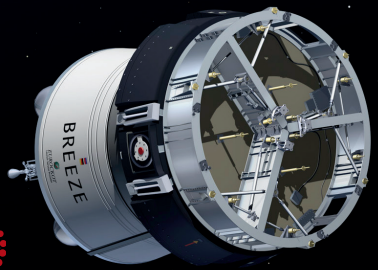
CZECH SPACE ACTIVITIES

November 2013



CZECH SPACE OFFICE

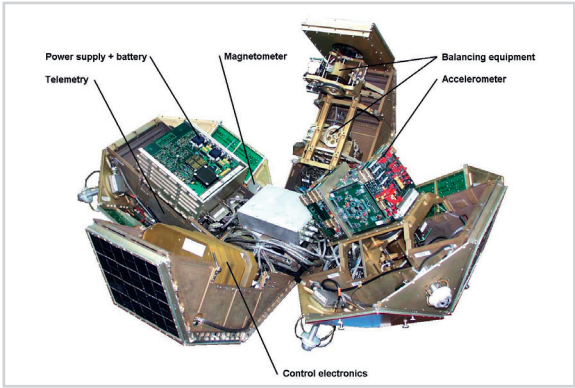
HISTORICAL OVERVIEW

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 program 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 first commercial contracts in satellite telecommunication business have been signed.

Czech space activities as a whole cover many different sectors of research, development and applications. The overall budget amounts to nearly twenty million Euros per year. 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.



The inside view into the MIMOSA satellite, which was launched in 2003.
Source: ASÚ AVČR

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 helped the Ministry of Education to consolidate 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 this mission, CSO follows national capabilities in various space related fields and analyses opportunities for Czech academia and industry in international programs. 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.
The office also maintains relations with space organizations and partners worldwide. The CSO staff carried out functions of national delegates to ESA bodies and to the EU programme committees for Space and GMES. CSO has been actively involved in actions of the UN COPUOS, like coordinating Czech activities during the World Space Week. Being a longstanding member of the IAF and its expert committees, the CSO organized in 2010 the 61st International Astronautical Congress in Prague.

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.

Director of the Czech Space Office Jan Kolář officially opens the space exhibition during the IAC 2010 in Prague. Source: CSO

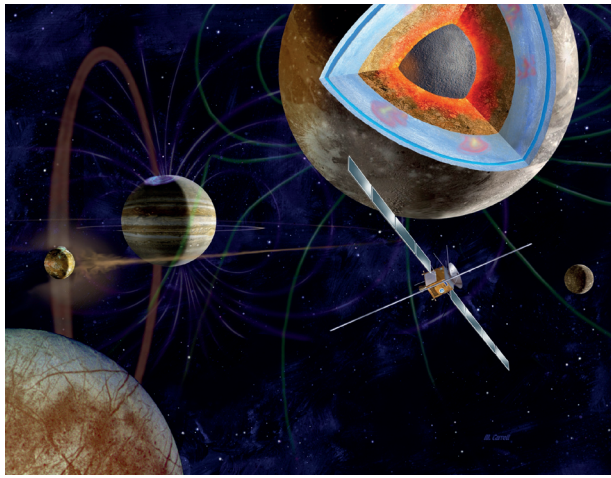
SPACE SCIENCE

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 of satellites and probes.

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

But the solar missions are not the only projects under preparation. 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: Magnetometer to characterise the Jovian magnetic field, its interaction with the internal magnetic field of Ganymede (J-MAG) and secondly the Radio plasma wave instrument to characterise 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 other space agencies. For example, they developed the long-wavelength electromagnetic radiation analyzer for the Russian Luna-Glob mission, which will perform a complex planetary research of our Moon from its orbit.



Artist's impression of JUICE, the probe investigating Jupiter and its icy moons. Source: ESA

SPACE SITUATIONAL AWARENESS

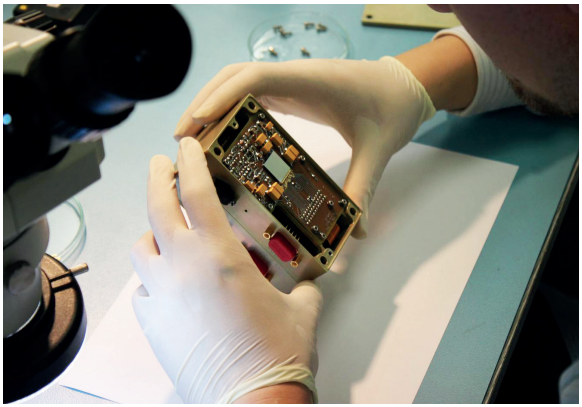
Space situational awareness (SSA) is the federated group of services providing real-time overview of the threats coming from the interplanetary space. SSA threats include harsh space weather, associated with solar energetic particle storms, prediction of near earth asteroid trajectories and tracking 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 most valuable contribution of the Czech Republic to the SSA 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 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. Having been sometimes launched years ago, many of them are still functional on orbit and currently providing relevant space weather data.

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 are provided in the scope of the International Space Environment Service though the Regional Warning Center in Prague.



SATRAM instrument in a protection aluminium box, ready for integration to the Proba-V satellite. Source: CSRC

LAUNCHERS

The independent access to space via operational launch pad and affordable and reliable family of launchers is strategic and crucial for space endeavor 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 and research institutions are already involved in development of specific components of launchers and maintenance of Europe's space port Kourou in French Guiana.

One of the key issues in launchers operation is their mass, which directly reflects in launch costs. To reduce the weight of the cryogenic propellant tanks, Czech company developed a new leak resistant polymer liner with powerful insulation properties allowing thinner walls of the tanks. Another project is focused on development of new epoxy core systems with syntactic foam structure with lower density, thickness and flammability and co-curable with standard epoxy carbon fibers enriched polymeric materials.

Another possible way to make the rocket lighter and cheaper is to use on the launcher's upper stage thermal insulation panels, which can be jettisoned away after they have fulfilled their task. To predict and mitigate the risks resulting from the strong mechanical stress forcing the insulation panels to vibrate during launch, a team composed by two companies developed computational methodology and performed experimental testing of scaled model of the panel in high speed wind tunnel to assess its flutter response.

Also universities are involved in the launcher systems. A group of mechanical engineers used the reliability engineering methods to evaluate and increase the inherent reliability of a nozzle design. Another project was performed in the field of cryogenic rocket propulsion, in which the Czech engineers were responsible for sensor instrumentation for online and offline diagnostics of the propellant electric pump.

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.

Visualization of the deformation of a thermal insulation panel and outer flux field on Ariane 5. Source: ESA & L.K. Engineering

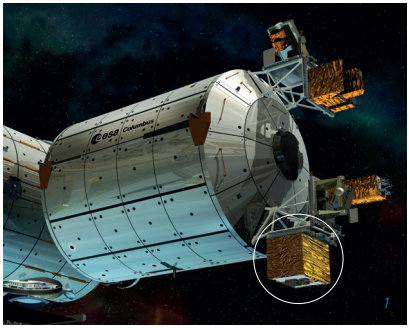
HUMAN SPACEFLIGHT AND MICROGRAVITY

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 have experience in researching 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 of 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 board 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 simulation mission conducted by Russia, ESA and China, includes three Czech research experiments with the aim 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.

Group of space enthusiasts, engineers and scientists develop underwater Hydronaut station, which can be used as a realistic simulator of conditions on board of manned spacecraft, orbital, Lunar and/or Mars stations. The Hydronaut will allow 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.



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1. Columbus laboratory on ISS with ACES box. Source: ESA
2. Single-photon laser timing ELT instrument. Source: IAP, ČVUT

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.

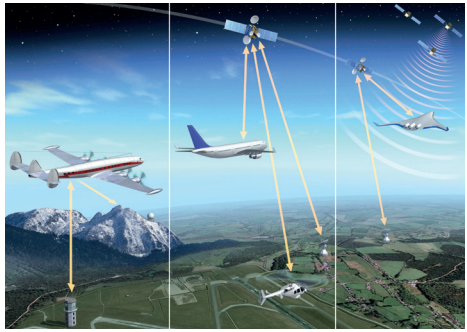
Some other activities were focused on preliminary design of satellite communication link for unmanned aerial systems, which encompasses both payload data and command & control flows. A key driver is the ability to ensure safe and secure communications between the remote pilot station and controlled aircraft.

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 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.



Satellite – aircraft communication scheme.
Source: Honeywell International

EARTH OBSERVATION

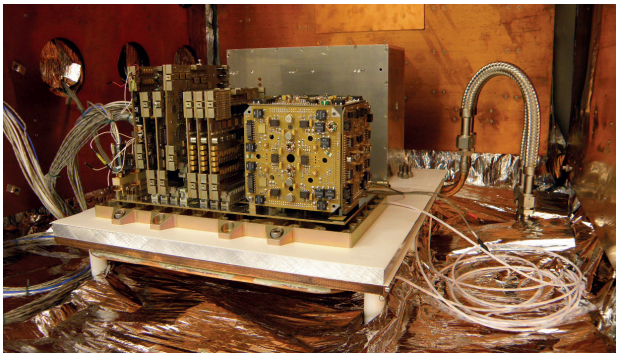
Earth Observation is a global initiative and the Czech Republic provides support through a participation in GEO, ESA and EUMETSAT. Czech public administration already benefit from EO applications and value added services in areas like urban planning, agricultural monitoring, forestry, environmental monitoring 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, 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 one 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.



Czech micoaccelerometer during a vacuum chamber test. Source: VZLÚ

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.

Hi reliability manufacturing and inspection in clean room.
Source: G.L. Electronic

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.

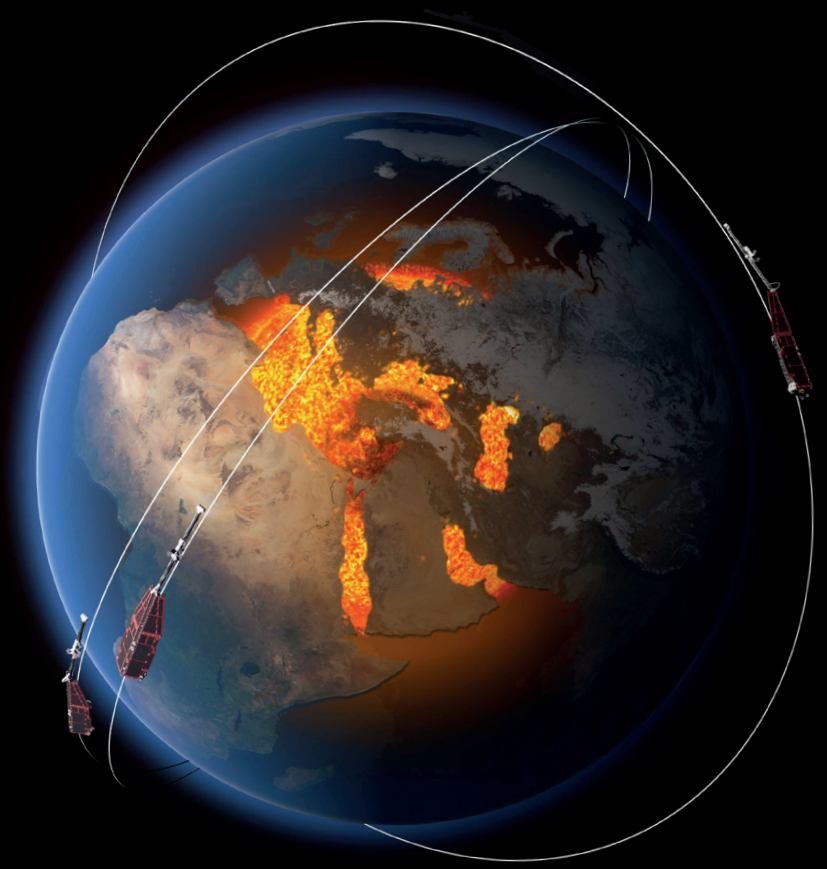
CSO provides outreach through a number of lectures for kids and students. It teams up with nursery, primary and secondary schools, NGOs, museums, libraries and other organizations interested in space education. It supports Czech students at multitude of international events like congresses and workshops, 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 if possible, it also looks for funding.

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.

Czech student Stanislav Fořt during a Zero-G flight. Source: CSO



ESA Swarm magnetic mission with three Czech micro-accelerometers on board that measure tiny non-gravitational forces pushing the satellites around their ideal orbit. Source: ESA

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