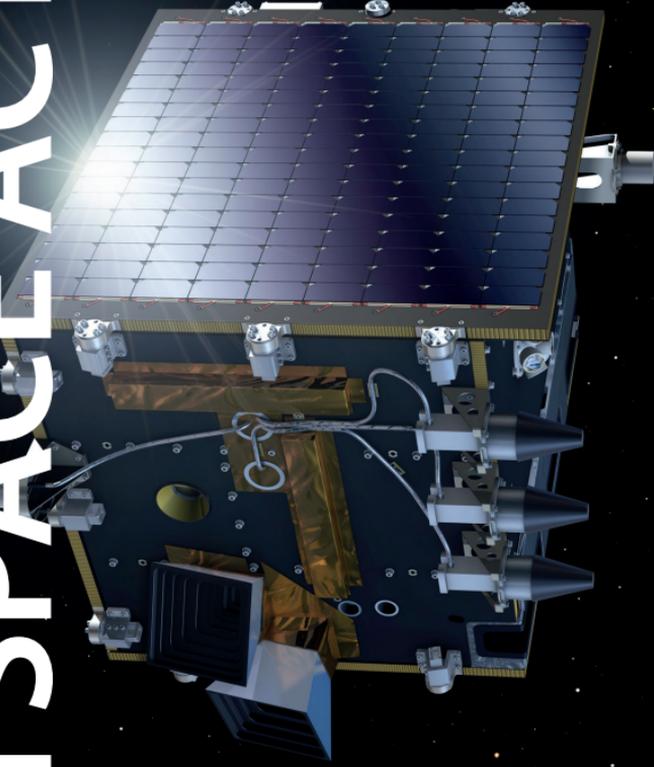


CZECH SPACE ACTIVITIES

September 2014



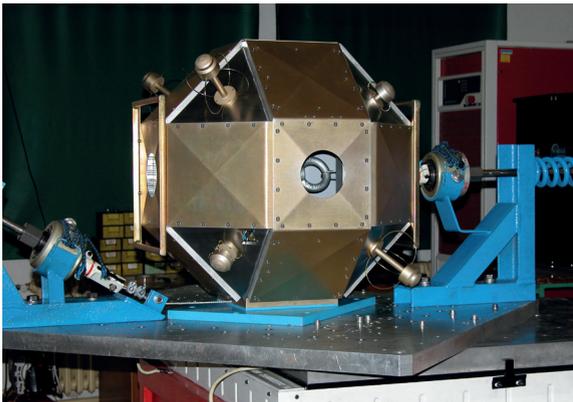
HISTORICAL OVERVIEW

Space research and development have a long tradition in the Czech country starting back in October 1969, when the first payload developed in the former Czechoslovakia flew into space on the Intercosmos-1 satellite. Several dozens of instruments and systems were carried by research satellites and on planetary missions to Venus, Halley comet, Mars and Phobos. When Vladimír Remek spent 6 days on the Salyut-6 orbital station in 1978, Czechoslovakia became the third country, which citizen entered space.

The first Czech satellite Magion-1 reached its orbit in October 1978, opening an era of small satellites. Several experiments were installed also on the Salyut and Mir stations, like four high-temperature furnaces for material research. In the eighties, the movable platform developed in Czechoslovakia provided base for scientific instruments on two Vega missions and on the Mir orbital station. Another small research satellite MIMOSA was launched in 2003.

Due to significant efforts of the Czech Space Office, growing relationships with ESA brought back the governmental funds dropping in the nineties and ignited again the Czech space research. Since November 2008, the membership of Czech Republic in ESA has opened new opportunities. Among the major projects accomplished in ESA programme so far, there are for example instruments on experimental satellites Proba-2, Proba-V and three microaccelerometers on Swarm satellite constellation. The maturity of the Czech space industry has been recognized, when commercial contracts in satellite telecommunication business have been signed.

Czech space activities as a whole cover many different sectors of research, development and applications. Entire Czech space expenditures are annually over 17 million Euro. For the Czech Republic, space research and technology development are becoming more and more indispensable means to increase the level of knowledge and economical competitiveness and to inspire the young generation. Those are stepping stones for securing decent level of scientific and industrial maturity, high economic strength and well established political and strategic position in the international community.



Mechanical testing of the MIMOSA satellite, that flew in 2003 with a microaccelerometer on-board, developed by Astronomical institute of Czech Academy of Sciences and company Space Devices. Source: CSO



CZECH SPACE OFFICE

The Czech Space Office (CSO) was founded in 2003 with aim to create a dedicated infrastructure required for working relations with ESA and to support government decision makers and Czech research and development organizations with qualified recommendations and advice.

In form of non-governmental non-profit organization the CSO has supported the Ministry of Education, Youth and Sports to coordinate and develop national science and engineering capabilities through several CR-ESA agreements, leading to ESA membership in November 2008.

Ministry of Transport has gained in 2011 the governmental responsibility for Czech participation in ESA and reduced further engagement of the CSO. All in all, CSO continues in its mission without being the official ESA point of contact and makes its best effort to increase Czech participation in national and international space projects.

To fulfill its mission, CSO follows national capabilities in various space related fields and analyzes the opportunities for Czech academia and industry in international programmes. It offers consultancy and assistance with preparation and management of space project and if suitable, also an establishment of strategic partnerships. It provides administrative, technical and professional support to everyone interested in space projects.

CSO also maintains the relations with space organizations and partners worldwide. The CSO staff carries out functions of national delegates to ESA programme bodies and to the EU programme committees for Space and Copernicus. CSO has been actively involved in actions of the Office of Outer Space Affairs, like coordinating Czech activities during the World Space Week and participating on Human Space Technology Initiative. Being a longstanding member of the IAF and its expert committees, the CSO organized in 2010 the 61st International Astronautical Congress in Prague. CSO is also active in several ministry advisory bodies.

In November 2013, CSO became an authorized payload integrator of XCOR's rocket-powered suborbital spacecraft Lynx®, currently being built at XCOR's headquarters in Mojave, California.

Finally, CSO promotes education and training in space science and technology, supports enthusiastic kids and promising student projects. It also communicates benefits of space research and technology to general public through TV, radio and other media channels.



Czech Space Office team with the astronaut Paolo Nespoli at the IAC. Source: CSO



SPACE SCIENCE

Space science is a broad discipline exploring objects and processes in our Solar System and everything beyond its formal boundaries, including far deep space. The Czech Republic has a long tradition in studying Sun and Sun-Earth interactions and interplanetary matter, as well as other planets. Several dozens of scientific instruments were launched into space on board the satellites and probes.

The most valuable contribution to the Sun research from outer space is the forthcoming ESA Solar Orbiter mission. The academic institutes together with their partners from the industry participate in the development of four scientific instruments for this technologically very demanding probe: Spectrometer/Telescope for Imaging X-rays (STIX), Radio and Plasma Wave Instrument (RPW), Multi Element Telescope for Imaging and Spectroscopy (METIS) and Solar Wind Plasma Analyzer (SWA). Another interesting project is the development of coronagraph (ASPIICS) for Proba-3 tandem flight experiment, where the participation is on the side of the optical system development.

Speaking about the space weather and research of the planetary magnetosphere, scientists also cooperate on the development of the electron analyzer for BepiColombo probe, that will visit Mercury and the JUICE probe, ESA's first large-class mission to investigate planet Jupiter and its icy moons. It will carry two instruments developed in cooperation with Czech scientists: the Magnetometer to characterise the Jovian magnetic field and its interaction with the internal magnetic field of Ganymede (J-MAG) and secondly the Radio Plasma Wave Instrument (RPWI) to describe the radio emission and plasma environment of Jupiter and its moons.

The Czech scientists participate not only in ESA missions, but they also collaborate with the other space agencies. For example, they have developed the long-wavelength electromagnetic radiation analyzer for the Russian Luna-Glob mission, which is to perform a complex planetary research of our Moon from its orbit.



Artist's impression of Proba-3. Source: ESA



SPACE SITUATIONAL AWARENESS

Space situational awareness (SSA) is the ESA programme federating group of services providing real-time overview of the threats coming from the interplanetary space. SSA threats include harsh space weather, associated with solar energetic particle storms, prediction of near earth asteroid trajectories and tracking of collision courses of artificial satellites. The predictions are based on scientific understanding and modelling of the relevant processes.

The Czech Republic has a long tradition in studying both the minor planetary bodies and Sun-Earth interaction including ionospheric effects, therefore this expertise allows significant contribution to its prediction and monitoring.

The valuable contribution of the Czech Republic are studies and monitoring of small meteoritic bodies and their interactions with the Earth's atmosphere. The Czech Republic is a founder of the European Fireball Network, which includes specialized antenna for monitoring day-time meteors and a number of stations located in the Czech Republic and Australia, where the meteoritic body can be easily recovered. Many of the Czech teams are focused on finding, tracking and reconstructing the surface characteristics of Near-Earth asteroids and comets.

Several scientific instruments are monitoring the space weather conditions, both directly and remotely. Most relevant instrument developments in the past include space radiation and high energetic particle monitors, thermal plasma probes, plasma waves and plasma particle instruments. Although launched years ago, many of them are still functional and currently in-orbit monitoring relevant space weather parameters.

Multi-point continuous Doppler sounding portable systems of ionospheric state were deployed at number of locations throughout the Czech Republic and based on its success also in Argentina, South Africa and Taiwan. The models and space weather predictions based on these data and Lowell digisonde ionospheric sounding from nearby Prague are provided in the scope of the International Space Environment Service through the Regional Warning Center Prague.

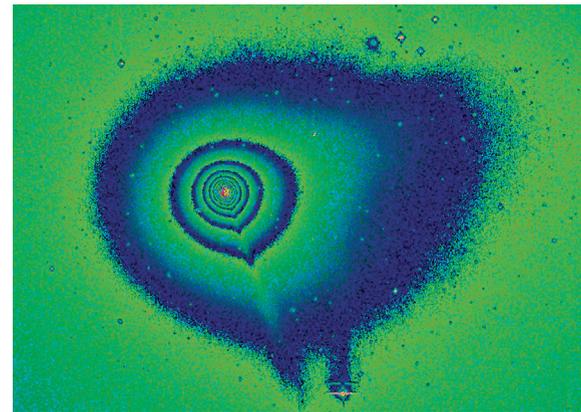


Image in false colors highlighting coma of comet C/2002 C1 (Ikeya-Zhang). Source: Miloš Tichý, Kleť Observatory

LAUNCHERS

The independent access to space via operational launch pad and affordable and reliable family of launchers is strategic and crucial for space endeavour and as such it is of high importance for every country. The Czech Republic is fully aware of its importance and several of our companies, universities and research institutions are already involved in development of specific components of European launchers and maintenance of space port Kourou in French Guiana.

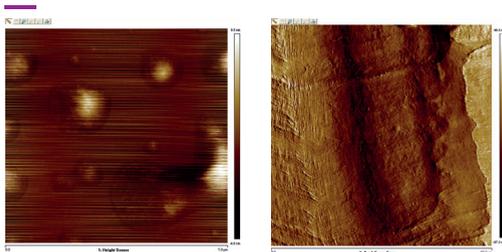
Czech companies excel in development of new advanced materials, for example leak resistant polymer liner for cryogenic propellant tank, epoxy core systems with syntactic foam structure, tailored adhesive bonding for thermoplastic composites or dedicated resin for foam to foam gluing compatible with cryogenic conditions. Many of these materials are unique in Europe and there is no other company able to produce them.

The evaluation, modelling and testing is another domain where our space industry is involved. These projects are focused on reliability methods to evaluate and increase the inherent reliability of a nozzle design, reliability analysis and life prediction of combustion chamber with probabilistic methods and based on survival analysis, computational methodology and experimental testing of scaled model of the upper stage thermal insulation panel to assess its flutter response or development of sensors instrumentation for diagnostic of the propellant electric pump.

Other experiences of Czech companies were gained by projects focused on design and development of complex flight hardware or software. We can mention preliminary design of the semi-active damping system for payload vibration isolation, qualification of the system of pyro-neutralisation cutting charges or development of the fully automated on-board software for the capsule designed to observe upper stage deorbitation behaviour.

Also studies and assessments are part of Czech projects. Our companies worked on suitability study evaluating potential of the ultra-wideband communication system for reliable on-board communication of satellites or launchers and assessment of existing plastic optical fibres and associated connectors for launcher application.

Last but not least, Czech industry was manufacturing and installing the telecommunication and security systems for the launch pads of Vega and Soyuz in Kourou and on a commercial basis, a few companies supply the manufacturing process of Ariane 5 launcher with mechanical parts and assemblies.



Atomic force microscopy analysis of nanoparticles in epoxy matrix. Source: Synpo

HUMAN SPACEFLIGHT AND MICROGRAVITY

Research in the microgravity conditions and human spaceflight related research in the Czech Republic have been reborn recent years. More than 30 experiments have been accomplished from mid seventies, with the significant decrement in the nineties. Czech scientists are experienced in research of the human factors and physiology, astrobiology, radiation dosimetry, fundamental physics and crystallization.

The biggest Czech contribution to microgravity research is the dedicated optical link for synchronization of a pair of extremely precise atomic clock on board the International Space Station with stations on the ground. This experiment called European Laser Timing (ELT) is part of the bigger Atomic Clock Ensemble in Space (ACES) instrument setup, which will be launched and attached to the Columbus laboratory not earlier than mid 2016. Instruments will allow clock comparisons, time transfer and ranging experiments in the optical domain. On board hardware development as well as ground stations calibration campaign is provided by Czech engineers and scientists.

Several dosimetry experiments were done during past years on ISS. The latest one, which conducted a three-dimensional survey of the radiation environment in all segments of the station, started in 2012. Czech experts prepared sets of passive dosimeters attached to the side walls of Columbus laboratory module. The Mars-500 mission simulation conducted by Russia, ESA and China, includes three Czech research experiments that are to explore the dynamics of relationships in small group of people, changes in perception and memory related to long-term isolation and to examine the source of human endurance in critical situations.

A group of space enthusiasts, engineers and scientists develop underwater Hydronaut station, which can be used as a realistic simulator of conditions on board manned spacecraft, orbital, Lunar and Mars stations. Hydronaut will allow the implementation of a broad range of human factor and physiology experiments in simulated conditions. Other experiments in microgravity conditions using ISS, small satellites and ground based facilities are being prepared.



Large Diameter Centrifuge in ESA/ESTEC, Netherland. Source: ESA

SATELLITE NAVIGATION AND TELECOMMUNICATION

Czech Republic already benefits from applications offered by satellite telecommunications and navigation and actively supports development of new technologies to exploit their potential. Several institutions and companies have taken part on the European Satellite Navigation Competition (ESNC) for over a decade and the capital city of Prague hosts the administrative and certification centre of the European GNSS Agency (GSA).

Referring to space telecommunications, one company is responsible for development of a prototype of the airborne user terminal with the main objective to create an open standard tool allowing worldwide deployment of compatible systems for safety critical air/ground data and voice communication for air traffic management.

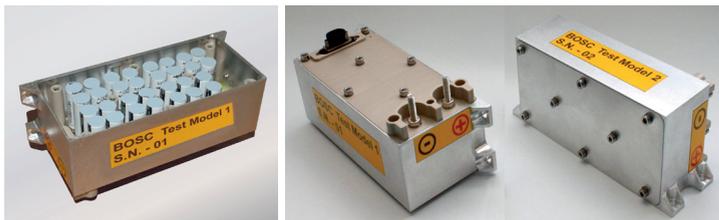
Some other activities were focused on preliminary design of satellite communication link for unmanned aerial systems, which encompasses both payload data and command & control flows. A key driver is the ability to ensure safe and secure communications between the remote pilot station and controlled aircraft.

From the university environment came up a research activity assessing the indoor loss of satellite communication signal in L, S and C-Bands due to penetration through building walls, with the prospects of application in satellite navigation services. Czech laboratory contributed to an extensive measurement campaign using the remote-controlled airship as a pseudo-satellite carrying a transmitter.

In the space navigation domain, Czech organizations collaborated on number of projects. For example one company developed an interference monitoring system for GNSS reference stations.

A unique demonstration of an interdisciplinary project was the development of educational tools, which would support better understanding of functionalities of GNSS systems, especially the EGNOS. Main contribution of the Czech software company was in running one EGNOS real-time monitoring network station.

In the commercial domain, one company succeeded in establishing a supplier role of mechanical parts for Iridium NEXT satellite systems and thus paved the way for future commercial Czech space industrial developments. Another Czech company develops a new interface of EGNOS system for its use in railway transport and continues its effort leading to certification of SBAS-R in Europe. Several Czech companies and an academic institution cooperated on the development, manufacturing and testing of a bank for supercapacitors that is suitable for high power space applications.



Bank of Supercapacitors Model. Source: EGGO Space

EARTH OBSERVATION

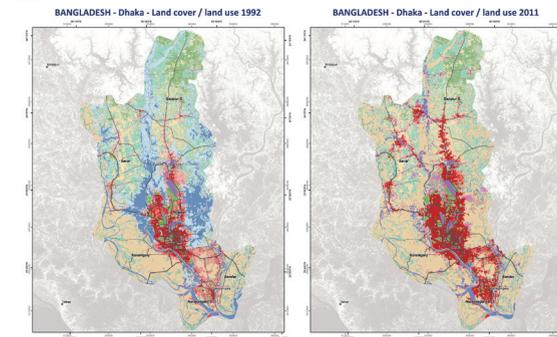
Earth Observation is a global initiative and the Czech Republic provides support through a participation in GEO, ESA and EUMETSAT. Czech public administration already benefits from EO applications and value added services in areas like urban planning, agricultural monitoring, forestry, environmental monitoring or flood risk mapping. There is a growing basis of young scientists and GIS professionals that receive university education in remote sensing, who may also help to foster the use of EO data in various human activities in the future.

Because of widespread cloud cover, radar satellite data are often used to monitor areas at risk of landslides and floods, the key environmental issues in Czech country. The value adding industry also contributes to a number of international projects in fields of urban planning, land monitoring and disaster management, mostly connected to the EU GMES/Copernicus programme or fulfilling the needs of EEA and international financial institutions. Specific group of scientists focus on LiDAR scanning and hyperspectral spectroscopy of the forests, dump sites and other areas and they are involved in the scientific part of the preparation of ESA FLEX mission.

In the area of Earth sciences, the data from ESA Earth Explorers satellites are very useful. One of them, the gravity mission GOCE, provides measurements utilized by geodetic research performed by a Czech scientific institute that also participated in the fine-tuning of the mission's orbit. Interest in the Earth's magnetic field has drawn a group of university researchers into the scientific preparation of ESA Swarm mission.

The Swarm mission also carries on board three supporting instruments – precise microaccelerometers developed by a consortium of Czech companies. Another promising development concerns an innovative acousto-optic tunable filter suitable for hyperspectral imaging. Based on a single calomel crystal and having no moving parts, it has a good potential to be deployed on future remote sensing missions.

Czech industry also participates in the development and manufacturing of the European operational satellites like Meteosat Third Generation and Copernicus/Sentinel missions. The contribution is on both software and hardware side.



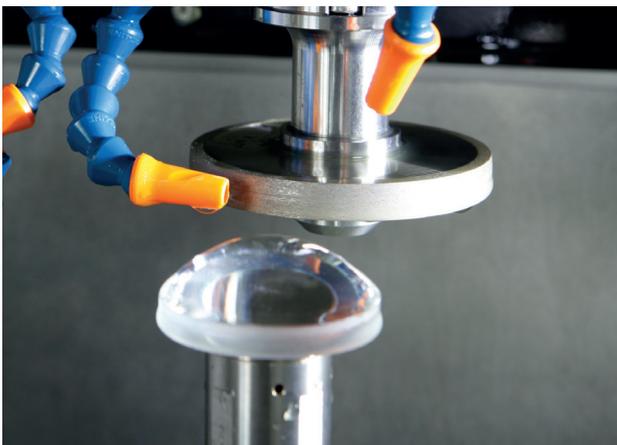
Landuse comparison for area of Dhaka in Bangladesh between years 1992 and 2011. Source: Gisat

SPACE TECHNOLOGY

The wide area of space technologies is one of the new emerging sectors in the Czech country. Several manufacturing companies have already been supplying mechanical or electronic parts and sensors for satellites. Apart from these, which already proved their capability to deliver for space, there are many companies with a potential to transfer and upgrade their technological skills into the space sector.

The main hardware competencies of Czech industry are as follows: high-precision mechanical alloy structures and assemblies; composites and polymers – sandwich structures, carbon fiber materials and other nanomaterials, nanostructured polymers, epoxy resins and adhesives; thermal, structural, thermo-elastic and electro-mechanical modelling; mechanical, structural and environmental testing; PCBs assembling in a clean room; tantalum capacitors, power supplies and power distribution units; high-quality optics, optomechanical or optoelectronic devices and X-ray optics; microaccelerometers, electronics for sensors, single photon detectors, cosmic radiation detectors and scintillation crystals for particle detectors. In the field of software development, the major skills include: vehicles health monitoring systems, ground segment software, on board software for operational instruments, complex software solutions, safety-critical systems, real-time systems, digital image processing and signal processing. As the scope of technologies covers a broad spectrum of activities, they have been developed through a number of national and European technological programmes, for example EU-FP7 and ESA- TRP/GSTP programmes.

Practical examples of results include: calibration system for the transportable laser communication terminal, hermetically sealed low ESR tantalum capacitor, real-time extrapolation methods for thermal testing, thermo-mechanical evaluation of Lunar Lander thruster platform, control and tracking system for ground station antennae, industrialization of the solar array deployment mechanism, on-board software reference architecture for payloads, real-time performance monitoring tool for EO data processing by GRID system and other projects.



Generator for planar, aspherical, cylindrical and freeform surfaces. Source:TOPTeC

EDUCATION AND OUTREACH

Beginning with little kids and going up to university students and young professionals, the Czech young generation has nowadays a number of opportunities to engage in the wide spectra of space projects and endeavors. Most of the information support including some funding comes from the Czech Space Office, which is the national partner of international events such as World Space Week and European Researchers' Night, workshops and student conferences on modern science and technology.

CSO provides outreach through a number of lectures for kids and students. It teams up with nursery, primary and secondary schools, universities, NGOs, museums, libraries and other organizations interested in space education. It supports Czech students at multitude of international events like congresses and workshops, the International Astronautical Congress or the Alpbach Summer School being the major examples. Participation of teachers in international workshops and space camps is also available and CSO supports the applicants not only with information, but also funding opportunities.

Students are also supported while applying to the international space-related studies. Most important one is the Spacemaster Erasmus Mundus programme, but there are many other master programmes throughout Europe, which offer training towards the degrees of space engineering or space management. The broadest scope related to space offers the International Space University.

Thanks to the educational programmes of the European Space Agency, students can gain practical skills by building their own experiments for balloon or rocket launches or by using ESA's ground infrastructure, such as experimental centrifuge or drop tower. After their experience with high school projects, such as building a microsatellite in a can (CanSat), students develop CubeSats or can participate in the development of the full-fledged ESA ESEO satellites.

In the Czech Republic, there is a new branch of the European Space Education Resource Office now being prepared under the ESA's guidance. Czech GNSS center of excellence is also supporting young students, mainly interested in application areas of satellite telecommunications, navigation and Earth observation.



Expedition Mars 2014 finalist during training. Source:CSO



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