.0. This regional limitation has significant consequences. Other giga-regions are also building new societies, but some of them in completely different ways. In fact, this is nothing new, giga-regions have always competed with each other, also in terms of development directions. Currently, a certain novelty is the inclusion of space into these directions of development and competition, but this time not only in an ambitious way, as it was before, but also in a completely mercantile, economic, operational and commercial way. As a consolation, it is worth adding that the innovation layer remains ambitious.

We are to generate and use knowledge much more effectively than before, not only at the Industry 4.0 level. We know today that it can be done. We just don't know whether we will be able to tame this complex element. This element is an explosive mixture of the gigantic knowledge we have, the social areas to which this knowledge has reached (in the source form, in a popularized form, distorted or not reached), the significant economic resources at our disposal and the policy (wise, far-reaching or ad hoc) of distributing these resources. To this element, perhaps not in a central position, but important enough, Space 4.0 belongs and was rightly added. However, the central position of the element is not technology and politics, but an independent living society undergoing intensive changes, expanding its activities and beginning to use more and more practically the functionalities offered by space. The domain and resource approach to space has existed in society for a long time,

R.Romaniuk is with Warsaw University of Technology, Poland (e-mail: ryszard.romaniuk@pw.edu.pl).

P.Orleański is with Space Research Centre, Polish Academy of Sciences, Poland (e-mail: porlean@cbk.waw.pl).



but it has become more specific as space technologies progress. Today, the level of these technologies is such that we see these resources very concretely and hence bold declarations, in the form of Space 4.0, are possible, optimized to the existing economic and industrial situation.

Space is becoming a rich resource and an area of intensive social development. If this is how we have understood space for some time, our approach to social development must change dramatically. At a certain stage, there will be no further social development if we do not take into account the powerful domain of space that is opening up to us, for now the practically accessible space, close to outer space. Each society itself, separately, must muster this courage, this significant effort and be mature enough to reach for this space. It is a very complex effort, intellectual, social, economic, scientific, technical and industrial, as well as educational and psychological. No one doubts that overcoming this high potential barrier is much easier together, in our European giga-region, than alone. What is also characteristic of the current period is that we are talking about Europe and other giga-regions, also about cooperation and competition between regions, in general and in the area of space, rather than about globalization.

Why is it so complicated? We have been on Earth for hundreds of thousands of years, equipped for this stay by evolution. We go into space wearing suits that barely support our physiology and little else. So we will first send more and more robotic Prometheuses to many tasks that will familiarize us with this new and difficult area, yet ours. This practical, resource-based understanding of learning and effectively connecting the modern economy with space (with its complex structure and the private sector), reducing the costs of operating near space, but also a response to significant competition from other regions, lies at the basis of the idea of Space 4.0. Outer space is not our foreign territory.

III. SPACE 4.0 IN THE COORDINATES OF INDUSTRY 4.0 AND EUROPEAN SOCIETY 4.0

Industry 4.0 is a sectoral challenge for manufacturing and services, defined more precisely as the first in a series of such challenges as part of a broader initiative to work on a kind of new European order. Industry 4.0 is a project aimed at building an intelligent industry, strongly connected with other areas. So strongly that it cannot be isolated experimentally or theoretically from other sectors, such as education, staff training, lifelong learning, human health and well-being, environment, safety, culture, sociology, and in particular social understanding and acceptance. Environment 4.0, natural resources, food, etc., have been developed, similarly to the Industry 4.0 documents, in the form of a broad set of ambitious guidelines and a package of policy initiatives called the European Green Deal. The EGD, or Environment 4.0, is the same as Industry 4.0, only it applies to different sectors. Similarly, Space 4.0 is a component of this puzzle. Without going deeper into these and other sectors, but looking at them a bit from a distance, in an integrating way, it is, of course, about the European Knowledge-based Society 4.0. We must remember what Europe's strategic goal is and what its sectoral implementation components are.

An important element of this puzzle is another, necessary sector challenge, i.e. the integrated Space 4.0 package of political and technical guidelines defined by the European Space Agency. We assume without any doubt that all the above-mentioned socio-political-civilization packages under the integrating umbrella of European Society 4.0 were created out of deep and good will related to the vision and willingness to implement appropriate directions of social development. Most of the assumptions of these packages are universal in nature, but they were created in Europe and, despite globalization, probably not all of them are implemented globally. Europe, despite its great social, scientific, technical and civilizational potential, is, of course, like other giga-regions, subject to strong impacts, including very effective and increasingly stronger competition on a global scale. It is worth noting that Space 4.0 is a sectoral ESA project, while Industry 4.0 and other projects constituting pan-European activities towards building European Society 4.0 are global initiatives and projects of the European Union. However, both ESA and the EU in their statements emphasize the affiliation of the Space 4.0 initiative and its intertwining with similar sectoral EU initiatives [3].

The above-mentioned studies, both comprehensive and sectoral ones, including Space 4.0, have in their assumptions this element of competitiveness, but also concern about the strength of competition. Withstanding the competition in the Space 4.0 area will not be so easy, but it is a kind of fight. Space 4.0 is not as much in the spotlight as Environment 4.0 or even Industry 4.0, and therefore the controversy in this area is lessened. The success of the above-mentioned, largely codified, sectoral and global integration activities will depend in Europe, but also in other giga-regions, not so much on the determination and speed of technical implementation, but on the development of social consensus. Such consensus looks and is developed differently in different regions of the world. This area also falls into the realm of global hard play.

It is impossible to completely isolate the Space 4.0 sector from the general conditions outlined above. There are many more of them. Giga-regions, i.e. Europe, the USA, China and India, as well as smaller actors such as Japan, Canada, Brazil, and others are launching large flagship projects directly or indirectly related to the Space sector. Some fall within the definition of Space 4.0, and some significantly exceed this definition. There are many such European projects and we will not analyze them here. We will mention one project as an example of the complexity of the development situation and the interconnectedness of various sectors. The European flagship project for quantum information technologies includes a significant space sector component. Europe must create its own secure quantum satellite communications system. Some of the components of this system undoubtedly belong to the BigSpace and SatCom area, but the development and testing part fits very well into the specificity of the Space 4.0 sector. Not all SatCom will be quantum. Many space technologies will and must remain in their classic version - which does not mean the cessation of constant intensive modernization. The area of business in space is potentially a very complex problem. We are only at the stage of crossing the threshold after opening the door.

IV. WHAT IS AND WHAT IS NOT SPACE 4.0 AND ARE WE MOVING TOWARDS SPACE 5.0?

Why does Europe need a special kind of Space with the marketing number 4.0i, and then perhaps the next 4.X and 5.0? Even after almost a decade of changes taking place in the global and also European space sector and aptly summarized by the marketing slogan Space 4.0 in 2016, it is not obvious today where the limits of this initiative are. Space 4.0 is even described as the name of an era, a new era conventionally dated from the success of the International Space Station, which opened new frontiers of cooperation and space exploitation. Space 4.0 opens an era of significant increase in the number of actors in the space game, including private companies, the science sector, universities and departmental institutes, ordinary interested citizens benefiting from popularization and education programs, engaging digitalization processes, active interaction on a number of social and industrial levels, educational, etc. Space 4.0 is defined as a process, an evolution into a completely new area of interaction between governments, the private sector, society, politics, finances and the economy. Space 4.0 is a major effort to irreversibly and comprehensively integrate space into the economy, industry, and social life. Space 4.0 is the construction of a common European space.

We put many useful tasks and functionalities into the Space 4.0 container [5,6,7,8]. We want as many of them to start working as soon as possible. Of course, this cannot be done. This is too broad and complicated a process, with significant inertia. This inertia results from many reasons: lack of knowledge, fear of economic risk, lack of reference to something similar in the past, failure to understand the usefulness of anything related to the void of space, etc. When watching Star Trek and space civilizations, we probably perceive them as fairy tales that do not concern us directly. The leap into the future is too distant, and the stage directions are very theatrical. Despite everything, this trend of pop culture somehow familiarizes us with the populated void of space. The difference between theater and reality is very distant. Space 4.0 is to cover this distance between us and the future functional space, laboriously, diligently, millimeter by millimeter, as one would like without rushing. Competition will not allow us to be lazy and not in a hurry.

Space cannot be learned in a decade. We have been learning it for many decades, but not on such a scale as proposed in Space 4.0. Millennia of persistent learning and active actions are needed, but together, as all of humanity. No society alone can accomplish this task. Of course, it will handle a smaller, more modest task, but it will take much longer time. Let us honestly admit how far we are from such a level of integration of humanity to undertake such great challenges together. Given such a challenge, how modest does our Space 4.0 discussed here look for now? This is the first step, without such a first step there are no further steps. Let's protect Space 4.0. Let's work for its continuation. If after the first decade, soon in 2026, it is considered a failure, it will be a disaster, a big step back in getting used to space, our natural living environment.

Another aspect of Space 4.0 is our human pride. One would like to say that the goal of this project is to take even the most modest step towards taming space. This is a mistake though. We are children of the Earth and space. We only open our eyes

wider and become more familiar with our natural environment. We are slowly maturing to realize not only Columbus's expedition over the ocean and Vasco da Gama's journey around Africa, and to start building a more solid base for perhaps even further journeys, but initially for the proper development of our civilization here on Earth with the active use of space. The

construction of this base is, hopefully, the beginning of building the foundation of a space civilization. We are surrounded by oceans and we did not once become only landlubbers long ago. We are surrounded by outer space and we must enter, with all the attributes of our civilization, this area, an area of which we are co-owners. For now, this co-ownership is, of course, very modest. Space 4.0 is perhaps intended to help us realize this and learn. By also expanding the economy into space and slowly, systematically strengthening this expansion, our general consciousness must change. We must finally slowly and deeply understand, perhaps quite painfully at first, that we are a cosmic civilization.

Not all of Space will likely be appropriated by Space 4.0 from the start. However, many components related to the distribution of security, cybersecurity, and the specific SafeSpace area can be distributed through sufficiently dense redundant systems implemented in Space 4.0 technology. There are many such examples of Space 4.0 covering many useful, smaller and larger functionalities within the integrated framework of the European Society 4.0 environment. Before its detailed ideological and technical description, we assume Space 4.0 here as a missing and important link in the entire civilization puzzle. Space 4.0 is a kind of political and economic response to the changes in Europe and the highly competitive world around it, especially the world in the area of space and satellite technologies. Space 4.0 is a type of fast track that is intended to test the effectiveness of several new ways of developing near space. This positioning of the European decision to develop the Space 4.0 direction and technology, and then perhaps its next generations, makes it perhaps easier to assess its importance and potential. The effectiveness of this decision is already starting to show in the near future. We are already feeling the symptoms of this decision in the Space community today.

If Europe is to be able to effectively coordinate the dynamically changing space sector here and now, it is necessary to create a kind of political, scientific, technical, economic and legal umbrella over it with appropriate tools. Each toolkit covering a large sector, suggesting or even imposing types of action, has a wider impact on society, is usually preceded by some form of education, popularization, outreach, political and economic lobbying, and work on a bill of laws. ESA presents this as a descriptive Space 4.0i action combining innovation, information, inspiration and interaction. This description is typical of European projects, i.e. present ideological guidelines indicating general directions and required attributes of the development and benefits of the Space 4.0 project. The innovation attribute means the need to undertake breakthrough and risky technologies. The information attribute means a significant strengthening of connectivity with various, broad social areas, as well as with the communities of producers, service providers and users. The inspiration attribute concerns continuity, sustainability, uninterrupted development and program activities connecting subsequent generations of

creators, users and the society. The political and economic attribute of interaction concerns continuous efforts to strengthen the European partnership between countries, European institutions, major international institutions and industrial partners. It also concerns the continuation of work on economic and social space law. We see all of these attributes actively developing today in Europe.

Under the general motto of Common Europe, the Space 4.0 package of policies and programs, prepared and coordinated by ESA, is implementing the next stage of uniting space over Europe. The proposed attributes of this project are closely related to the European (but also partly to the global) social and economic situation, and are aimed at strengthening those sectors that will generate synergies and significantly strengthen Europe's competitiveness in the global space market. Taking research and technical risks towards innovation is an indispensable element of competition in the area of new technologies. This is a significant area covering new materials and structures suitable for space technologies, cost-optimized strategies for testing space technologies, significant parallelization of implementation paths and operation of space technologies, reduction and distribution of innovation risk among many participants in the implementation and testing processes of space technologies, optimal scaling of single satellite experiments and other.

Space 4.0 is the precursor of a completely different understanding of space. Space 4.0 is a political, economic and social package of recommendations, guidelines, but also prepared laws aimed at completely changing our perception of space. This space, in a sense, is to become our friendly property. Space 4.0 is a dream of socializing space and including it in the living cycle of life and social activity. This is a completely new and very ambitious approach. Perhaps Space 4.0 is a bit like the oceans of the times of Vasco da Gama and Columbus? The complete integration of space into European society and economy will take many years. This is a demanding process that will take decades. The first decade of its formulation will soon pass. Therefore, it is worth devoting these few reflections to it and collecting the first experiences from its initial implementation. A decade in technology development is a lot these days. A decade in the implementation of a massive project of reconstruction of many sectors of the economy and social adaptation is relatively little. A decade in mastering space with our current technology is almost nothing. Time moves differently in space. We plan to exploit planetary resources. We almost know how to do it. When will we do it? Will this still be possible in Space 4.0, or only in Space 5.0 and later?

Forgetting about the ideological or political background for a moment, Space 4.0 is, at its most practical level, a long-term process of innovative and commercial integration of space into everyday economic circulation in society. This is a completely new idea and a significant challenge. We've never done anything like this before. Almost 10 years ago, we suddenly decided to expand the area of economic activity in Europe and include into economic circulation a foreign, dangerous, infinite, empty space, seemingly useless for anything, known only to scientific institutions and astronauts. This space is even more dangerous because we are aware of its potential for military, offensive and defensive use.

How much work is needed to change the popular thinking about space as an area for incredible, daring action in science fiction films, as a dangerous and useless area, an area from which we are threatened by alien, much more developed civilizations. How much time do we have to devote to fully understand and get used to the fact that space is an inevitable area of our development, the operation of our economy, and finally the entry of our culture and civilization there? This is too much for the modest Space 4.0 project. And what would happen if we didn't even take this first step and start this process of true changing the society with even the very modest Space 4.0 project? Space 4.0 is a real breakthrough, even though it is only a modest beginning in building the foundation, the launching platform of our civilization into space. We don't know yet, after a short period of less than a decade, whether Space 4.0 will live up to the hopes placed in it. Will it cement together many different economic and social sectors, including acceptance, maturity and readiness for action, and create a strong platform for further development from such sectoral integration?

It is very easy to ridicule and completely discredit such a broad, over-the-top understanding and commentary around the idea and the planned package of specific economic programs briefly known as Space 4.0. Moreover, the name is intentionally and beneficially suited to other sectoral flagship European programs. On the one hand, Space 4.0 is a fragment of a much larger and relatively coherent whole. On the other hand, it is a novelty that has a chance of becoming the first step towards an important socio-economic reconstruction. We will probably evaluate it more deeply after a decade of project implementation. Space 4.0 is not a panacea, it is an addition that never existed to the active area of space research. Space 4.0 is an overlay on what we believe is a prepared economy and suitably mature space technologies to add an additional new sector to this area.

The space sector needs to expand and it is happening. Space 4.0 is a component of this sectoral development. Breaking space records is perhaps important because it triggers the public imagination and perhaps shows the current limits of possibilities. Today we are beginning to understand that space exploration is multi-layered. Space 4.0 adds a utilitarian, economic layer, preferably fragmented into many industrial sectors. Space 4.0 has a chance to be the beginning of diverse technological tests regarding the use of space for business and industrial activities, both directly and indirectly with orbital production. Space 4.0 is the first laboratory in the history of humanity to transfer, anchor, or simply connect in any way economic activity and technological innovations with space. This is a big but natural and expected step towards the consumption of our necessary space ambitions.

It doesn't have to work out at all. Perhaps the project is premature. It is not only about admiration that as a result of the implementation of this project, several dozen or several hundred private companies related to the space sector have been established in Europe, and soon perhaps several thousand. We can be very happy about this fact today, because we are observing a kind of space boom in the economy. This is an excellent sign, and probably also a result of the strengthening of the policy direction defined in Space 4.0. The main point here is that Space 4.0 connections with many different sectors will

slowly start to work. It's about education, about the process of expanding social consent and acceptance to practically go into space, it's about understanding that we are a cosmic civilization. A decade is not enough time, it is necessary to implement subsequent editions of Space xx, and then Space 5.0.

One of the main packages of ideas defined in Space 4.0 concerns the granulation of economic and innovative activities. Space 4.0 will be successful if it starts breaking down space stereotypes. For the general public, space is a somewhat useless void. For specialists, this is a very complicated area where any activity requires advanced, highly specialized technologies, operating procedures, safety rules, energy management and other resources. All these elements are subject to constant development, because as a learning space civilization we are only at the beginning of learning the rules of proper behavior in space. Development at this stage of ours requires constant, patient, even persistent testing of everything related to space. Such tests of various larger and smaller things, as well as thousands of little things, are performed all the time, both on Earth in simulated conditions and in space. Space is an ideal place to conduct numerous tests related to technological innovations in various economic sectors such as health, agriculture, materials engineering, chemical industry, pharmacy, construction, telecommunications, security and many others.

Such thousands of tests cannot be performed during large, expensive space missions. Missions serve a completely different purpose, rather large, cognitive research aims at the limits of our knowledge, but so far they have also been used, in some guest way, to perform various smaller tests. According to Space 4.0, granulation means scaling space engineering significantly down in terms of size, energy and complexity, significantly reducing the costs of the satellite and its transportation to orbit, but not reducing safety, and it becomes the foundation of our new economic activity in space. This activity enables the implementation of numerous necessary tests needed for the development of space and satellite engineering and other hi-tech industry sectors, but also other services, including advanced and popular ones, or commercial production for the economy and the consumer market. For the first time, Europe surrounds and supports such activities in an integrated, coherent project.

Granulation defined by the idea of Space 4.0 also has a very important political and social aspect regarding equal and fair regional support for innovation in Europe, industrial implementation, testing of numerous new technologies, introduction of new services and products related to space. Granulation of space technologies simply enables and significantly facilitates such distribution processes. The EU and ESA, above programs such as Space 4.0 and others such as Industry 4.0, must ensure an even distribution of development resources and initiate appropriate local initiatives so as not to leave regional white spots. The generation or historical maintenance of unnecessary development gradients, in any way justified, will always raise unnecessary political tensions. The space sector has developed in the world, including in Europe, quite unevenly geographically. This unevenness should be optimally eliminated. Space 4.0 also plays a role in eliminating them. We will carefully check it practically, first economically, and if necessary, politically and socially, in 2026. We are all

sure that these processes of democratization of space, in the economic, political and social sense, will proceed in the direction planned by ESA, most beneficial for the sector. space and the entire European society.

Developing the space sector at the pan-European level is an obvious necessity. This applies to all its layers, the new political, economic and social layer of Space 4.0, the layer of various sizes of close and distant space research missions, the SatCom satellite telecommunications layer, the defense and security layer, including satellite cybersecurity, the geophysical layer of observation of Earth's resources, atmosphere and climate, layers of space cooperation with other giga-regions. From here you can see how the potentially new Space 4.0 layer plays a seemingly minor but important integrating role. Depending on the exact directions of development of the Space 4.0 idea, which we do not know yet because the intentions of the ESA initiator in such a complex socio-economic matter are never precisely reflected in the practical implementation of the idea, it may play a potentially key role in the space transformation of society at the practical level. .

V. SPACE 4.0 – THE FIRST DECADE OF IMPLEMENTING THIS AMBITIOUS CHALLENGE ENDS IN 2026!

The year 2026 will mark the first decade of undertaking and implementing the ambitious Space 4.0 challenge. What have we done during this decade? Have we started something very important? Are we slowly changing society's understanding of space as our development environment? What hasn't even been started yet? Can we briefly summarize this first decade? Are there any weaknesses that could be improved? These, and similar questions will inevitably be asked when the project has to prepare a kind of summary of a decade of activity. Here we ask them without knowing the exact answer, but rather adding them to the subjective portrait of this pioneering, great socio-economic initiative.

Looking at the implementation of the Space 4.0 idea almost from the perspective of a decade, it can be said that in 2016 it was a kind of very brave political, economic and social manifesto. At that time, some of the formulations were cautious and conditional, as if the proposers were not entirely sure of the possibility of their implementation. Space 4.0 is materializing during implementation. Certain larger processes are beginning to form, which seem beneficial from a social point of view. Legal regulations are maturing at the national, European and international levels. A new space law is being created which also covers the economy, industry, copyright and culture. In our interest, space should unconditionally become a new area of civilization expansion.

Space 4.0 was, at the time of announcement, and still remains, a bold declaration and at the same time a significant obligation for ESA to strongly support the SME sector of space technologies, both directly and indirectly. It is also an obligation to take continuous initiatives to implement the Space 4.0 initiative towards activating various sectors of the economy to increase practical connection with space.

Granulation, a significant increase in the scope of scaling space technologies, makes space incomparably much more accessible. This was probably the first effect of the encouragement, logistical, legal and economic assistance

declared in Space 4.0 in the area of innovation and undertaking many new initiatives. This is not only thanks to Space 4.0. The innovative processes, also in the space sector, have effectively contributed like: the global digital transformation of everything, optical and satellite telecommunications, the Internet of Everything, intelligent sensors and telemetry, the emergence and rapidly expanding applications of artificial intelligence environments, generative artificial intelligence GenAI, machine learning ML, large LLS language systems, cloud computing and big data technologies, introducing highly effective principles of Industry 4.0, a new way of operating business according to the principles of clever agile teams, entering the sector by new companies with new people who do not require any form of initial familiarization with the space - sometimes called generation space, currently called Space 4.0 Generation.

Space 4.0 only to some extent catalyzes the ongoing beneficial transformation processes of the significant expansion of the space sector, in the socio-economic aspect. It indicates the need to bring initiatives, innovations and space activities to the economic level, including MSEs, and preferably as many different MSEs as possible, representing the most scattered sectors possible. If it were to significantly rebuild anything, Space 4.0 would have to be a gigantic multi-billion program. Of course, Europe can afford to launch such a program if necessary. However, such a decision needs to be matured. It must be based on many indicators showing the need and benefits. The current implementation time of almost a decade shows that Space 4.0 is perhaps a preparation for launching such projects, but under many different flags, including purely business and industrial ones. To make such decisions, it is necessary to have factors of a breakthrough scale. Such factors include research benefits and benefits related to important frontiers of knowledge, significant social benefits, strengthening of very favorable directions of economic and social development, a favorable industrial breakthrough regarding the development of civilization, the possibility of mass introduction of new industrial and consumer products, the construction of a new generation of communication, and security and defense.

Space 4.0 clearly and quite formally defines outer space as a new area of expansion of our civilization. This is seemingly nothing new, but the decision to open space and move from full government control to partial public control is a significant change with fundamental consequences. During the implementation of Space 4.0, we can observe clear processes of socialization and democratization of this area and even a slow, systematic expansion of the practically appropriated space for various purposes. This is an excellent symptom. Is this due to Space 4.0, or just the kindness of governments and simply opening access to an interesting and attractive new space for innovative activities for business? A more detailed study of the achievements of the last decade may reveal something interesting in this area. Many positive economic processes are already clearly visible. Probably both of these factors, opening and encouragement, have an impact on the clearly observed activation of the space engineering and services industry. The third factor, incredibly fierce competition from other economic giga-regions, is also influential.

Failure to widely open space for business would simply mean quick suicide for Europe in this area of economic activity. The

idea of continuing to keep ownership of space in government hands is an anachronism. The positive results of the decision to free space over Europe are visible to the naked eye, everywhere, in all European countries, including here in Poland. It seems that the main driver of these observed changes is the opening itself as a consequence of peer pressure. Such opening of a large new sector must be accompanied by the introduction of rules and the establishment of laws, perhaps also providing guidelines for development. In this aspect, to be honest, the Space 4.0 initiative is simply a set of organizing rules and guidelines for the development of open space. Analyzing the Space 4.0 documents, one has the impression that they are quite simple and obvious. The most important thing was the consent to open and democratize the space. Of course, this does not diminish the importance of the Space 4.0 initiative by ESA. There must be order in business in space, otherwise chaos will creep in.

Many success metrics, or rather changes, can be associated with the opening of the space sector for business and the Space 4.0 initiative to democratize space [9, 10, 11, 12]. These changes affect different economic sectors and different areas of Europe. It's hard to call it a success because there is no benchmark. This is a ripening process. There was nothing like this before. The situation is completely unique and singular in the history of the humanity. Opening the sector means that any company that has such capabilities and appropriate licenses can send a constellation of satellites into space for the purposes of ensuring secure satellite communications, servicing space technologies, performing unique production requiring space conditions, providing satellite services, geo-satellite services, Earth imaging and observation, etc. And it happens. More and more companies are entering this market. What can also be observed concerns the development of changes in business models related to the specificity of the space economy.

REFERENCES

- [1] ESA, 2016-2024, What is Space 4.0?, https://www.esa.int/About_Us/Ministerial_Council_2016/What_is_space_4.0
- [2] Space 24 <https://space24.pl/polityka-kosmiczna/polska/rada-ministerialna-esa-w-erze-space-40>
- [3] J.Foust, 2021, ESA and EU mend relations, SpaceNews, January 22, <https://spacenews.com/esa-and-eu-mend-relations/>
- [4] M.Chrysaki, 2017, Space: Still an important Matter of National Prestige?, <https://www.europeanbusinessreview.eu/page.asp?pid=1820>
- [5] E.Ferretti (edit), 2020, Space capacity building in XXI century, Springer, ISBN:978-3-030-21937-6
- [6] U.M.Bohlmann, 2020, Space 4.0, In: S.Ferretti (eds) Space Capacity Building in the XXI Century. Studies in Space Policy, 22, Springer, https://doi.org/10.1007/978-3-030-21938-3_3
- [7] G.S.Aglietti, 2020, Current challenges and opportunities for space technologies, Front.Space Technol, <https://doi.org/10.3389/frspt.2020.00001>
- [8] G.Denis, et al, 2020, From new space to big space: How commercial space dreams is becoming a reality, Acta Astronautica, 166(1), 431-443, <https://doi.org/10.1016/j.actaastro.2019.08.03>
- [9] H.K.Athanasopoulos, 2019, The Moon Village and Space 4.0: the open concept as a new way of doing space?, Space Policy 49(101323), <https://doi.org/10.1016/j.spacepol.2019.05.001>
- [10] Thales, Space 4.0 <https://www.thalesgroup.com/en/worldwide/space/news/space-40-unlocking-value-digital-transformation>
- [11] McAfee, Space 4.0, <https://www.mcafee.com/blogs/other-blogs/mcafee-labs/securing-space-4-0-one-small-step-or-a-giant-leap-part-1/>
- [12] Polska, Space 4.0, <https://polsa.gov.pl/en/space-tech-expo/polish-space-sector/>