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Chapter 14

Czechs in Space*

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Introduction

This is a nutshell history of the Czech nation's long-standing interest and achievements in space science, technology and education. It attempts to show that despite difficult periods, this country has always been able to bring up new ideas and contribute to progress of sciences. The current transition into market economy, democratic society, and preparation for integration into the European Union is one of those difficult periods. However, given the determination of its people, and proven past record, it has all the prerequisites again to contribute significantly to future space exploration on a global scale, and return to the forefront of technology and science.

Origins

The history of space exploration is inseparable from the progress of science in the Czech lands. Charles University, founded in Prague in 1348 by Emperor

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Charles IV, has for centuries been a major center of learning. Prague became the world capital of astronomy during the reign of the Holy Roman Emperor Rudolf II, thanks to Tadeáš Hajek z Hajku (Hagecius) who was instrumental in bringing celebrities such as Tycho Brahe (1546–1601) and Johannes Kepler (1571–1630) to Prague.

Figure 1: Picture of the Holy Roman Emperor Rudolf II.

The results of Kepler's 12 years of work in Prague, and his use of Mars data compiled by Brahe, include two of his three laws for calculating the motion of planets in space. Here, he also wrote several important works, which later influenced the development of space exploration. In 1610, he was inspired by browsing through a booklet that belonged to the emperor—*The Star Messenger—Nuncius Siderius*, written by Galileo Galilei. Kepler was the first scientist to publicly endorse the discoveries in his open letter, titled "Conversation with the Star Messenger," to Galileo:

> Provide a ship or sail adapted to space environment and there will be people unafraid of such distances. I imagine scores of brave men clambering to attempt such a journey. And so, Galileo, we will jointly found—you Jupiter, and I Moon astronomy.

During his stay in Prague, Kepler wrote a unique paper, which only came out in print after his death. "A Dream, or Post-mortem Work about Moon Astronomy" is the first work in history of a scientist who wished to describe the lunar environment. He wrote: "The objective of my dream is to demonstrate the motion of the Earth on the example of the Moon," and he accompanied his texts by a host of footnotes. He mixed humor with fantasy and scientific considerations with naïve imagination.

Figure 2: Picture of the Johannes Kepler
(Photo Credit: by permission of Sternwarte Kremsmünster).

In subsequent centuries, a continued series of personalities, which influenced exploration of space, worked here, such as physicist and mathematician Jan Marek (1595–1677) in the 17th century. He used a pendulum for time measurements, studied light and its decomposition into different wavelengths, mechanics, and astronomy. A Moon crater is named after him. The first quarter of the 18th century saw the inauguration of the Klementinum observatory, beginning a long record of meteorological measurements, which could be the oldest in the world. In the 19th century, the Austrian physicist and mathematician Christian Doppler (1803-1853) taught and worked at the Prague Technical University. In 1842, he presented to the Royal Czech Learned Society the results of his investigation into changes of wave frequency, resulting from the motion of its source with respect to the observer. When the source is approaching, the observed wave frequency rises, and vice versa. The Doppler effect is now applied in astronomy, astronautics, and communications technology.

Seventy years later, another professor was hosted at Charles University. It was Albert Einstein (1879–1955), who was then putting final touches on his theory of relativity—a baseline physics theory of the 20th century.

Czechoslovak Republic

The creation of the Czechoslovak state at the end of the First World War gave new impetus to investigations and sciences, such as astronomy. The private observatory in Ondřejov, founded in 1897, was donated 30 years later to the young Czechoslovak state. It followed on to become the heart of the Astronomical Institute of the Academy of Sciences, established in 1953. The Prague Stefanik observatory opened its doors in 1928.

In the 1950s, foundations for later space experiments were laid down, predominantly under the leadership of Zdeněk Ceplecha (born 1929) in interplanetary mass movements (resulting in the first calculation of the interplanetary orbit of the Luhy/Pribram meteorite), and Zdeněk Svestka (born 1925) in predictions of solar proton eruptions, for which he won the U.S. Guggenheim prize in 1968. The development of the latter methodology is paramount to the safety of crewed spaceflight. An important contribution to stellar astronomy was the construction of a 2 meter telescope in Ondřejov in 1967. The control system of this telescope was recently modernized and automated by the budding Czech space systems development company Science Systems (CR). A host of scientific investigations using satellite data is in progress.

In the 1920s, Czechs showed interest and skills in developing launcher technology. In 1929, a young engineer Rudolf Pešek (1905–1989) registered a patent for a rocket engine that accelerated aerial bombs. Unfortunately, a lack of funds prevented construction of the engine. The ambidextrous inventor Ludvík Očenášek (1872–1949) constructed a number of solid fuel rockets and tested them in 1931 near Prague. His two-stage rocket reached 1500 meters. Očenášek later tried reaction propulsion on riverboats and even envisaged rocket launches from aircraft—the principle used now, half a century later, by Orbital Sciences Corporation, for its Pegasus launcher.

In the 1930s, the Czech aircraft engineer Alois Šmolík (1897–1945) proposed an antiaircraft missile project, called TRUL, to the Air Force. In the 1950s, Bedřich Růžička (1913–1986) and Oldřich Svoboda (1898-1986) led a sounding rocket development project at the Military Academy in Brno. The development peaked in 1965–1968, when the team tested a series of solid fuel prototypes. The objective was to build a light and cost effective two-stage launcher kit, capable of reaching a 40 kilometer altitude, for use in geophysics and meteorology. The project was formally stopped because of a lack of funding and interest in 1970. The real reasons, however, were political, following the invasion of the Czechoslovak Republic by the Warsaw Pact armies on 21 August 1968. In the following two decades, the rocket motors were used for dynamic tests of various constructions, such as simulations of side wind burst effect on cars, bridges, television masts, and factory chimneys—an early example of the use of space technology for practical applications. The first popular Czech book on space flight, *Rocket Flights to Space* by Dr. Vilém Santholzer, was published as early as 1928. In that period, Czechs were also laying down foundations of space law, in a study published by Vladimír Mandl. Note that in the 1940s, Frank J. Malina (1912–1981), a Czech living in California at that time, co-founded the Jet Propulsion Laboratory with Theodore von Kármán (1881-1963). Malina also participated in the development of the first U.S. rockets, Private and Corporal.

Period Under Soviet Influence

During the Soviet era, Czech scientists and engineers were welcomed partners in the Soviet space programs, while under a strict delimitation from Western contacts. Czechoslovakia succeeded in the first optical detection and radio acquisition outside the Soviet territory of *Sputnik 1* and its launcher. This earned Czech experts priority access to applications in a number of disciplines. The director of the Astronomical Institute, Dr. Bohumil Šternberk (1897–1983), was the first in the world to use the Doppler effect on the radio signals of these early satellites. Using orbit calculations of *Sputnik 2*, Prof. Emil Buchar (1901–1979) from the Czech Technical University developed a methodology that enabled refinement of measurement of Earth spherical deformation. According to his calculation, the Earth axis was 42.8 kilometers shorter than the equatorial diameter—with a deviation of only 26 meters! Moreover, Buchar proposed a method of measuring distances between continents using satellite data, thus becoming accepted as the father of satellite geodesy.

The Astronomical Institute scientists studied other disciplines. While investigating disturbances of geostationary satellite orbits, they discovered that satellite stability was affected by the Moon. Frantisek Link (1906-1984), who later immigrated to France for political reasons, studied high atmosphere and lunar luminescence and discovered a light attenuating layer at a height of 100 kilometers. Later, this band, consisting of micrometeorites and cosmic dust, was named the high atmospheric absorption layer.

The use of astronautics for the investigation of scientific, but also more down-to-Earth problems, encouraged extensive international collaboration. Unfortunately, Czech scientists and engineers were hampered by the political circumstances of that time. Contacts with foreign colleagues were significantly limited. A first attempt to come out of the isolation was the entry into international organizations. Apart from the Astronomical Union, it was principally the International Astronautical Federation (IAF) where Czech scientists participated for the first time at the 1960 congress in Stockholm. This was thanks to Rudolf Pešek (1905–1989), who in the 1960s became one of the leading personalities of the IAF and the International Academy of Astronautics (IAA). The next decade was when the astronomer Luboš Perek (born 1926) continued the diplomatic effort of upholding the participation of Czechoslovakia in the international space community as the director of the Office for Outer Space Affairs of the United Nations (UN) from 1975 to 1980, and president of IAF in 1980–1982. Lawyer Professor Vladimír Kopal (1928–) was the next director of the Office for Outer Space Affairs of the UN, from 1980 until 1982, in addition to being an active member of the IAF for many years.

Joining the European Space Research Organisation (ESRO), later the European Space Agency (ESA), was not politically acceptable for the communist government. Equally unacceptable at that time was any cooperation with the National Aeronautics and Space Administration (NASA), such as the investigation of Moon rock samples. Consequently, the only gateway to space projects for Czech specialists in many disciplines was the Interkosmos Program (1965–1989).

The first satellite that flew Czech instruments was *Interkosmos 1* in October 1969. The Czech payload measured soft X-ray radiation from the Sun and investigated aerosol layers as the Sun was setting down below the Earth's horizon. This investigation continued on several other satellites. In the 1980s, this culminated in the construction of low-cost X-ray lenses. The orbital station *Salyut 7* in 1982 carried a 240 millimeter diameter telescope, which was the largest of the kind at that time.

In March 1975, *Interkosmos 13* carried a Czechoslovak payload for recording cosmic rays, supplied by the Physics Institute of the Academy of Sciences, the Faculty of Mathematics and Physics of Charles University, and the Institute of Experimental Physics of the Slovak Academy of Sciences. Apart from Interkosmos, Czechoslovak payloads were flying from 1975 on Prognoz satellites, with highly elliptical orbits—apogees of about 200,000 kilometers. The Intershock project on *Prognoz 10* in 1985 studied shock waves in cosmic plasma, where 7 out of 11 experiments came out of Czechoslovakia and two in collaboration with Soviet scientists.

Czechoslovak interstellar dust detectors were installed in many sounding rockets, satellites and Mars spacecraft. Czech specialists participated in all sections of the Interkosmos Program and their payloads were on 23 of 25 Interkosmos and a number of Prognoz satellites. In all, more than half the experiments were built either in Czechoslovakia or in collaboration with Czechoslovak specialists.

One of the most complex space payloads designed and built in Czechoslovakia was an automatically stabilized platform, allowing accurate pointing to a studied object, of a quality comparable to that developed in the United States. About 60 companies and institutes participated in the development. Two Vega spacecraft used the platform to photograph and study Halley's Comet in March 1986. In 1989, the platform was installed on the Kvant module, which was docked with the *Mir* station. It carried remote sensing and stellar observation experiments.

Through the initiative of a group of Czech experts, dedicated to the development of new materials for space applications, a new specialized section was founded in the Interkosmos Program. Czechoslovak crystallizer ovens were installed in *Salyut 7,* and the *Mir* stations. They were used to study the dependency of structure and physical properties of selected crystals and glass materials on environmental conditions during their creation.

Biological and medical experiments of Czechoslovak scientists undoubtedly provided important contributions to world astronautics. These included the study of the effects of cosmic radiation on laboratory animals, in continuation of previous ground research carried out at Brno since 1959. It turned out that the radiation and microgravity set of distinct biological mechanisms do not amplify each other.

In the 1970s, scientists in Bratislava carried out a number of experiments to study the effects of weightlessness on the incubation of birds, both on uncrewed spacecraft and crewed stations. The culmination of this research was the selection of the first Czechoslovak astronaut and preparation of his research program. In March 1978, Air Force pilot Vladimir Remek (1948–) represented the third nationality to reach Earth orbit. He was transferred by *Soyuz 28* to the *Sal-yut 6* station, where he carried out scientific experiments. The political background of the selection and its use for propaganda does not belittle the significant scientific importance of the flight. Its scenario was different from subsequent flights of astronauts from other communist countries and became an example for future cooperation of the Soviet Union with Western countries, mainly France and Germany.

Czech specialists also participated in the development of satellite geodesy. In the 1960s, they placed mirrors on several satellites, to reflect laser rays beamed from the ground. They used the time taken by the ray to return to them to calculate the distance between the satellite and the ground station. Such measurements enabled the refinement of orbit parameters and the ground station coordinates. The Czech Technical University in Prague built the first satellite geodesy laser in 1970. In August of the same year, the first reflections from the satellite were detected—the fourth team in the world to achieve this, after the French, Japanese, and Americans. As a result of this success, a worldwide Interkosmos network of mobile laser locators of Czech production was commissioned.

Magion—The First Czech Satellite Program

The design, construction, and scientific exploitation of a series of five Magion (MAGnetospheric and IONospheric) sub-satellites is a chapter apart. The idea of parallel measurements from two satellites with controlled special separation was original at the time and was later followed by other scientific teams. They measured space plasma from two not very distant points, and were launched piggyback on Russian scientific satellites.

Magion 1 was launched as part of the *Interkosmos-18* experiment, and separated from its parent spacecraft on 14 November 1978, with a relative velocity of 0.2 m/sec. Its mission lasted for three years. The satellite mass without the separation mechanism was 15 kilograms.

Magion 2, launched in 1989, was the first sub-satellite of a series of international scientific projects ACTIVE, APEX, and INTERBALL. It already had a mass of 52 kilograms, folding booms, propulsion, and digital data collection. *Magion 3,* launched in 1991, had a similar construction and mission. All three had magnetic stabilization, while the following models had spin stabilization. After the Velvet Revolution, the axe fell on a number of scientific activities. Fortunately, Magion was saved by the Institute of Atmospheric Physics, which took over the entire ionospheric department from another institute that was to stop supporting it, and became responsible for the project, in addition to the Tracking Telemetry and Command (TT&C) station in Panska Ves. The last two satellites of the series were already launched under the new conditions of international cooperation. *Magion 4* (*S2-X*) was launched with a Tail Probe main spacecraft on 2 August 1995 as part of the INTERBALL project. The simultaneous measurements at different altitudes were provided by two main satellites with two sub-satellites, each of which was injected into orbit as the passenger of its main satellite. *Magion 4* was produced in the Czech Republic, Russia, Poland, Hungary, Romania, Bulgaria, and the Slovak Republic.

Magion 5 (*S2-A*) was launched on 29 August 1996, together with *Auroral Probe*, into an elliptical orbit with an apogee of 20,000 kilometers and an inclination of 65 degrees. After one day of operation, *Magion 5* ceased to transmit telemetry because of a critical power deficit. Telemetry analysis concluded that the failure was due to a short circuit in the solar array. It was decided to continue periodic attempts to reactivate the spacecraft. The first response was detected at the Panska Ves TT&C station, operated by the Institute of Atmospheric Physics of the Czech Academy of Sciences, on 6 May 1998—20 months later! By the next day all principal subsystems were reactivated, and it remains operational.

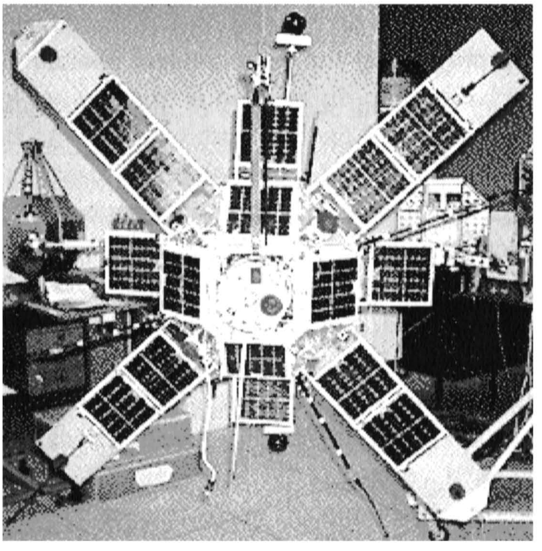

Figure 3: Photo of *Magion 4.*

Czech Republic

The dramatic political changes in Europe in 1989, and the Velvet Revolution in Czechoslovakia, with the breakup into Czech and Slovak republics, created a completely new situation, which was not particularly supportive of new scientific projects. The Interkosmos Program fell apart. The structural changes of the eastern and central European economic systems did not allow the initiation of substantial new independent programs. On the other hand, the new political scene enabled cooperation with the democratic world and membership in international organizations, such as Eutelsat (through Ceske Radiokomunikace, 0.145947 percent), Intelsat (0.103211 percent), and Inmarsat, while maintaining membership in Intersputnik. Czechoslovakia signed a cooperation agreement with EUMETSAT in 1992—now only Slovakia remains a signatory.

The experience gained in the past remained the backbone of projects by which the Czech scientific community remained a partner in international research, including geophysics, solar physics, and psychophysiology. The principal organizations involved include the Czech Academy of Sciences (www.asu.cas.cz), the Institute of Atmospheric Physics (www.ufa.cas.cz), Czech Institute of Hydrometeorology, Masaryk University in Brno, Czech Technical University in Prague, Military Academy, or the Observatory and Planetarium of Prague.

The latest interesting project is MIMOSA (MIcroMeasurements Of Satellite Acceleration), in progress at the Astronomical Institute of the Academy of Sciences of the Czech Republic. Its mission is to study non-gravitational forces that severely affect satellites in Low Earth orbits (LEO). As such, it will develop new models of atmospheric density distribution and variation and study Earth's albedo and its infrared radiative fields. The principal payload of the satellite will be a three-axis electrostatically compensated microaccelerometer (MACEK), which will cancel gravitational effects in the satellite. The first version has already been successfully tested in orbit onboard Space Shuttle *Atlantis*, mission STS-79, in September 1996. This flight opportunity, in collaboration with the University of Alabama, Huntsville, demonstrated the sensitivity and accuracy of the equipment. The success led to financing by the Grant Agency of the Czech Republic of an improved version of the accelerometer, a GPS tracking system, and the satellite platform. The project is in final stages with the launch envisaged for 2001.

Apart form the traditional research institutes and scientific investigations, opportunities arise for budding private enterprises. Space is not only research and science, but also industry, business, and profit. From the remnants of the application laboratories and scientific teams, small private firms are being founded. These include, for example, BBT (space materials processing), GISAT (remote sensing applications), Space Devices (mini-satellite platform and payload construction), CSRC (space qualified hardware), and Science Systems (CR) (satellite control software). These companies have shown their technical and cultural abilities and their competitiveness in international space markets. Through subcontracts to companies from member countries of ESA, EUMETSAT, and others, these small budding Czech companies have already been participating in European space projects before the Czech Republic's membership will allow them to bid for such work independently. For instance, CSRC is a well established supplier of space qualified hardware for the Italian satellite manufacturer Alenia. In the software industry, Science Systems (CR) has already accumulated some 40 years experience in subcontracts to ESA, EUMETSAT, and other space projects. Its Czech staff even worked with space agencies as far away as Argentina

(CONAE) and Brazil (INPE) and supplied its services, as a partner in an international consortium, to an Inter-American Development Bank Geographic Information System-based project in Argentina. These Czech companies are highly mobile and are ready to contribute their extensive experience at competitive conditions on the international space market.

Conclusion

This article has attempted to show that the lands that are now the Czech Republic have, since the Middle Ages, been the cradle of genius that contributed new ideas in space exploration and astronomy, in addition to providing fertile conditions for many foreign personalities to carry out their work. The Czech Republic can even today boast highly qualified, experienced, and enthusiastic scientific and engineering human resources. While it is still undergoing economic and political reforms, and preparing itself for membership in the European Union, its potential to contribute more to international and bilateral programs, as the country becomes more integrated into the global economic systems, has not been fully tapped. But the ability of Czech scientists and inventors has been shown to shine through, even in constraining conditions such as those which prevailed in the second part of the 20th century.

While concrete research and technology projects, both national and with international cooperation are in progress, no single nationwide organization has yet been established to coordinate the varied activities to streamline the diverging interests, and to set priorities or focus—in other words to outline a national space program. Excluded is the word "investigation," as this is only a part of what such a program should encompass. The first step toward coordination was to establish, in the mid-1990s, a governmental focal point, coordinated by Ing. Petr Křenek at the Czech Education Ministry, under the Minister of Education Eduard Zeman. Among its results was the signing of a cooperation agreement with ESA on 7 November 1996 and specific collaboration under the ESA PRODEX program.

There are two organizations, with limited authority or decision power, which independently support interests of its members and associated interest groups. Under the mentioned Education Ministry, there is a Commission for Cooperation with ESA, chaired by Jan Kolář. The Academy of Sciences nominated its own National Committee for Research and Use of Space. It represents the Czech Republic in the Space Research Committee of COSPAR and in the IAF, with Dr. František Fárník as its chair.

What is still needed is for all groups with interest in space, be they academic, intellectual, legal, business, technological, industrial, or other, to get (or perhaps, be put) together, and define common goals that would:

1. ensure more effective use of existing resources, be they scientific, human, technological, industrial, or financial—which will always remain limited (as indeed they are, even in larger and richer countries).
2. justify and enable stronger financial and political support from the Czech government—necessary to participate fully in organizations such as ESA or EUMETSAT.

As can be seen from successful examples elsewhere, it will be necessary to demonstrate to politicians, and to the general public, that space research is not all science, environment monitoring, and Teflon pans, but also that if used and focused correctly, it can be about industry, economy, exports, and even profit. There are many examples of countries that can be looked to for inspiration or for taking advantage of their distinct experience—from Europe (Spanish CDTI, British BNSC, French CNES, or perhaps more relevant Portugal, a small country that succeeded in joining ESA) to overseas (Brazilian Space Agency, its Space Institute INPE, and its long-term space program PNAE; Argentinean CONAE with its space program; and others) defining such common goals, which can be demonstrated to bring benefits to the interested parties and also to the whole country. But this will not be possible without compromises and probably sacrifices from many of those concerned. However, ultimately it will be the only way for everybody to get the maximum benefit from the excellent scientific, educational, and technological resources that the Czech Republic is lucky to possess, and from which it is currently not able to reap maximum benefits.

Once this has been archived, or significant progress along these lines made, then the Czech Republic, despite it small size, will be able to reestablish the world reputation it had between the two World Wars, contribute even more to those international organizations of which it is already a member, and become a significant member of ESA and other international organizations and collaborative projects.