CZECHS IN SPACE

Petr Bareš, Science Systems (CR) a.s., Evropska 61, 160 00 Praha 6, Czech Republic
Fax: +420-2-3525 1934 or +44-7092-034415, E-mail: petr@compuserve.com Website: www.scisys.cz
Marcel Grün, Prague Plantarium, Královská Obora 233, 170 21 Praha, Czech Republic
Fax: +420-2-3337 6434 E-mail: grun@planetarium.cz Website: www.planetarium.cz
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Abstract

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

History of space exploration is inseparable from progress of science in the Czech lands. Charles University, founded in Prague in 1348 by the emperor Charles IV, has for centuries been a major centre of learning. Prague became the world capital of astronomy during the reign of the Holy Roman Emperor Rudolf II, thanks to Tadeáš Hájek z Hájku (Hagecius) who was instrumental in bringing to Prague celebrities such as Tycho Brahe (1546-1601) and Johannes Kepler (1571-1630).

The Holy Roman Emperor Rudolf II

The results of Kepler’s 12 year’s 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. He also wrote here several important works, which later influenced development of space science. 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 is the 1st scientist to endorse publicly the discoveries in his open letter to Galileo, entitled “Conversation with the star messenger: “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 1st work in history, of a scientist who wishes to describe lunar environment. He says: ”The objective of my Dream is to demonstrate the motion of the Earth on the example of the Moon”, and he accompanies his texts by a host of footnotes. He mixes humour with fantasy and scientific considerations with naïve imagination.

Johannes Kepler

In subsequent centuries a continued series of personalities, which influenced exploration of space, worked here, such as the physicist and mathematician Jan Marek in 17th century. He used pendulum for time measurements, studied light and its decomposition into different wavelengths, mechanics and astronomy. A moon crater is named after him. 1st quarter of 18th century saw the inauguration of the Klementinum observatory, the long record of meteorological measurements of which could be the oldest in the world. In the 19th century, the Austrian physicist and mathematician Christian Doppler 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. Doppler effect is now applied in astronomy, astronautics and communication technology.

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

CZECHOSLOVAK REPUBLIC

Grounding of the Czechoslovak state from the Austro-Hungarian Empire in 1918, 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, and 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 50’s, foundations for later space experiments were laid down, predominantly under the leadership of Dr. Ceplecha in interplanetary mass movements (resulting in1st calculation of the interplanetary orbit of the Luhy/Pribram meteorite) and Dr. Svestka in predictions of solar proton eruptions, for which he won the US Guggenheim prize in 1968. The development of the latter methodology is paramount to safety of manned space flight. Important contribution to stellar astronomy was the construction of the 2m telescope in Ondřejov in 1967. The control system of this telescope was recently modernised and automated by the budding Czech space systems development company Science Systems (CR). A host of scientific investigations using satellite data is in progress.

Already in the 20’s, 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, which accelerated aerial bombs. Unfortunately, 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 1500m. Očenášek later tried out reaction propulsion on riverboats, and even envisaged rocket launches from aircraft – the principle used now, half a century later, by Orbital Sciences Corp. for their Pegasus launcher.

In the 30's, Czech aircraft engineer Alois Šmolík proposed an anti-aircraft missile project to the air force, called TRUL.

In the 50's Bedřich Růžička and Oldřich Svoboda led a sounding rocket development project in the Military Academy in Brno. The development peaked in 1965 – 1968, when the team tested a whole series of solid fuel prototypes. The objective was to build a light and cost effective 2-stage launcher kit, capable of reaching 40 km altitude, for use in geophysics and meteorology. The project was formally stopped owing to lack of funding and interest in 1970. The real reasons, however, were political, following the invasion of the Czechoslovak Republic by Warsaw Pact armies on 21st 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 use of space technology for practical applications. The 1st popular Czech book on space flight "Rocket flights to space" by Dr. Vilém Santholzer was published as early as 1928. In that period, the Czechs were also laying down foundations of space law, in a study published in 1932 by JUDr. Vladimír Mandl. Let us also note that in the 40's Frank J. Malina, a Czech living in California at that time, co-founded JPL, together with Theodor von Karman. He also participated in development of the first US rockets Private and Corporal.

PERIOD UNDER SOVIET INFLUENCE

During the Soviet era, Czech scientists and engineers were welcome partners in Soviet space programs, whilst under a strict delimitation from Western contacts.

Czechoslovakia succeeded in the 1st optical detection and radio acquisition outside the Soviet territory of both Sputnik 1 and its launcher. This earned Czech experts priority access to applications in a number of disciplines. The then director of the Astronomical Institute Dr. B. Šternberk was the 1st in the world to use Doppler effect on the radio signals of these early satellites. Using orbit calculations of Sputnik 2, professor Emil Buchar from the Czech Technical University developed methodology, which enabled refinement of measurement of Earth spherical deformation. According to his calculation the Earth axis was 42,8 km shorter than the equatorial diameter – with deviation of only 26 metres! Moreover, prof. Buchar proposed a method of measuring distances between continents using satellite data, so becoming accepted as the father of satellite geodesy.

The Astronomical Institute studied other disciplines. Whilst investigating disturbances of geostationary satellite orbits, they discovered that their stability is also affected by the Moon. Doc. Link, who later had to emigrate for political reasons to France, studied high atmosphere and lunar luminescence and discovered a light-attenuating layer at a height of 100 km. Later on, this band, consisting of micrometeorites and cosmic dust, was named the high atmospheric absorption layer.

The use of astronautics for investigation of scientific, but also more down to earth, problems encouraged extensive international collaboration. Unfortunately, Czech scientists and engineers were hampered here by the political circumstances of that time. Contacts with foreign colleagues were significantly limited. First attempts to come out of isolation were entry into international organisations. Apart from the Astronomical Union, it was principally the International Astronautical Federation, where Czech scientists participated for the first time at the 1960 congress in Stockholm. This was above all thanks to Rudolf Pešek (1905-1989), who became in the 60's one of the leading personalities of IAF and the International Academy of Astronautics. The next decade was in the name of the astronomer Dr. Luboš Perek, who 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 from 1975 until 1980, and then president of IAF in 1980 – 1982. The lawyer Prof. Vladimír Kopal was the next director of the Office for Outer Space Affairs of the UN, from 1980 until 1982, as well as being an active member of the IAF for many years.

Joining ESRO (later ESA) was not politically acceptable for the communist government. Equally unacceptable at that time was any cooperation with NASA, such as investigation of moon rock samples. Consequently the only gateway to space projects for Czech specialists in many disciplines was the Interkosmos programme (1965-1989).

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 horizon. This investigation continued on several other satellites. In the 80's this culminated in construction of a special stabilised platform for X-ray observation and an original technology for construction of low-cost x-ray lenses. The orbital station Saljut 7 then carried in 1982 a 240mm diameter telescope, which was the largest of the kind at that time.

In March 1975 Interkosmos 13 carried a Czechoslovak payload for recording of 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 excentric orbits - apogee of about 200,000 km. The Intershock project on Prognoz 10 in 1985 studied shock-waves in cosmic plasma where seven out of the 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 programme and their payloads were on 23 out of the 25 Interkosmos and a number of Prognoz satellites. In all, more than half of 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 stabilised platform, allowing accurate pointing to a studied object, of 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 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 development of new materials for space applications, a new specialised section was founded in the Interkosmos programme.

Czechoslovak crystalliser ovens were installed in Saljut 7, and Mir stations. They were used to study dependency of structure and physical properties of selected crystals and glass materials on environmental conditions during their creation.

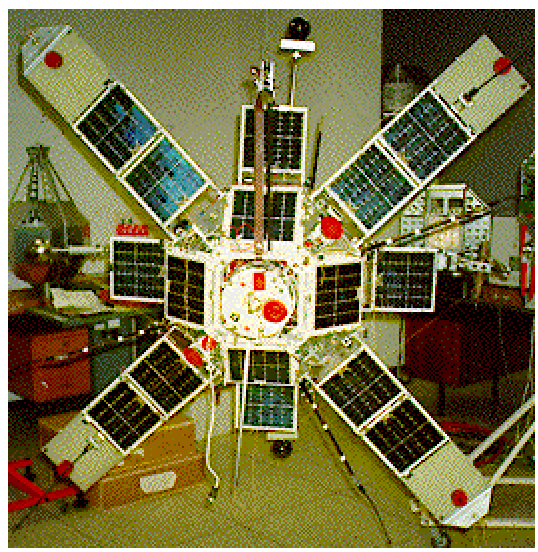
Biological and medical experiments of Czechoslovak scientists undoubtedly provided important contributions to world astronautics. These included study of the effects of cosmic radiation on laboratory animals, in continuation of previous ground research carried out in Brno since 1959. It turned out that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

In the 70's, scientists in Bratislava carried out a number of experiments to study the effects of weightlessness on incubation of birds, both on unmanned spacecraft as well as on manned stations.

Culmination of this research was selection of the 1st Czechoslovak astronaut and preparation of his research program. In March 1978, air-force pilot Vladimir Remek represented the 3rd nation to reach earth orbit. Sojuz 28 transferred him to Saljut 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 USSR with western countries, mainly France and Germany.

Czech specialists also participated in development of satellite geodesy. In the 60's they placed mirrors on several satellites, to reflect laser rays beamed up from 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 refinement of orbit parameters, as well as the ground station coordinates. Czech Technical University in Prague built the 1st satellite geodesy laser in 1970. In August of the same year, 1st reflections from satellite were detected – 4th team in the world to achieve this, after the Americans, French and Japanese. As a result of this success, a worldwide Interkosmos network of mobile laser locators of Czech production was commissioned.

MAGION
1ST CZECH SATELLITE PROGRAMME



Magion 4

The design, construction and scientific exploitation of a series of five sub-satellites Magion (MAGnetospheric and IONospheric) are a chapter apart. The idea of parallel measurements from two satellites with

controlled spacial 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 as piggyback on Russian scientific satellites.
Magion 1 was launched as part of the Interkosmos-18 experiment, and separated from its parent spacecraft on November 14, 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 kg.
Magion 2, launched 1989, was the 1st sub satellite of a series of international scientific projects ACTIVE, APEX and INTERBALL. It already had a mass of 52 kg, folding booms, propulsion and digital data collection. Magion 3, launched 1991, had similar construction and mission. All three had magnetic stabilisation, whilst the following models had spin stabilisation. After the velvet revolution, axe fell on a number of scientific activities. Fortunately, Magion was saved by the Institute of Atmospheric Physics, who took over the entire Ionospheric department, responsible for the project, and the TT&C station in Panská Ves, from another institute that was to stop supporting it. The last two satellites of the series were already launched under the new conditions of international cooperation. MAGION-4 (S2-X) was launched together with Tail Probe main spacecraft on August 02, 1995 as part of the INTERBALL project. The main feature of this project was multi point simultaneous measurements at different altitudes provided by two main satellites together with two sub satellites, each of which is injected into orbit as the passenger of its main satellite. Magion-4 was produced in the Czech Republic in collaboration with Russia, Ukraine, Hungary, and Austria and has onboard scientific instruments and sensors designed and built in Czech Republic, Russia, Poland, Hungary, Romania, Bulgaria and Slovak Republic.
MAGION-5 (S2-A) was launched on August 29, 1996, together with the AURORAL PROBE, into an elliptic orbit with apogee 20000km and inclination of 65°. After one day of operation, Magion 5 ceased to transmit telemetry owing to 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 1st response was detected at the Panská Ves TT&C station, operated by the Institute of Atmospheric Physics of the Czech Academy of Sciences, on 6 May 1968 - 20 months later!! By the next day all principal subsystems were re-activated and it remains operational to this day.

CZECH REPUBLIC

The dramatic political changes in Europe of 1989, the velvet revolution in Czechoslovakia, and the break up into Czech and Slovak republics, created a completely new situation, which was not particularly supportive of new scientific projects. The Interkosmos programme fell apart. The structural changes of the eastern and central European economic systems did not allow initiation of substantial new independent programmes. On the other hand, the new political scene enabled cooperation with the democratic world and membership in international organisation such as EUTELSAT (through Ceské Radiokomunikace, 0.145947%), INTELSAT (0.103211%) and INMARSAT, whilst maintaining membership in Intersputnik. Czechoslovakia signed 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, psychophysiology etc. The principal organisations 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, for 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 which severely affect satellites in low orbits (LEO). As such it will develop new models of atmospheric density distribution and variation, study Earth albedo, Earth infrared radiative fields, etc. The principal payload of the satellite will be a three-axis electrostatically compensated microaccelerometer (MACEK), which will cancel out gravitational effects on the satellite. The 1st version has already been successfully tested in orbit on board the Space Shuttle Atlantis, mission STS 79, in September 1996. This flight opportunity, in collaboration with the University of Alabama, Huntsville, demonstrated the sensitivy 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, the launch envisaged for 2001.

Apart from the traditional research institutes, and scientific investigations, opportunities arise for budding private enterprises. Yes, space is 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 e.g. 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 on international space markets. Through subcontracts to companies from member countries of ESA, Eumetsat, etc. these small budding Czech companies have already been participating in European space projects before 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 software industry, Science Systems (CR) has already accumulated some 40 man-years experience in subcontracts to ESA, EUMETSAT and in other space projects. Its Czech staff even worked with space agencies as far as Argentina (CONAE) and Brazil (INPE), and supplied its services, as a partner in an international consortium, to an Inter-American Development Bank GIS based project in Argentina. These Czech companies are highly mobile and are ready to contribute their extensive western experience at very competitive conditions on the international space market.

CONCLUSION

We have attempted to show that the lands which are now Czech Republic, have since the middle ages been the cradle of genius that contributed new ideas in space exploration and astronomy, as well as provided 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. Whilst it is still undergoing economic and political reforms, and preparing itself for the membership of the European Union, it's potential to contribute more to international and bilateral programs, as the country becomes more integrated into the global economical system, has not yet 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 this century. Whilst concrete research and technology projects, both national and with international cooperation, are in progress, **no single nationwide organisation** 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 programme**. And I deliberately exclude the word "investigation" or similar from this, as this is only a part of what such program should encompass. The 1st step towards coordination was to establish in mid 90's a governmental focal point, now coordinated by Ing. Křenek at the Czech Education Ministry, under the minister Eduard Zeman. Among its results was the signing of a cooperation agreement with ESA on 7th November 1996 and specific collaboration under the ESA PRODEX programme recently.

There are currently two organisations, with limited authority or decision power, which independently support interests of its members and associated interest groups. Under the mentioned Education Ministry, there is the **Commission for Cooperation with ESA**, chaired by Doc. J. Kolář (jan.kolar@gisat.cz). The Academy of Sciences nominated its own National **Committee for Research and Use of Space**. This organism represents Czech Republic in the Space Research Committee of COSPAR and in the International Astronautics Federation. Its chairman is Dr. František Fárník (ffarnik@asu.cas.cz)

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 which would

a) 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 much larger and richer countries)
b) justify and enable stronger financial and political support from the Czech government - necessary to participate fully in organisations such as ESA or Eumetsat

As can be seen from successful examples elsewhere, it will be necessary (among other) to demonstrate to the 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 which can be looked for inspiration or for taking advantage of their very distinct experience - from Europe (e.g. Spanish CDTI, British BNSC, French CNES, or, perhaps more relevant - Portugal, a small country which recently succeeded in joining ESA….) to overseas (Brazilian Space Agency, its Space Institute INPE and its long term space programme PNAE; Argentinean CONAE with its space programme, etc. etc.). Defining such common goals, that can be demonstrated to bring benefits not only to the interested parties, but to the whole country, 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 this country is lucky to possess, and from which it is currently not able to reap maximum benefits.

Once this is has been achieved, or significant progress along these lines made, then Czech Republic, despite it small size, will be able to re-establish the world reputation it had between the two world wars, contribute even more to those international organisations of which it is already a member, as well as become a significant member of ESA and other international organisations and collaborative projects.

ADDENDUM

Since the presentation of this paper at the IAF conference in Rio, Czech government requested the Commission for Cooperation with ESA to prepare a draft of a national space plan. The Commission itself has been extended to include industry, including the author, but above all by inviting the Chairman of the Committee for Research and Use of Space. These two decisions are important steps towards consolidation of the space interests, and have the potential to fulfil the needs as expressed in the above conclusions of this paper. The website of the Commission for Cooperation with ESA is at www.czechspace.cz. It is currently in Czech only, but steps are being taken to include an English version soon.