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Hungarian Development Opportunities of the Resilient and Innovative Space Industry

SUMMARY: This study was motivated by the fact that space industry has become one of the most innovative, rapidly developing, least crisis-sensitive industries, which grows dynamically worldwide. Its resilience to shocks is quite apparent. Since the outbreak of the pandemic[1] in spring 2020, the sector preserved many jobs and created new ones, while its innovative and technological advances remained uninterrupted. This study – based on surveys, statistical and other databases – aims to take stock of the current state of the Hungarian space sector and industry, and to set out possible directions for state involvement to enhance further progress. Our research confirmed that the Hungarian space industry, although its direct contribution to social performance is moderate today, employs a significant number of highly skilled workers and introduces cutting-edge technologies. Furthermore, through its innovations and technological and scientific transfers, its contribution to the competitiveness of the Hungarian economy is significant, even at the current level of its capacities. With adequate support and wise investments, the added value, the growth and international potential and the global space industry value chain involvement the space industry can be exploited to a much greater extent than at present.[2]

KEYWORDS: Space Research, Space Economy, Technological Change, Covid-19, Crisis Management, International Competitiveness, Economic Growth and Sustainable Development
JEL CODES: G18, H11, H12, O11, O44, Q01, Q55, Q56, Q58
DOI: https://doi.org/10.35551/PFQ_2021_1_2

The telecommunications, broadcasting, information technology, metal technology, health, earth observation, meteorology services of space industry have become part of our everyday life, and society's dependence on satellite systems has grown. Space technology has become a determining, a so-called critical infrastructure in operating economy and public services. Our study gives a cross-section picture of the status of Hungary in space economy, focusing especially on the development of space industry[3], and specifies the state involvement and institutional conditions necessary for our country to, after identifying the social-economic interests of our country, exploit the opportunities of the technological development – offered by the industry – for the benefit of the state, economy and society (and to ultimately increase common good). Although no attempt to survey the Hungarian space industry from this point of view has yet been made, the development of

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space industry has a positive impact on both the modernisation of the economy and social welfare (NATO, 2018). The study intends to contribute to space economy-related researches, which is, at the same time, its set scientific added value[4], by focusing on the examination of the features of domestic space economy, the economic-industrial implications of civilian use. This also includes the service-related service provision background linked with the design, production and industrial activities of space and ground equipment belonging to domestic businesses, which has become commonin geolocation, telecommunications, earth observation, etc. by now.

THE DEVELOPMENT OF SPACE ECONOMY IN THE LIGHT OF SOCIAL JUDGEMENT

Although their number is increasing, presently the national agencies of approximately two dozens of countries and, lately, international private enterprise giants founded in symbiosis with them are capable of economic performances related to space carriers and complex space objects. It can be established that the success of information technology and related development objectives have become fundamental in the worldwide development of space industry in recent decades (Ferencz, 2020).

The following trends describe these changes.

Growing demand: demand for space industry services arises in the case of an increasing number of economic operators.[5] The global space industry is presently an approximately USD 300-500 billion industry, which, according to surveys, can develop to two and a half times its size by 2040 (Morgan Stanley, 2020), and become a line of business with USD 1100-3000 billion production value (OECD, 2011).

New business models: new operators and new business models result in innovative solutions in the space industry.

Cost reduction: due to new business models and technological development, expenses related to, for example, satellite launches have dropped by 50-70 percent since 1970.

A record number of projects: due to new demands and service-oriented trends, a record number of small satellites were launched during the last decade, which may reach 1700 per year in the upcoming 5 years in the 150-500-kilogram category, demanding the multiplication of the present industrial capacities.

High return: every one euro investment spent in the space sector results in a six-euro return, because the profit, multiplied via the complex supplier system, is realised in the economy (EIB, 2019). Additionally, NASA estimates an eightfold return in the American economy.

The total turnover of the space industry – primarily from satellite services – amounted to about USD 277 billion in 2018. A new, high-tech sector with significant impact on everyday life has evolved. According to forecasts, space industry will provide 10 percent of the world's GDP within thirty-forty years, thus, if the USA does not wish to fall behind, a more intensive participation will be necessary (SpaceCom, 2020). The total value of investments in space industry grew by USD 8.9 billion in the year 2020, affected by the Covid-19 pandemic. According to the opinion of international analysts, another record amount of investment is expected in the upcoming years due to some giant companies increasing their space activities. Tendencies of access to the dominant technologies of the future and their resources will bring about increasing competition between the global space industry operators.[6] In Europe, line with the mentioned trends, as

part of the long-term framework programme, the National Development Plan of Ireland views space industry as strategic investment priority, the key element of which is the Space Technology Programme (Project Ireland, 2019). Practically every developed national economy of the world is inclined to exploit the opportunities presented by the new perspectives, and to join in and create value. Today, over 80 countries have space programmes, and 17 of the 22 ESA member states have special legal material in terms of space activities under their jurisdiction (Bartóki-Gönczy, 2020). This segment of the world economy grows dynamically, the trend to join in accelerates. There is an interesting competition: failure to join in may result in the social-economic separation of a country, while successful involvement may contribute to long-term catch-up (OECD, 2011).

Supportive social attitude to space economy and space industry motivates developments. Although – understandably – the public opinion was dominated by spectacular scientific and technical feats related to researches, due to information technology gaining ground, space economy has created utilisation possibilities and synergies demanding a far wider interpretation of the concept of space industry. The change in European attitude shows that while only the world powers performed activities in space, the European Community (EC) did not consider space industry and space research a priority, as the fundamental objective of EC was the establishment of internal market and single economic space. By the beginning of the liberalisation of markets (including telecommunications markets), however, the situation changed. The Single European Act, signed in 1986 (HL L 169/1.), authorised the Commission to take steps in the interest of 'research and technological development', which naturally included space industry (Bartóki-Gönczy, 2020). Yet, social opinion still identifies the opportunities related to the exploitation of space economy mostly with rocket technology, space station work and getting to other planets, all of which deplete huge financial resources, while space industry uses far more material-intellectual resources and opens a new, directly accessible growth path to a wider economic sector today.

THE RISES OF WORLD ECONOMY AND THE RESILIENCE OF SPACE INDUSTRY

Depending on the type of crisis, of course, similarly to other industrial sectors, the space industry is also affected by the crises of world economy , however, it is less sensitive to them. This industrial sector is crisis-resistant for a number of reasons:

- space economy has become part of the critical infrastructure, demand for which decreases only moderately even in the course of economic recession;
- due to long project cycles, the space industry is less exposed to political and economic cycles;
- the wide value chain of the space industry and its diversified operation covering other industries also increase the stability of the sector.

As a result, between 2005 and 2017, space industry grew by 6.7 percent per year at a world level, which was nearly twice the 3.5 percent world average. Additionally, it achieved an annual increase of over 3.5 percent even during the period of financial crisis between 2007 and 2010. Its output amounted to nearly EUR 300 billion – almost USD 400 billion – in 2019 (EIB, 2019).

The general and long-term uncertainty caused by coronavirus has also affected the space industry, which has primarily been manifested in

broken supply chains, and financial difficulties concerning both the state and private sectors. Within the space industry, the virus has had an especially negative impact on the activities of SME-s and start-up companies (OECD, 2020). Nevertheless, differing resilience characterises the different segments of the space industry: despite the decrease in tourism and air transport, telecommunications and earth observation services facilitated by geo-stationary satellites have been proven the most resilient. Another favourable factor has been that the fight against the Covid-19 crisis itself has opened the way for new fields of utilisation (PWC, 2020).[7]

The outbreak of the coronavirus crisis has further increased the key role of space industry: its position in the critical infrastructure has continued to grow as the crisis progressed, so, even under the circumstances of the Covid-19 pandemic, the processes of 2020 indicate development or only a minor break. Despite the described difficulties, the latest literature has identified space industry as an industry less exposed to the pandemic, which has also been confirmed by the Hungarian experiences. Hence, incentive state involvement influencing orders and maintaining financing plays an essential role in the crisis resistance of space industry by enforcing the defined priorities and strategic support. Consequently, despite the crisis and the related budgetary difficulties and reallocations, countries with significant space industry consider space sector a national economic and national strategic industry of key importance.[8]

HUNGARIAN SPACE INDUSTRY BETWEEN THE END OF SOCIALISM AND THE PRESENT DAYS

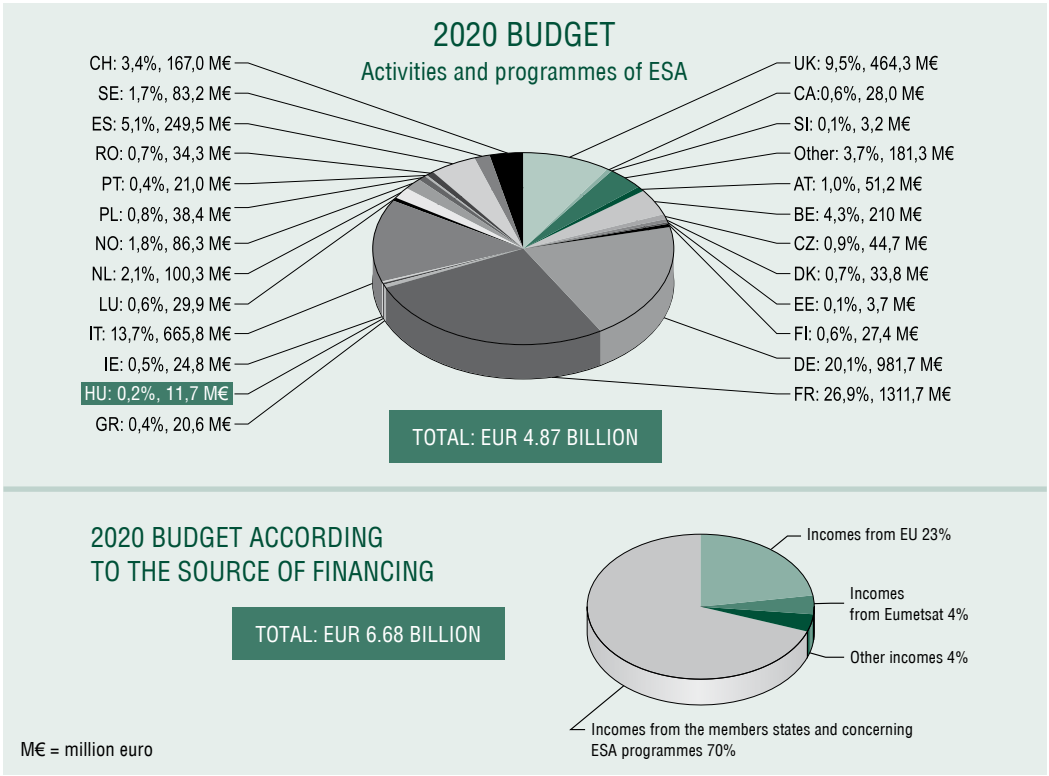
Hungary has been part of the international professional network since the beginning of space activity, proved by several results. Although a number of outstanding accomplishments had a driving effect on domestic space research, the different subfields –if results were achieved at all, especially in the 1980s – did not get as far as effectively contributing to technical, technological development or the strengthening of innovation capacities in industrial volumes. Notwithstanding the fact that several companies have been in the sector for decades, individual, occasional project-related operation has become typical. Therefore, based on knowledge ability levels, as opposed to international trends, we have not succeeded in establishing market-based profitable spin-offs (vigorous space industry departments, new corporate 'side profiles') in larger numbers. The space industry of Hungary does not occupy, either globally or regionally, its place anymore in the space industry of the world, justified by its relative development level achieved earlier, in the 1980s. The fallback is striking because the level of development of the domestic processing industry is, in a European context, middle-ranking (Nagy, 2016).

In 2017, the GDP proportionate expenditure on the space sector of Poland was twice, that of Romania was 3.5 times, and that of the Czech Republic was 5.5 times more than that of Hungary (OECD, 2019). Taking the space industry-related state subsidies of countries of similar abilities into account, the Hungarian volume (EUR 11.7 million in 2020) was still significantly behind the ESA budget *(see Figure 1)*. Due to more active state involvement and the success of some companies integrated into international relations, change has been perceptible since 2018.

The achieved results and incentives in the bi- and multilateral relations and domestic control have measurable effects today both on the fundamental and applied researches and on the development of production and service companies of the space industry. In addition to the previous predominance of individual

Figure 1

MEMBER STATE PAYMENTS AND OTHER INCOMES OF THE EUROPEAN SPACE AGENCY



Source: ESA, 2020

supply activity linked with the supply chains of recognised European space industry companies[9] established mostly with the intention to follow the trends of international space research in isolated, university and research institutional respects, clusters, cooperating network initiatives and research-production service circles also exist today. There are two dominant organisations clustering space industry companies in Hungary (HUNSPACE, EI-Tech Center), the main uniform objectives of which are to strengthen the cooperation between the operators of the sector and to establish international relations by harmonised activity. There is an existing space industry – although of moderate size – in Hungary today.

THE PRESENT SITUATION AND THE CHARACTERISTICS OF DOMESTIC SPACE INDUSTRY

Database constituting the basis of the research

Only scattered information was available on space industrial activities, corporate performance, profiles, capacities, headcount figures until the beginning of the research.[10] In order to perform research and evaluation, the necessary database had to be built first, the foundations of which our research wishes to lay down from two back-to-back, supplementary source groups, and additional statistical,

controlling authority and international cooperation information.

Given limited information and statistical data-obtaining possibilities, one of them is the database extracting data from different public tender and ministry documents, publications, company information data, workshop information and personal consultations, which is ideal for, as the first step, outlining the sector.

The other – more targeted and detailed – database is expected to enable versatile conclusions drawn from the production value, profile, capacity data of companies, their human resource preparedness, the financial conditions of their operation, potential problems and relations, and to enable the display of operation tendencies. Therefore, further exploratory work has begun with the support of the Ministry of Foreign Affairs and Trade (MFAT).

Cooperating with the Hungarian Chamber of Commerce and Industry (hereinafter referred to as: HCCI)[11], the first (initial) survey launched to learn more about the space industrial activity of the members and their related expectations was carried out in September 2020 by the Defence Industry and Space Technology Section of HCCI. The questionnaire was filled out by 63 companies from the 94 members of the section, of which 26 companies presently perform some type of space industry-related activity. We wish to point out that the second survey concerning companies operating in the Hungarian space industry was carried out in February 2021, some of the preliminary data of which are also presented (23 of the responding 38 companies – 61 percent – perform space industry-related activity).

The results of the survey carried out in September 2020 cannot, on their own, be deemed representative for the entire space industrial sector, however, they can be considered a preliminary survey performed in the subject, which – with the high percentage of replies also taken into account – provides a valuable picture of the activities, headcount management, turnover, development activity and finance-related expectations of the section members. The questionnaire-based research was performed online.

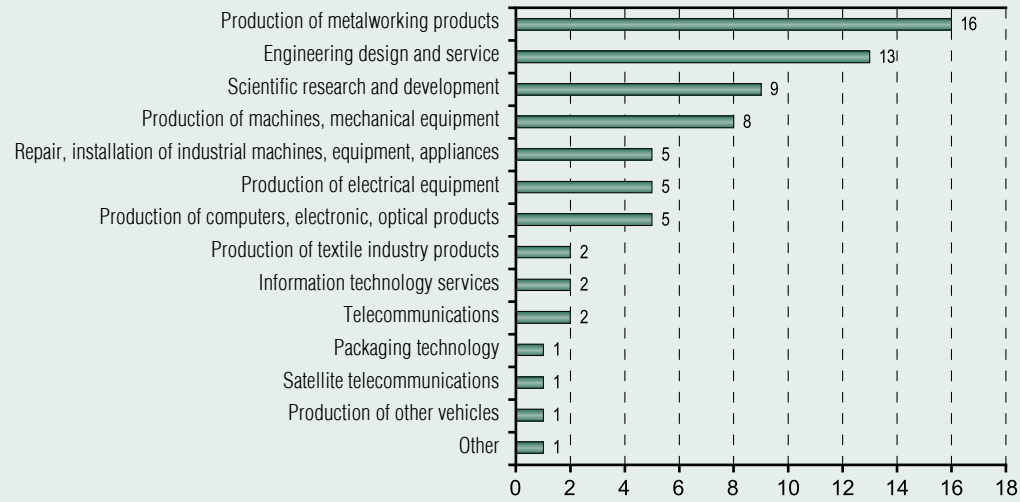
The key features of the Hungarian space industry in light of the initial survey

Based on the survey, it can be established that 41 percent of the respondent companies in the Defence Industry and Space Technology Section of HCCI perform some kind of space industry-related activity. The majority of the 26 companies performing any kind of space industrial activity produce metalworking products, for example spacecraft components or spare parts (16 companies). 13 companies offer engineering design and service, 9 perform scientific research and development (for example earth observation, geodesy, meteorology, cartography, agricultural product forecast, space resource research, testing). 8 companies manufacture some kind of space industry-related machines or mechanical equipment (for example satellites). However, none of the companies chose the option of airplane or spacecraft repair, space transport or defence services (*see Figure 2*)

The survey confirms that the companies of domestic space industry have decades of history: companies performing space industrial activities have been in operation for an average of 20 years; the youngest company was founded in 2019, while the oldest in 1981. The number of companies and such profile expansions gradually increases year by year, and significant growth reserve can be identified. The average net sales revenue of the respondent companies performing space industrial activity amounted to HUF 717 million in 2019. An important conclusion can be drawn from the forecasts of

Figure 2

SPACE INDUSTRY-RELATED ACTIVITIES PERFORMED BY THE RESPONDENTS



Note: We asked the respondents to indicate all their space industry related activity performed at the company, so one company could mark several answers.

Source: own editing based on HCCI, 2020

the companies concerning the crisis resilience of the sector related to the sales revenue: the majority of the companies do not expect to change in the pandemic period, one quarter of them expect growth. The answer to the question regarding the outlook for the upcoming ten years is clear: there will be increase in the volume of both the income from space industrial activity and the expenses of related innovations. Referring to the preliminary data of the 2021 HCCI survey, the sales revenue of the majority of the respondent companies expanded in 2020 compared to data of 2019, and the majority of them expect further boost in the future.[12] We would like to direct attention to the fact behind the calculations and forecasts of the companies that according to the data of the 2020 HCCI survey, the questioned companies spend on average 11 percent of their sales revenue on space industrial activity-related developments.

Taking into account the size category of the companies participating in the survey, it can be established that 50 percent of them are small and 5 are micro companies. Five companies have a headcount between 50 and 99 people, and the three largest companies operate with a headcount between 100 and 249.

It is a characteristic of the companies in this field that the qualification of human resources is much higher than that of other areas of the industry. Highly qualified employees are employed: 48 percent of them are skilled blue collar workers, 38 percent of them are white collar employees with university degree. Approximately half (51 percent) of the employees have jobs related to space industrial activity, and one-fifth of the total headcount works as researchers. We wish to emphasise here that based on the preliminary results of the latest survey carried out with the technical help

of HCCI in 2021, knowledge intensity is even more prominent: 60 percent of the employees working at the companies participating in the survey worked in white collar jobs requiring university degree (we would like to point out that the percentage of those performing engineering services was high in the survey), while, based on the 2020 Q4 figures of HCSO, 25 percent of employees in the entire national economy have a higher education degree.

The project approach of the space industry indicates that averagely 40 percent (an average of 11 employees per company) of the total headcount work related to space industrial activities with a contract of indefinite period. An average of 14 percent of the total headcount (averagely 1.9 persons per company) are employed on a project basis with a fixed-term contract. Compared to 2019, the number of persons employed in connection with space industrial activities grew in average both in the form of indefinite-period contracts (from 7.4 persons to 11 persons) and fixed-term contracts (from 1.55 persons to 1.9 persons) by 1 September 2020 at the companies participating in the survey, which also reflects the resilience of the space industrial activity to the Covid-19 crisis. In the case of the majority of such companies, the dominant forecast is that the headcount of employees employed within the framework of space industrial activity will increase, and, related to the development of the activity, it will be at least one and a half or two times its present size.

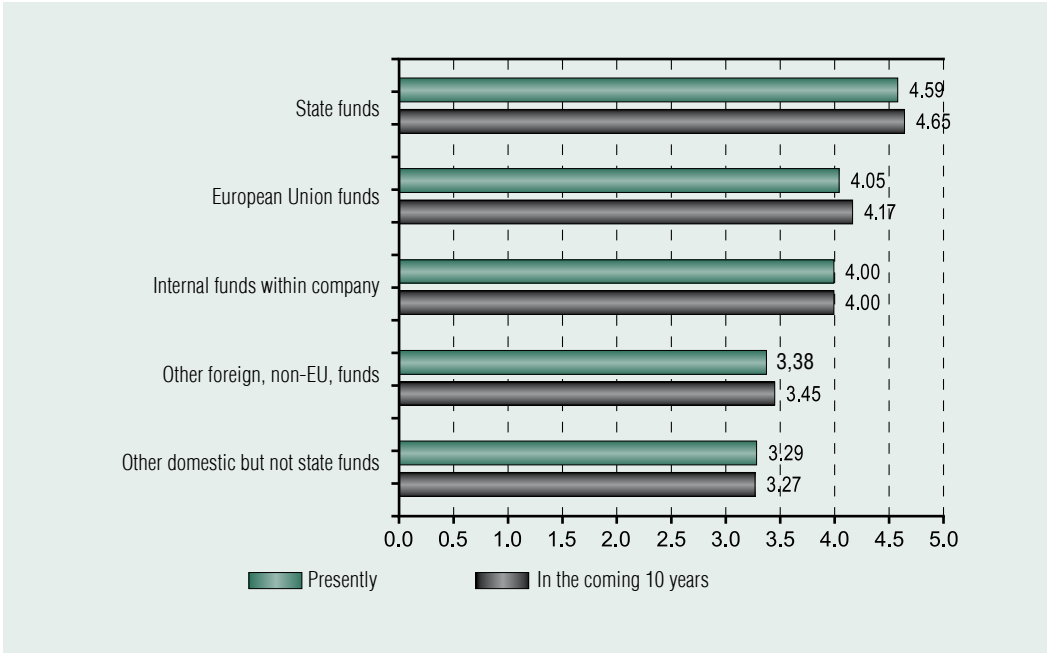
It must be emphasised that the majority of the companies is in one hundred percent Hungarian ownership (foreign capital is present in the registered capital of three companies), three-quarters of them perform export and realise over half of their sales from export with a rather high import ratio. Its partial replacement, the increase of Hungarian participation, is facilitated by the majority of the ESA programmes (communications, navigation, averting round-the-world natural and artificial threats, manned space travel and researches, earth observation) becoming available as a result of state involvement – the target-oriented contract development work of MFAT –, which also serves the purpose of increasing entrepreneurial choices. The picture of exporting companies is further nuanced by the preliminary data of the second HCCI survey of 2021, according to which it is reassuring that 18 different companies are listed among the key export target countries. The most frequently named target countries were Germany, Austria, the Netherlands and Switzerland. The foundation of the prosperity of this knowledge-intensive space industry is targeted and calculable state involvement with strategic orientation and long-term thinking. These internationally valid findings were also confirmed in the case of the Hungarian space industry. In line with the extremely dynamic trends of the sector, the majority of companies interested in space industry deem domestic incentive and assistance vital in order to achieve dynamic development in the coming years. State funds allocated to the space industry are valued the most in this more dynamic development, to which European Union funds and own funds within the company can be added (*Figure 3*).

It is important that based on the preliminary data of the survey carried out in February 2021, the respondent companies still expect increase in the role of state funds (deemed the key source) in the performance of space industrial activities in the coming 10 years in addition to funds inside the company and European Union funds.

These sector specific features and our researches show that the efficient, incentive and predictable allocation of both the state funds and the European Union funds is essential for the Hungarian space industry to reach a higher level of development, which

Figure 3

THE IMPORTANCE OF DIFFERENT FUNDS IN PERFORMING SPACE INDUSTRIAL ACTIVITIES PRESENTLY AND IN THE NEXT 10 YEARS



Note: We asked the respondents to evaluate the importance of the different funds in performing space industrial activities. In the course of the evaluation, 1 meant that the given funds were not important at all, and 5 meant that they were of key importance in the space sector related activity.

Source: own editing based on HCCI, 2020

is also justified by longer financing project cycles (of minimum 4-5 years), characteristic of the space industry.

Based on the available data of the presented survey and further additional inquiries, approximately 40 companies performing space industry-related activities can be identified in Hungary in January 2021. This is a piece of data of great significance, because due to the high response rate experienced in the course of the previously detailed survey, we managed to gain information on the space industrial activities and the related forecasts of about two-thirds of these companies.

From the point of view of global space industry, the production-specific field of the Hungarian space industry is primarily satellite and related component production, while there are only few companies in the field of ground equipment manufacture.

Observing the trends defining space industry for a long time, the Hungarian participants also dealt primarily with the fulfilment of prototype-based special orders, thus international production and service activity driven by foreign businesses is characteristic of the sector, within which module manufacturing and wagework dominate. Supply is in the foreground, where the potential of participation by cooperation depends on the strength of the competences of the given Hungarian company.

Due to the capital intensiveness of the industry, the model, by which a company

operates on incomes from the space industry only, is fundamentally not characteristic. Not even companies with Technology Readiness Level (TRL) rating[13] have capacities necessary for serial production of large volumes, and they typically do not plan to take this route either, although, due to international events in the sector, a significant market potential is in the making in this field.

The following factors hindering development were specified by the space industry participants in the course of the research.

- Entrance limits of starting a company, presently difficult forecasts of the return on investments, general lack of internal funds.
- Lack of staff with appropriate professional qualifications, lack of stable resource supply: it is primarily due to the deficiencies of inherited university, secondary school, basic education.
- Limited domestic cooperation reducing the number of applicable tenders and corporate cooperation, as well as the synergy effect.
- Obtaining references and accreditations necessary for international tenders, and the lack of a Hungarian accreditation and qualification system.
- Lack of a domestic organisation with control-coordination power.

The described difficulties also mean limitations of control concerning action, incentive and development. Ending these limitations can accelerate the development of the Hungarian space industry. Abandoned development, the spontaneous, uneven formation of the sector in occasional steps cannot be useful for the businesses operating in this field. Incentive-developing, targeted state involvement, including providing the national-level regulatory (space act), control, international contact institution, quality assurance conditions and financing terms, may unlock new possibilities in reducing the deficiencies, and in development. It would be a strategic error to allow the exclusive influence of the generating impact of market interests and external interest-based cooperation in the environment surrounding the operation of the company – in the ecosystem –, following the effects of international trends only.

The connections between the space industry and technological development in the condition system of the incentive state[14]

The high commitment of space industry to innovation with appropriate targeted financial and organisation support significantly larger in volume than before also helps it strengthen and become a more significant operator in the world space industry.

With the narrowing of extensive increase opportunities following successful budgetary and economic stabilisation, a growth path must be followed, an important pillar of which is the change in competitiveness (NBH, 2019), which, at the same time, means a new level of the knowledge and technology-intensive development phase. An innovation-oriented growth model may give a framework to the state approach aimed at reaching a sustainable growth path based on knowledge, capital and productivity, for which the intention to increase R+D expenses and R+D headcount is essential (NBH, 2020). The approach stating that the role of the state cannot be reduced to primarily the termination of market failures and deficiencies is becoming more and more prominent in the world, because this approach is counterproductive as it narrows the leeway of the state and contributes to the development of wide-ranging economic and social impacts of R+D+I with inappropriate efficiency (Mazzucato, 2018). *Mazzucato* regards innovation orientation, which also has a competition-generating effect, the key to success in the mission-oriented state

programmes. Another forward-looking condition of the development potential of the Hungarian space industry is that the percentage of national economic R+D spent on space research and its use had an increasing tendency in the recent years (between 2017 and 2019), growing from the 0.3 percent value in 2017 to 0.41 percent by 2019, according to HCSO data. Investment in knowledge and technology-intensive industries may increase the innovation capacity supporting convergence to the countries of the Visegrad Group and the EU average. The change in the number of patents registered annually shows that the utilisation of R+D expenditure is not efficient enough in our country – targeted opening to knowledge-intensive industries, which can also be an efficiently incentive step to digitalisation, may also be an improvement.[15] We emphasise that striving for budgetary sustainability also belongs to digitalisation, which may preserve and expand resources available to future generations (Domokos, Pulay, 2020). The task of adapting to the emerging megatrends of our age must be solved by putting the Hungarian economy on a long-term sustainable growth path more dynamically after recovering from the coronavirus pandemic. The results of the technological development must be used wisely in the interest of the common good, while the domestic national economy must benefit from the perspective potentials of future industries as fully as possible (Báger, Parragh, 2020).

On one hand, state management may focus on the space industry by meeting the requirements of wise and high-quality public money spending, thus by observing the threefold golden rule of public money spending pursuant to the Fundamental Law (Kovács, 2020) (regularity-expediency-efficiency), and, on the other hand, by approaching the potentials of technological development determining our everyday lives more and more by focusing on sustainability and crisis resistance. More emphasis may be given to the state incentive of new directions, the positive spillover effects of which can be identified in a wide spectrum, and business models based on the cooperation of the state and the private sector can be created. The incentive state support of the space industry fits this economic policy approach well, which takes the economic-social role of the space industry into account (Ferencz, 2020).

In relation to the above, we present the industrial features which especially justify the national economic relevance of space industry nowadays and during the coronavirus crisis *(Table 1)*.

Using solid strategy in the case of exploiting the perspectives listed in Table 1, the road to European convergence opens before Hungary in this field, too.

CHALLENGES OF THE FUTURE IN LIGHT OF THE OBJECTIVES TO ACHIEVE – CATCHING UP AND ECONOMIC SOVEREIGNTY

In light of the international trends, domestic capacities and the potentials offered by the industry, Hungary – in line with the spirit of the new industrial revolution – cannot miss out on the development built on automation and information technology, which, at the same time, may also contribute to the establishment of modern, sovereign spacecraft production and service. This naturally needs a similarly receptive corporate approach, because otherwise, the support using capacity-increasing modern management techniques helping to enter the market will not be exploited sufficiently. It is essential that gradualim is observed, capacities are expanded and thus the industry is put on a stable and organic growth path.

Table 1

SPACE INDUSTRY AS AN INDUSTRY WITH PERSPECTIVE

SPACE INDUSTRY AS AN INDUSTRY WITH PERSPECTIVE SUBSIDIES BY INCENTIVE STATE				
Social embeddedness of the achievements of technological development	**Harmony of sustainability considerations and the common good**	**Spillover industrial effects, wide-range corporate involvement and social usability**	**Crisis resistance and long-term economic development**	**Necessity of state and market coordination**
Technological equipment which became part of our everyday life: • smartphone, computer, • GPS-location, • navigation, • satellite-based telecommunications, • weather forecast, • precision farming, • climate protection, • environmental protectio	• UN 2030 sustainable development goals, • economy catalysing space industrial objectives of the EU, • more complete exploitation of joining opportunities provided by the ESA membership, • Fundamental Law in the interest of realising the common good*	*Positive social and economic effects, and wide-ranging industrial benefits:* • public health, • agriculture, • high-tech industries • vehicle industry, • education, • green industries, • R+D+I, • international partnerships, • international corporate cooperation, • joining the global value chain, • developing bilateral and multilateral diplomatic relations	• 2008-2009 NPV crisis resistance, • 2020 coronavirus resistance, • cross-economic cycle development	• significance of state involvement, growing harmony between state and market,** • targeted economic development and economic stimulus in partnership between the state and private sector,*** • international cooperations.

Notes:

*Space industry plays an increasingly significant catalyst role among the three known pillars and objectives of sustainable development.

**Transformation of the training system of space research and space activity, its incorporation in the primary and secondary training, harmonisation of the training systems of the concerned higher educational institutions began together with the Ministry of Human Capacities and the Ministry for Innovation and Technology.

***Initiative based on the cooperation of the state and private sector for founding Carpathia Sat company intending to put the first Hungarian telecommunications satellite into orbit may provide the companies with the opportunity of joining the global value chain.

Source: addition and editing by the research team based on Parragh, Báger, Tóth, 2020

The conditions are the following:

- catching up to regional competitors,
- increase of the professional quality of workforce necessary for the space programme by education (providing workforce for the space programme in necessary quality and quantity by continuing training) and companies (dual training),
- finding and exploiting breakout opportunities,
- implementation of state-of-the-art and sovereign spacecraft production covering the complete value chain.

The strengthening of existing competences and the establishment of targeted competences in segments with high market potential and return may substantiate development for the Hungarian market. Taking the domestic status of the industry and the international trends into account, we can see that incentive

state involvement may effectively support the development and catch-up of the industry.

Outstanding attention must be given to the development of key knowledge-intensive special sectors and fields yielding higher domestic added value, also vital for the space industry and the support of the related investments (Kádár, Németh, Kerekes, Tóth, 2019). We note here that – as these are innovative activities with high added value – the future growth of the number of companies cannot be accompanied by general and significant increase in labour force need, but more by the rise in the demand for highly qualified workforce. Additionally, the development capacities of the domestic space industry must also support the sector extensively in joining the international space industrial cooperation, facilitating the entrance of Hungary on the service side, e.g. the implementation of the Hungarian sovereign satellite programme, increasing the capacity of the state. Assisted competitive companies may support more intensive and growing participation in ESA, which will pay off simultaneously with the higher ESA contributions of Hungary.[16]

A FEW SUMMARISING THOUGHTS

Our research confirms that space industry has an outstanding significance among the industries of the future, as the key of the achievements to date as well as of the ambitious plans for the future also lies in the wide base of highly qualified experts experienced in the field of research and development. Referring to the fact that the protection of the industry receiving little attention previously has been pushed to the foreground in Hungary: the space industry was identified as one of the future (growth) industries in the Economy Protection Action Plan serving the purpose of reducing the economic effects of the pandemic situation in the first wave of the coronavirus pandemic (Economy Protection Action Plan, 2020). *Matolcsy* emphasises the common feature of the countries implementing successful catching up: '*Catching up for us was brought about by the technology and knowledge-intensive model*' (Matolcsy, 2020b).

The research results achieved to date have been proven suitable for outlining the sector and thus for illustrating perspectives in the case of spontaneous development and incentive state support, provision of conditions. All this can provide starting points for further research work. In addition to the systematic establishment of an information base characteristic of the activity of the space sector and the increase of the precision of the 'map', these researches may help to answer the questions of

- the conditions necessary to increase the existing resilience, 'crisis resistance' of the domestic space industry,
- the roles space industry may have – in case of spontaneous and supported development – in the general technological development, the strengthening of the country's competitiveness, and the economic performances, innovations in which these can be measured and forecasted in medium and longer terms,
- what interactions, potentials, restrictions prevail in the international cooperation relations of the space industry and the value system of economic sovereignty, how can they be interpreted, and what balances can be maintained.

The answer to these three questions may lead to the answer to the researchers' question on how the characteristics of space industry can materialise in the upcoming years and what additional performance they may yield in Hungary.

Notes

[1] Deducted from the conceptual framework established by the international organisations resilience in general terms means the ability of flexible resistance, that is to say, the ability of a system to successfully adjust to strong, repeated, even shock-like, external impacts. The concept of resilience is also added to the vocabulary of managing the crisis due to the pandemic. The central element of the recovery plan elaborated by the European Commission (hereinafter referred to as: Commission) is called 'Recovery and Resilience Facility (EU, 2020), (Pulay, Simon, Kisapáti, 2020).

[2] From June 2020 the authors of the article performed research in the topic related to the title upon the assignment of the University of Public Service. The constitution of the group determined the cooperation of researchers with university and civil service background familiar with the framework of the development concept of the incentive state representing monetary, budgetary and investment aspect system experienced in macroeconomic analyses.

[3] We deem every primary research, experiment, training, organisational, production, service, spacecraft production, putting into orbit, space and ground observation, information technology, communications activity, infrastructure development and related control, international relations etc. task in connection with the exploitation of space to belong to the category of space industry and thus space economy. According to the definition of the European Investment Bank: the space industry is an economic sector the production service profiles, economic interests, control solutions and relationships of which are related to space economy, space industry (EIB, 2019)

[4] The research team examined university and research institution presentations and development to the extent which directly concerned the industrial-economic implications, so it did not review Hungarian results achieved recently within the framework of university-institution researches, such as 'MASAT', 'ATL' and 'SMOG' satellites.

[5] According to the calculations of the European Commission ICT (information and communications technology) created six times more jobs (40 percent) in 2011-2019 in the sector than the growth of the number of employees in the European Union (6.9 percent). The industry is a large user of satellite technologies, that is to say that it uses and offers services based on equipment operating in space almost without exception. 3.4 percent of the employees work in this industry in Hungary. The percentage of employees in the ICT sector is 4.0 in the Czech Republic, 3.7 in Slovakia, 2.3 in Romania, 3.1 in Poland (Eurostat, 2020).

[6] Future technologies are, for example, artificial intelligence, quantum technology, space mining, space solar technology, space tourism, space communications systems, production industry in space, spacecraft propulsion systems. The resources of the future are energy carriers, oxygen, water and hydrogen.

[7] The study identifies the fact that space industry has provided significant assistance in monitoring the economic, social and defence areas of the crisis as a positive impact. These areas are, for example, trade, logistics, and the precise and fast detection of migration processes.

[8] Although private enterprises have been playing an increasing role lately, and this trend, set out from the USA, is expected to grow, the targeted (state) subsidies may strengthen corporate innovation and R+D activity. (State) contribution to the costs of specific projects may in many cases be more

efficient than general contribution to the costs of innovation without differentiation.

[9] Performing small batch or special metalworking, IT software and hardware development activity for international large companies is not economical anymore.

[10] The corporate database was established in several steps: based on data available according to the 'Hazai Űrkörkép 2019' (Space Caleidoscope 2019) and 'Hazai Űrkörkép 2020' (Space Caleidoscope 2020) space catalogue published by the Hungarian Astronautical Society, a total of 21 companies were identified in 2019 and 2020. Companies in the scope of the members of Hungarian Chamber of Commerce and Industry's (HCCI) Defence Industry and Space Technology Section and the Department of Space Research and Space Activity of the Ministry of Foreign Affairs and Trade added to the circle of examined companies. Based on the 2020 data of the HCCI survey https://www.mant.hu/kiadvanyok/HungarianSpaceCaleidoscope2019.pdf and the preliminary data of the 2021 survey https://www.mant.hu/kiadvanyok/HungarianSpaceCaleidoscope2020.pdf, there were approximately 40 companies performing space industrial activity in Hungary in February 2021. The availability of sector specific statistical data (Hungarian Central Statistical Office, HCSO) may significantly support the progress of the topic-related research.

[11] Our research team prepared the thematic questions of the survey and the analysis of the answers given to the questions summarised technically per question, presented in the article. The latter, of course, also shows the questions themselves as well, which we did not include separately for volume reasons.

[12] The crisis resilience of the space industry is shown by the HCSO data valid in national economical context (first forecast), according to which the performance of the economy dropped by 5.1 percent in 2020 compared to the previous year.

[13] The international classification for measuring technological maturity levels rates the readiness of projects on a scale from 1 to 9.

[14] By the concept of incentive state, the use of financial, support, organisational, condition provision, educational and various social policy tools is understood by which the state – consciously in its activist approach and in determined directions – helps the operators of the economy or one of its specified sectors, for example space industry, ensuring harmony between community/social objectives and business interests (Parragh, 2019).

[15] E-trade, e-public administration, e-corporate development solutions etc. are all solutions based on space technology.

[16] Payments are redistributed according to the geo-return principle, which means that the companies and research institutions of the space industry of the state making the payment will receive payment from the member state contributions after deducting the internal costs of the organisation. Obtaining 'space heritage' (reference) thus available to the state making the payment facilitates the entry of the companies to the market and the increase of the prestige of research institutions and universities, as well as the increase in competitiveness, quality training of new recruitments and keeping the training staff (Ferencz, 2020).

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