Defense & Space: Opportunities for Science and Industry

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An increasing number of companies and research teams are participating in international space projects. NATO has recently recognized space as one of its operational domains and the Czech military has also started developing its own capabilities in this area. Space technology, both civilian and military, may be what the Czech Republic needs to move away from being the "assembly plant" of Europe and join the ranks of advanced developed countries. It can also boost the country's security and help meet the country's commitments to allies.

Introduction

While the Czech Republic managed to sign some important military procurement contracts last year and increased its defense spending to 1.19% of its GDP (of which 14.4% was earmarked for investments),[1] the country is still among the worst performers in reaching the agreed goal of spending 2% of GDP on defense with 20% of that number being investments. This, unfortunately, also concerns defense research and development spending, for which 2% of the military budget should be used. In reality, it is about one quarter of that amount in

1) *NATO Secretary General 2019 Annual Report* [online]. 19. 3. 2020 [retrieved on: 2020-08-06]. Available at: https://www.nato.int/cps/en/natohq/opinions_174406.htm.

the Czech Republic. The coming years are not likely to bring about a positive change. There is one exception however, the country's promising space research projects.

On 1 January 2020, the Czech Republic opened its Satellite Center and space technologies became a priority for defense research. The Czech Republic also decided to significantly increase its contribution to the European Space Agency (ESA) budget. Over the last decade, moreover, an increasing number of Czech institutions and companies have been participating in civilian space projects involving development and manufacture of cutting-edge technologies with high added value.

Space Competition

In the twentieth century, space was used by the competing superpowers mostly for military purposes. In the twenty-first century, however, space technologies are an essential piece of infrastructure allowing modern societies to benefit from services such as satellite navigation, communications and weather forecasts. Space technologies drive progress in areas such as robotics, mechanical engineering, electronics, sensors, optics, material science, biomedical engineering, automation and autonomous systems. Space-based technologies affect practically all aspects of people's lives, from their cell phones, the Internet, air travel and banking systems to the environment and agriculture.

Industries participating in space activities also tend to expand into other areas of the economy, which positively impacts the transfer of knowledge and space technologies for future use and commercial applications. Within a couple of years, the advanced technologies have trickled into the aircraft and automotive industries. Companies utilizing experience from space research often have a significant competitive edge. Satellite systems enabling communication, navigation, surveillance, observation, intelligence gathering, as well as targeting and guidance of precision weapons are also ever more important for the armed forces.

It is estimated that 88 nations and government consortia conduct some level of activity in space.[2] The number of commercial satellite operators is also rapidly increasing. The first artificial satellite of the Earth was launched by the Soviet Union in 1957. Currently, there are approximately 2,200–2,600 satellites in orbit and this number is set to increase five-fold in this decade. Just by 2025, 1,100 satellites will be launched into space each year. In comparison, the number was 365 in 2018. SpaceX's *Starlink* satellite Internet constellation alone will require twelve thousand satellites in orbit by 2027. While this is by far the largest such initiative, it is not the only one. Governments are not lagging too much behind private

2) ROBINSON, Jana. Space Security Policies and Strategies of States: an Introduction. In: SCHROGL, K.-U. *Handbook of Space Security.* Springer Publishing International, 2020, p. 2.

companies: 1,150 government-owned civilian and military satellites are set to be launched over the next 10 years.[3]

NATO

In December last year, the North Atlantic Treaty Organization (NATO) declared space as one of its operational domains alongside air, land, sea and cyberspace. Space is the key to the twenty-first century battlefields in terms of all levels of command and control. Practically no contemporary combat operation, conducted by the military of a developed nation, is possible without some reliance on space technologies. For this reason, the United States has also created a new branch of its military, the *United States Space Force* (USSF), and other countries will likely follow suit.

As concerns the use of space technologies, a modern military relies on three main components: global satellite navigation systems, telecommunications and remote surveillance of the Earth. Space is also emerging as a brand-new battlefield. The orbital space around the Earth may specifically experience aggressive actions against the aforementioned navigation, telecommunication and observation systems. Satellites can be either directly armed, cyber-attacked, temporarily or permanently put out of operations, or even attacked from the ground by anti-satellite weapons. These actions can result in disruption of intelligence gathering, satellite navigation and operation of early warning systems. NATO's chief interest in this area is to secure reliable and permanent access to space technologies, which is why it earmarked over EUR 1 billion for satellite communications for the period from 2020 to 2034 to ensure fast and secure information transmission.

Budgets

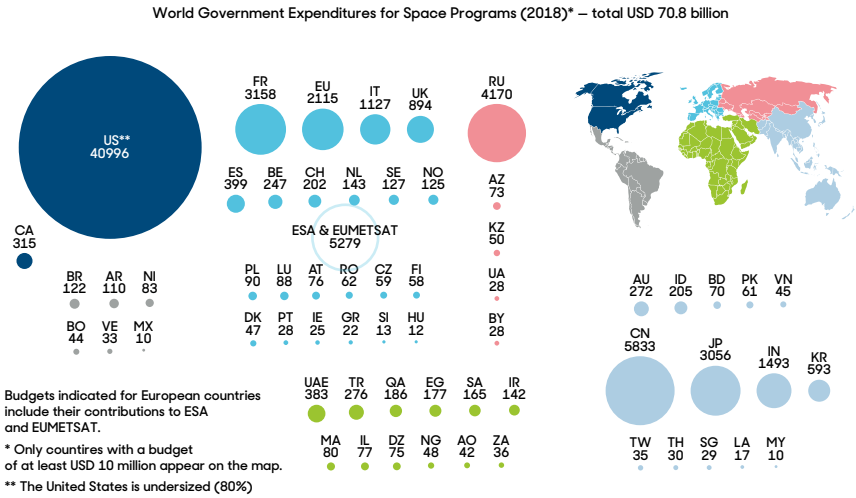
All major powers interested in maintaining their military capabilities and technological edge are investing in space programs. Global government expenditure for space programs reached USD 70.9 billion in 2018. In 2024, this number should increase to USD 84.6 billion. The United States remains the largest spender, followed by China, Russia, France and Japan. The US space budget in 2018 was USD 40.9 billion, which is 58 percent of the total global space program expenditure. (The US share, however, historically reached up to 75 percent.) In the same year, China invested USD 5.83 billion and the Russian budget dropped from a record-breaking USD 9.75 in 2013 to USD 4.17 billion.[4] France's space expenditure

3) Euroconsult Government Space Programs Report. *SpaceRef* [online]. 25. 6. 2019. [retrieved on: 2020-08-06]. Available at: http://spaceref.com/news/viewpr.html?pid=54448.

4) Euroconsult. Profiles of Government Space Programs. 2019. In: SEMINARI, Simon. Global government space budgets continues multilayer rebound. *SpaceNews* [online]. 24. 11. 2019. [retrieved on: 2020-08-06]. Available at: https://spacenews.com/op-ed-global-government-space-budgets-continues-multiyear-rebound/.

of USD 3.15 billion[5] was the largest in Europe (except for Russia) and was higher than that of Japan at USD 3.1 billion. The next largest spenders were Germany, the European Union, India, Italy and the United Kingdom. Out of smaller countries, Israel had one of the most developed space programs as well as considerable capabilities in this area.

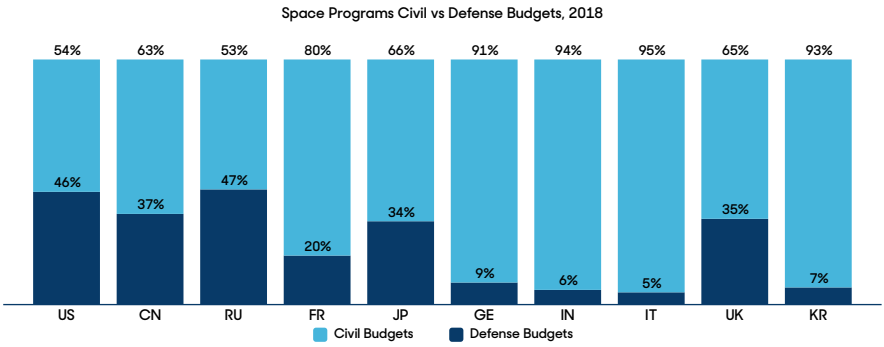
Chart 1: World Government Expenditures for Space Programs in 2018 (in USD million)
Source: Euroconsult.



It is also interesting to see how much governments spend on civilian and military space programs. In 2018, USD 44.5 billion (63%) was spent on civilian space programs out of the total of USD 70.9 billion while USD 26.4 billion (37%) was spent on military programs. This was an 8.3% increase in the military space budgets compared to 2017. The military share in national space program budgets is the highest in Russia (47%) followed by the USA (46%), China (37%), UK (35%), Japan (34%) and France (20%). Countries thus still slightly favor civilian programs, with the caveat that individual institutions, research centers and companies often participate in both civilian and military programs, which often overlap and complement each other.

5) The amount includes both national space expenditures as well as France's contributions to the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT).

Chart 2: Share of civilian vs. military space programs in national budgets in 2018
Source: Euroconsult.



The Czech Republic

Czech (previously Czechoslovak) space research has a long history spanning multiple sectors such as cutting-edge optics, mechanical engineering and aerospace. The development of the Czech space industry has recently been stimulated by two key events: the country became a member of the European Space Agency (ESA) in 2008 and the European GNSS Agency (GSA) decided to move to Prague in 2010. New incentives are certainly also being created by NATO in terms of new projects with the participation of the Czech armed forces. Still more opportunities will be presented when in 2021, the GSA will be transformed into the European Union Agency for the Space Programme (EUSPA) and Prague will serve as the HQ for all EU space programs,[6] making the Czech Republic one of the key "space centers" of Europe.

Thanks to the ESA membership and the GSA move to the Czech Republic, the country has become attractive for important players on the space research market. Many Western companies have opened subsidiaries in the Czech Republic and started building partnerships with the local players. One of the key factors behind this trend is the principle of geographic return ensuring that the vast majority of funds paid as a contribution to the ESA budget will find their way back to the national economy. Indeed, in practical terms, it remains impossible to join the supply chains of the large aerospace contractors such as Airbus, Thales and OHB without also participating in ESA projects.

The rate of return on public investment into space programs is usually higher than in other types of programs and this positive contribution has been demonstrated by a number

6) The staff working in Prague will also be increased from 200 to 700 as part of the GSA's transformation into EUSPA.

of different studies. One euro invested in ESA space activities thus yielded, in strictly economic terms, 4.8 euros in Norway (in the period from 1985 to 2012), 4.5 euros in Denmark (2000–2007), 2.2 euros in Portugal (2000–2009) and 2.07 euros in Canada (2000–2009). A similar economic effect was also noted in OECD reports released from 2007 to 2011.[7] Reaching the rate of return seen in Nordic countries would be excellent, but the Czech Republic definitely does have the potential to even achieve levels of return similar to Canada and Portugal, if that is not already the case and these numbers already mean that the money is well spent.

From 2008 to 2020, Czech companies and universities carried out nearly 400 projects.[8] In 2018 alone, over 60 Czech companies participated in ESA projects and dozens of other businesses took part as subcontractors. There is a great deal of room for growth in this decade as the competitiveness and capacities of Czech companies and institutions continue to improve. The Czech government has also recently approved the National Space Plan for 2020–2025, which also includes an increase in annual funding for ESA activities to CZK 1.530 billion.[9]

A Czech Footprint in Space

The European Union recently created the *Directorate-General Defence Industry and Space*. While the planned space budget was slashed as a result of the Covid-19 pandemic, the EU plans to invest EUR 13.2 billion in the next seven years[10] to reflect the increasing scientific and geopolitical importance of space. Moreover, Czech companies and institutions can greatly profit from the allocated funding to increase domestic research and manufacturing capacities. There is no doubt that the participation of the Czech private and public sectors in space projects is a welcome contribution towards the Czech industry and economy, whose importance can increase even further in the future. The growth in the Czech space industry also helps to dispel the rather unflattering reputation of the Czech Republic as the "assembly plant" of Europe.

The size of the Czech space industry will, for obvious reasons, never be comparable with the leading powers. Given its size, however, the Czech Republic's know-how and its

7) National Space Plan 2020–2025, p. 7.

8) NESLÁDEK, Václav. Na investice do budoucnosti ČR v kosmickém průmyslu půjde o bezmála 300 milionů Kč více než letos. *Czech Space Portal* [online]. 2. 12. 2019 [retrieved on: 2020-08-11]. Available at: https://www.czechspaceportal.cz/na-investice-do-budoucnosti-cr-v-kosmickem-prumyslu-pujde-o-bezmala-300-milionu-kc-vice-nez-letos/.

9) CZK 1.205 billion from the budget of the Ministry of Transport and CZK 0.325 billion from the Ministry of Education.

10) Prior to the crisis caused by the Covid-19 pandemic, the plan was to allocate EUR 16 billion to the space program, a 50% increase over the 2014–2020 long-term budget. In: HENRY, Caleb. European Commission agrees to reduced space budget. *SpaceNews* [online]. 21. 7. 2020 [retrieved on: 2020-08-11]. Available at: https://spacenews.com/european-commission-agrees-to-reduced-space-budget/.

capacities in businesses and research institutes are definitely noteworthy and have an upward trend. The Czech Republic is also becoming an increasingly successful participant in NATO and EU space programs. For illustration purposes, ESA is currently using two launch vehicles developed in Europe, *Ariane 5* and *Vega*. The payload fairing is an important part of *Ariane 5,* and Aerotech Czech, a company based in Klatovy, supplies its important components. The same company is also participating in the manufacture of components for the new *Ariane 6* launch vehicle, the future flagship rocket of the European space program. Additional Czech businesses, MCE Slaný and UNEX (Uničov) are respectively involved in the construction of the new launch complex and of the undercarriages for the launch base. Brno-based SAB Aerospace is developing a new type of payload adapter for the *Vega* launch vehicle.

In 2017, the Czech Republic launched a nanosatellite developed and built by a consortium of nine companies and university research centers under the auspices of the Czech Aerospace Research Centre (VZLÚ). VZLÚ is currently preparing a new satellite to be launched into space by SpaceX's *Falcon 9* rocket in late 2020. Research teams from eleven institutes of the Czech Academy of Sciences are coordinated under the *Space for the Mankind* program also associating six university centers and nearly twenty industrial partners. Thanks to ESA membership, Czech businesses and institutions could participate in the agency's flagship project, the *Solar Orbiter* probe launched on 10 February 2020. The exceptional mission carries ten instruments, four of which were developed with some form of Czech participation. By the end of 2020, *Solar Orbiter* will be followed into space by the *Taranis* mission led by the French space agency (CNES), which Czech researchers have also worked on. Other important feats of Czech science include instruments developed as part of the international consortia for ESA's Jupiter Icy Moons Orbiter *(JUICE)* and the *ExoMars* rover bound for the Red Planet's surface. Both missions are set to be launched within two years. Future European missions such as *ATHENA* will provide still more opportunities for academic centers to participate.

The concentration of space research know-how in the Czech Republic is considerable, which is demonstrated by deliveries of Czech-made measuring instruments, as well as articles published in prestigious peer-reviewed journals and membership in a number of international research consortia. Opportunities thus abound to further interconnect university research centers and boost their role as initiators of contracts with industrial partners. This area provides significant opportunities for the growth of the economy and knowledge and for creating added value, promoting a shift from the role of a subcontractor to that of a technology leader.

SATCEN CR

The Ministry of Defence of the Czech Republic also follows current trends. Its own satellite center (SATCEN CR) reached operating capability in early 2020 and has become a unique expert center in NATO, joining other relevant players in the space exploration arena. The center's mission is to provide specific, detailed and accurate information on the observed targets. Its main benefit consists in the ability to obtain, utilize and analyze high-resolution electro-optical (multispectral) and radar imaging from space in near real time. Aside from its defense tasks, the center as a national institution is also able to obtain imaging for civilian use, thus benefiting the Czech public administration.

SATCEN CR also has potential significant overlaps with research and development in both the private and public sectors, since Earth observation is a rapidly developing industrial and scientific discipline. The center thus follows the latest trends and tries to flexibly adapt to changing demands and developing technology as concerns obtaining and analyzing data, as well as presenting information. Its ambitious objective is to maintain its place among the global elite and push the limits of technology still further, in cooperation with technology companies.

Data collection has expanded to encompass far more than just traditional electro-optical sensors, i.e. photographic imaging. The center is able to obtain rapid series of images or use other parts of the electromagnetic spectrum such as near infrared, thermal and *RADAR/LIDAR* imaging. Its analytical division focuses on securing top technological equipment and the expertise of its specialist staff. Excellent software tools and AI systems can only run on a robust hardware infrastructure. These systems are used by experts with extensive knowledge and skills in the individual areas of image interpretation and analysis. 3D models and the possibility to see the surveilled area in virtual or augmented reality provide radically different means of absorbing information and have an influence on the planning process, a key part of command and control. Cooperation with external technology contractors is essential. Last but not least, the center's staff have excellent job prospects, in terms of monetary compensation, if and when they should decide to move on.

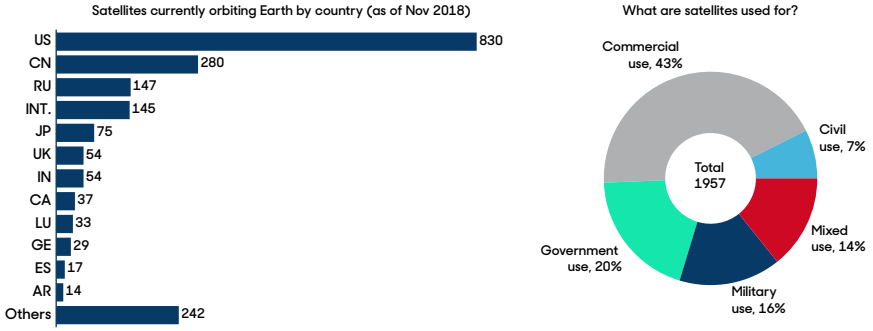
Three defense research and development projects are currently in development for the center. A modular expert system using machine learning is being developed in the area of AI to automatically detect, extract and identify targets in satellite images. Another project is oriented on data independence and involves a stratospheric imaging system designed for continuous surveillance of a particular surface area of the Earth. The Czech Republic has also been working on its own satellite system for civilian and military Earth observation: the *GOLEM X* project is designed to conduct experiments in orbit and help identify technologies necessary for introducing a national satellite observation system. This should

be followed by a larger *GOLEM* constellation consisting of several satellites designed to fulfill various roles in space operations. All these projects count with the participation of Czech teams, research centers and companies.

A satellite system can be perceived as a strategic investment into the future. For the academic sphere, it means not only developing the product and testing the associated technologies in orbit, but also involving many fields connected with the use of Earth observation data. From a military and safety perspective, the satellite observation system will significantly improve planning, command and support in domestic and international exercises, as well as in overseas military deployments and intelligence. The information obtained will also be useful in border security operations, transport, construction, diplomacy and international trade.

A systematic investment in a national satellite system will doubtlessly improve surveillance capabilities, which represent one of the Czech Republic's key commitments to NATO. In this capacity, it will also help the country meet the obligation to spend 2% of its GDP on defense and increase military research and development spending to the required 2% of the overall military budget. Developing the entire system is clearly complementary to other Czech activities within ESA and can lead to even deeper participation of Czech businesses and institutions in the far larger American public and private research programs.

Chart 3: Countries with the most satellites in space
Source: World Economic Forum



Conclusion

Public and private space programs best demonstrate the importance of a comprehensive understanding of defense, economy and science. Even more so than at present, space research and exploration will certainly be crucial for ensuring national security and competitiveness in the near future.

Civilian and military space programs will receive increasingly more attention and funding. Developing adequate capacities by the Czech government and public support for the systematic involvement of domestic companies and research centers in international projects open up vast opportunities. The membership of the Czech Republic in ESA and NATO, as well as the HQ of the European Union Agency for the Space Programme (EUSPA) located in Prague, give the country a certain competitive advantage.

The Czech Republic's space program will obviously never be comparable to that of leading space powers, but the growing number of Czech companies and institutions in various space consortia and projects offers hope that the country could play a role in the new space race. This will require, however, long-term commitment and consistent cooperation between government institutions, universities, other R&D centers and private companies. If it succeeds, the Czech Republic will shift from being a country of cheap labor towards becoming a hi-tech developed nation.

Recommendations:

1. **Actively participate in EU and NATO space programs, including national programs of key member states.**
2. **Develop the Czech armed forces' space capabilities.**
3. **Reach the required 2% of research and development spending in the budget of the Ministry of Defense and maintain space projects among the departmental priorities.**
4. **Achieve optimum levels of cooperation between military and civilian activities; offer maximum support for collaboration among public, private and R&D institutions.**
5. **Take steps to create a Czech National Space Agency.**