SPACE ACTIVITY AT BME

Edited by
Kálmán Kovács

BME EIT SPACE FORUM

MANT
2017

Space activity at BME

BME EIT Space Forum handbook

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BME SPACE FORUM FOR TECHNICAL UNIVERSITY SPACE ACTIVITY SUCCESS

Introductory thoughts to the extended Space Forum handbook

The year that has passed since the publication of the last BME Space Forum issue proved to be momentous period for domestic space activity stakeholders, as finally Hungary was able to contribute to the work of the European Space Agency (ESA) as a full member. The first step was the identification of programs and related technology and research areas where Hungary – based on experience and future objectives – could effectively take part. In this process of discussing the terms, BME Space Forum attended several meetings, and on the basis of the concluded agreements we are proud to say that we could effectively represent the Technology University.

For decades, various research workshops have been performing space research related activities, from basic research to technology development through the actual implementation of diverse devices and services, as well as various forms of education and training at the Faculties and Departments of the Budapest University of Technology and Economics. Recognizing the worthwhile opportunities in harmonizing the work of the numerous individually operating research groups, a few years ago BME Faculty of Electrical Engineering and Informatics leadership initiated that the various space activities are brought together in a single forum. Participation (joining) the Space Forum is open for all organisations and research groups of the Technical University.

Participants of Space Forum joined voluntarily. It is their common objective that the various space activities performed at the Technical University should not be dissipated, but all activities in this field should be coordinated along a jointly worked out strategy. Space Forum represents its member organisations in a uniform manner towards BME's current and future partners, and initiates cooperations that may significantly contribute to the more efficient utilization of the university research and other creative-educational capacities.

With its updated data, it is the objective of the BME Space Forum handbook series to introduce through BME Space Forum member organisations and groups the activities, achieved great results and further aims in the area of space research, space technology, space devices and space related applications at the Budapest University of Technology and Economics.

We trust that our compilation will serve useful information to our current and prospective partners, and to the engineers and scientists of the future.

January 2017

Dr. Kovács Kálmán, President, BME Space Forum

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I. BME SPACE FORUM - SPACE ACTIVITY AT BME

The mission of Space Forum

It is the mission of the Space Forum to harmonize, coordinate by common vision and strategy, the activity of Departments, groups at the Technical University participating space activities, to recognize the joint human and technical resources, amazing achievements, to make internal and external knowledge transfer more efficient, and to utilize opportunities lying in synergies granted by joint capabilities and unified representation. The common aim of Space Forum members is to become the bridge between academic research and production, service application, and to participate all phases of research-development-innovation and application processes of space activity. Any Technical University organisational unit or group that is involved in space activity or intends to do so in the future may be member of Space Forum. Joining the Space Forum is voluntary.

In order to successfully enforce the above, Space Forum participant organisations attach key importance to that Space Forum coordinate and assist:

- the integration of BME space technology and space research human and infrastructure capacities, internal knowledge sharing,
- the definition and representation of the directions and key programs of BME space activity,
- the formation of research partnerships and industrial cooperations by joint objectives and R+D directions,
- external knowledge and technology transfer processes, primarily to strengthen domestic space industry,
- in the area of space research and space technologies, the development of education-training for developer supply primarily at the technical University, but at any level of education-training,
- the promotion of space activities, raising awareness of its importance,
- BME participation at key domestic and international space research and space technology projects and tender applications.

Space Forum members and management

Currently 12 Departments of 4 BME Faculties participate Space Forum voluntarily. Space Forum members and representative are:

Faculty of Civil Engineering (ÉMK)

- Department of Geodesy and Surveying (AFGT)
  Dr. Szabolcs Rózsa, head of department, associate professor
- Department of Photogrammetry and Geoinformatics (FMT)
  Dr. Árpád Barsi, head of department, professor

Faculty of Mechanical Engineering (GPK)

- Department of Mechatronics, Optics and Information Engineering (MOGI)
  Dr. Krisztián Samu, deputy head of department, associate professor
- Department of Applied Mechanics (MM)
  Dr. Gábor Stépán, head of department, professor

Department of Transportation Engineering and Vehicle Engineering (KJK)

- Department of Control for Transportation and Vehicle Systems (KJIT)
  Dr. Péter Gáspár, head of department, professor
- Department of Aeronautics, Naval Architecture and Railway Vehicles (VRHT)
  Dr. Dániel Rohács, head of department, associate professor

Department of Electrical Engineering and Informatics (VIK)

- Department of Electronics Technology (ETT)
  Dr. Tamás Hurtony, senior lecturer
- Department of Electron Devices (EET)
  Dr. András Poppe, head of department, associate professor
- Department of Networked Systems and Services (HIT)
  Dr. László Bacsárdi
- Department of Measurement and Information Systems (MIT)
  Dr. Ákos Horváth, research fellow
- Department of Broadband Infocommunications and Electromagnetic Theory (VHT)
  Dr. Lajos Nagy, head of department, associate professor
- Department of Telecommunications and Media Informatics (TMIT)
  Dr. Klára Vicsi, scientific advisor

Space Forum operation and management is performed by the Federated Innovation and Knowledge Centre (EIT) of BME Department of Electrical Engineering and Informatics. Head of Space Forum (president) is Dr. Kálmán Kovács, director of EIT; deputy head is Dr. László Bacsárdi.

Professional vision and key RDI topics of Space Forum

Professional objectives and vision

We intend to participate jointly in programs financed by international programs, mainly EU tenders, and international and domestic industrial cooperations, projects that provide access to infrastructure, and long-term projects in order to:

- keep up with advanced technologies that are applied increasingly widely
- domestic businesses and research groups should benefit from the advantages of an outstandingly high added value, very prospective market by the research and innovation activity of BME,
- avoid buying necessary services and professionals for increasing costs.

The aim of the participation is to further strengthen the international recognition of the domestic space research sector, to increase the extent of Hungarian space activity, and increase the education-training role of BME in domestic supply of professionals.

Our major research, development and innovation (RDI) topics

In the area of space activities, we see general technology researches and experiments in the space segment, and the communication segment, the Earth segment, payload development as RDI directions to be successfully continued at BME, as in these areas we have significant research experience and there are expected significant research achievements.

RDI directions of BME space activities

Space segment:

- Further development of the BME Small satellite ground station, and instruments, measurement equipment related to small satellite manufacture and testing (for space qualification),
- instrumentation for individual remote sensing experiments with and manufacture of optical devices,
- multi-domain (electro-thermic) testing of small satellite systems, thermic design, monitoring,
- Evaluation of the usability of complex hardware technologies for size optimization for space missions,
- Temperature-compensated light sensor development for space applications,
- Development of on-board base units – power supply system,
- Development of on-board base units – on-board data collection and telemetry systems,
- Course stabilization algorithm research in small satellite missions.

Communication segment:
- Communication channel research,
- Research of climate change effects,
- Telecommunications systems convergence,
- Research of high-speed small satellite digital communications systems.

Ground segment:
- Satellite tracking with microwave adaptive antenna systems,
- Research of autonomous (including power supply), remote controlled, unattended ground station and ground station systems.

Payload:
- Microfluidics and Lab-On-a-Chip technologies in space research,
- Multispectral camera system in small satellite missions with specified usage areas,
- Flying antenna – that is, radio frequency monitor experiment on LEO satellites,
- Installation of analogue and digital cross-band repeater on satellite surface.

Researcher and engineer base

On average, annually, 70-80 lecturers-researchers perform space activity – full time or part of their time - in the above professional areas at the Technical University Projected to Full Time Equivalent (FTE) this means 20-22 full-time staff.

Research personnel remuneration, as well as directly research related devices, materials cost approx. HUF 90-120 million per annum. In the last 5 years, key external sources came mostly from industrial cooperations, ESA PECS grant programs, domestic EU (mostly TÁMOP) projects, individual government subsidies, and private (business) sponsorships.

Educational topics and supply of professionals

The education of technical and scientific fundamentals of space activity has been part of the curriculum for decades at various Faculties of BME. Currently available courses, among others:
Faculty of Civil Engineering – Satellite positioning (BSc), Satellite geodesy (MSc), Global navigation satellite systems (MSc), Environment and remote sensing (MSc),
Faculty of Mechanical Engineering – Optical systems design (BSc), Analytical mechanical analysis of planetary motion (NASA student exchange program),
Faculty of Transportation Engineering and Vehicle Engineering – Space dynamics (BSc/MSc), Special propulsion, rockets (BSc), Aerodynamics and dynamics of hypersonic flight (MSc),
Department of Electrical Engineering and Informatics – Space technology theory and practice (BSc/MSc), Critical embedded systems (MSc), Cyberphysical systems (MSc), Quantum communication (MSc), and participation in ESA educational experimental programs.

Space research and space industry (including space services) requires qualification not only for the professional staff; it is necessary for the utilization for society that knowledge is built in primary and secondary education, as well. The first steps have been taken in recent years. Space activity, beyond the above, requires special training, as well: In Hungary, as an ESA member state, Education necessary to the introduction of AS-9100 quality assurance system is a key educational task. Businesses that design and manufacture on-board satellite equipment and participate ESA-coordinated space program, are required to have passed the ESA (or NASA) qualification.

In the future, BME could assume significant part in the above educational, training tasks. However, the establishment of the laboratory infrastructure necessary to the education, training aligned to ESA engineer/researcher requirements (ESA qualification, space qualification, AS-9100 quality assurance) is yet needed.

It is an encouraging result in the area of young researchers that the number of students selecting space research courses has increased at BME. In the past 5 years, Earth observation (climate), model-driven engineering, satellite positioning systems, satellite orbit modelling, space dynamics and space communication areas had PhD students, what's more, four of them are involved in the satellite course, as they participated earlier in the Masat-1 project. Annually, 1-2 successful PhD thesis defences are seen in these topics.

Major professional partners

The institutional background of Hungarian space research is provided by 25-30 research centres. The number of professional (but not necessarily full-time) space researchers is around 250-300 (mostly engineers, physicists, other scientists, doctors, etc.).
The most significant domestic partners of BME Departments with space activity:

- Hungarian Academy of Sciences (HAS) institutions (e.g. Space Dosimetry Research Group of Centre of Energy Research, Wigner Research Centre for Physics, Research Centre for Astronomy and Earth Sciences)
- FÖMI (e.g. Satellite Geodetic Observatory, Department of Photogrammetry/Remote Sensing)
- ELTE (e.g. SRG – ELTE TTK Space research group)
- University of Miskolc and Bay Zoltán Institute (Institute of Physical Metallurgy, Metalforming and Nanotechnology)
- National Meteorological Service (e.g. Observation department)
- Professional organizations (e.g. MANT Hungarian Astronautical Society, HUNAGI Hungarian Association for Geoinformation)
- Government agencies (e.g. NFM Hungarian Space Office)

The majority of domestic space industry players are businesses that are only partially involved in space activity. At the same time, their annual space activity revenue is a few billion Hungarian forints, which comes from the sale of very high value-added, technologically world-class product or service. Their activity is essential to the uninterrupted operation of the most important sectors of economy (banks, telecommunications, freight, transport, agriculture, security, etc.).

The majority of domestic space industry is covered by three organisations:

- Hungarian Space Industry Cluster (HUNSPACE)
- Hungarian Airspace Technology Platform (HATP)
- Hungarian Association for Geoinformation (HUNAGI)

We have significant professional cooperation with each organization, within that with a few businesses, as well.

Space Forum and Hungary's ESA membership

Hungary's full membership in the European Space Agency (ESA) grants us access to ESA research infrastructure in order to develop BME and Hungarian space activity.

- Following on the success of the first small satellite, Masat-1, developments related to small satellites are highly important for BME; in the long run, the use of the launch pad in French Guyana, the development centres of the VEGA rocket, and – among others – the French testing facilities and control stations are indispensable.
- The participation in scientific projects is also very important for BME such as the Hungarian contribution – KFKI (Wigner) and BME – to the manufacture of Rosetta spacecraft and the Philae landing unit (in this several domestic research institutes and businesses participated besides BME).
- For BME, in the future, to have the benefits of space activity appear in the widest possible domestic economic audience, it is important to have access to remote sensing and data transmission satellite data and services, and increased cooperation primarily with French, Italian, Dutch and German academy, university and industrial research centres.

Another great opportunity of ESA membership is that the membership fee can partially be reclaimed by grant applications. Grant research areas and Hungary's voluntarily selected topics are currently under negotiation between Hungary and ESA. By autumn 2016, the relevant research areas and the forms of Hungarian participation within the ESA scope of activity will be finalized. NFM MŰI represents the government in the negotiations, while Space Forum is representing BME professional areas.

II. A HISTORY RICH IN SUCCESSES

Technical University – the cradle of excellence

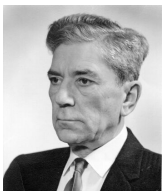
At the more than two centuries old Technical University, several researchers and development engineers pursued their education or their work who attained world-class achievements in the area of modern space research.

A few outstanding personalities from the long list:

Tódor Kármán, known in the world as the father of rocket technology, obtained his mechanical engineering diploma in 1902 and lectured for years at the royal József Technical University, as it was called then.

Ferenc Pavlics, received his diploma in mechanical engineering in 1950, became famous for being the development engineer of the first extra-terrestrial vehicle, the Moon rover used in the Apollo program.

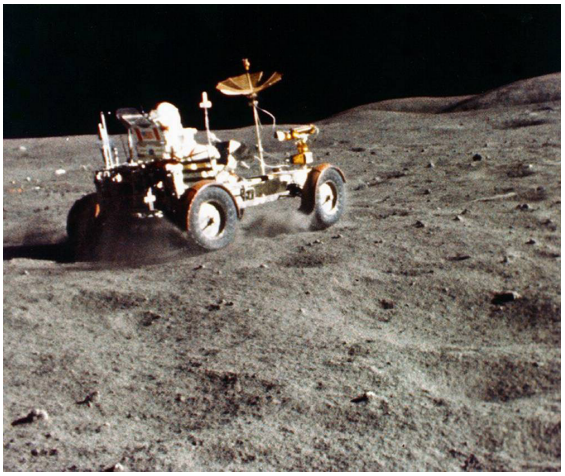
Antal Bejczy, developer of the remote control engineering for the Mars Pathfinder, studied at the Faculty of Electrical Engineering until 1956.



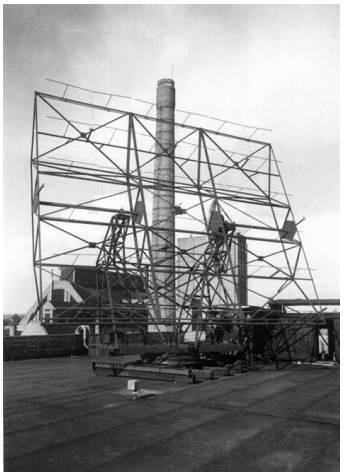
Zoltán Bay, leader of the 1946 ground-breaking Moon radar experiment, established and headed the Department of Atomic Physics at the Technical University.

Gyula Tófalvi, who in 1958 won the Grand Prize of the Brussels World Fair with his ionospheric research equipment, was among the first to obtain electrical engineering diploma at the University.

Detrekői Ákos, the internationally renowned expert of geoinformatics and remote sensing, remained with the Technical University from receiving his civil engineering diploma through his entire professional career.



Lunar rover on the surface of the Moon in 1971 (Ferenc Pavlics)

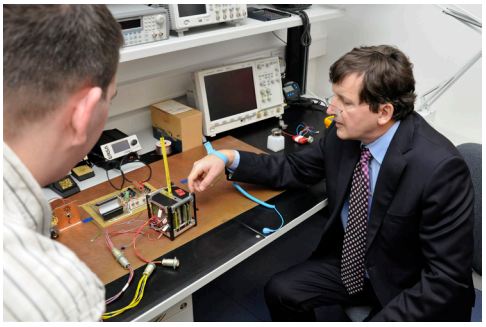


The world's first Moon radar (Zoltán Bay)

BME and Hungarian astronauts

Everybody knows that Bertalan Farkas is the first Hungarian to enter space: on the board of Soyuz-36, on May 26, 1980. But it is less known that Bertalan Farkas has close ties to the Technical University: researchers graduating from or working at BME participated the preparations of several experiments developed by Hungarians on the Salyut-6 space station, and he obtained his diploma in engineering at the Faculty of Transportation Engineering of BME.

Bertalan Farkas



The second Hungarian to enter space, Charles Simony, also has several connections to BME: his father, Károly Simonyi was an outstanding lecturer of BME VIK. Living in the USA, Charles established radio contact with BME during his space flights (April 7, 2007 and March 7, 2009), and later visited the Masat-1 development team.

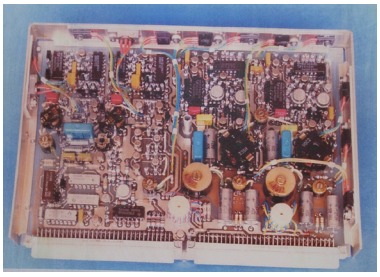
Charles Simonyi with Masat-1 test specimen at BME ground control station

Bertalan Farkas (m) with two invited astronauts and personalities of Hungarian space research in the Hall of the Technical University – at the conference celebrating the 35th anniversary of the first Hungarian space flight organized by BME Space Forum and NFM in 2015.

Technical university building blocks of Hungarian space successes

BME Rocketry Student Scientific Circle

In 1961, organized by Csaba Ferencz, third year BME electrical engineering student, the Rocketry Student Scientific Circle started its operation at the Budapest University of Technology, which became BME Space Research Group in 1965. In 1966 – first in Central Europe and with their own developed equipment - they received images of weather satellites. This group gave birth to ELTE Space Research Group (its international success is the SAS equipment) and the first space research group of Central Research Institute of Physics of Hungarian Academy of Sciences, where later the world famous Pille dosimeters were manufactured.



Orbital Data Collection System (1979)

BME Space Research Group

András Gschwindt received his electrical engineer diploma at BME in 1965. He has been very successfully heading the Space Research Group since 1970. A Soviet satellite took one of their own equipment, a power supply unit to space already in 1973. Up to date, they have manufactured equipment for fifteen satellites, two comet probes (Vega and Rosetta), and the Mir space station. None of these equipment was faulty. In 2009, under his professional guidance, the construction of the first Hungarian satellite, Masat-1 commenced.

Simonyi uses Pille in live feed

From BME to HAS Space Research Group

István Apáthy graduated from BME as electrical engineer in 1969, got to know space research and soon started working at the HAS Research Centre for Nuclear Energy. The further development of the most successful Hungarian space device, the Pille dosimeter, is connected to his name. The first Pille instrument was used by Bertalan Farkas on-board the Salyut 6 space station in 1980. Later versions of Pille were taken aboard US space shuttles, the Russian MIR space station and the International Space Station. The second Hungarian astronaut, Charles Simonyi also used it.

From BME to the largest Hungarian space industry firm

János Solymosi worked as development engineer from 1983 in the Space Research Group of Department of Microwave Infocommunications of BME. He participated the development of several on-board satellite space devices, among them the historic VEGA program. He is the founder and leader of Hungary's largest space industry firm. Their equipment is present on the International Space Station and a number of satellites, what's more, they participate India's Mars program, as well.

III. PRESENT TIME – WORLD CLASS ACHIEVEMENTS

Masat-1 – a Hungarian space historic milestone

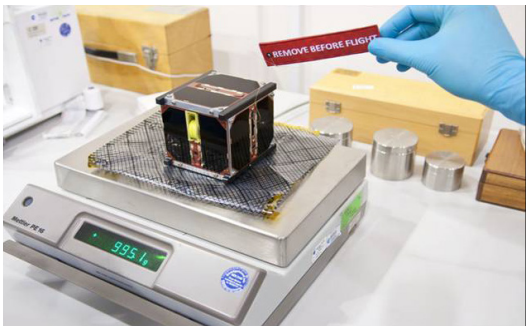
Masat-1 is the first Hungarian satellite, important piece of Hungarian history of science, designed and manufactured at the Technical University. It was not since the space flight of Bertalan Farkas that such a highly popular Hungarian related space event took place, as the successful space mission of this little cube with 10cm side edge. But its voyage was followed with attention not only from home: at more than two hundred locations on the surface of Earth, enthusiastic radio amateurs continuously received its signals and transmitted them over the internet to the Masat-1 ground control station at the Technical University, what's more, even ESA and NASA experts commented highly on the performance of the small satellite operating impeccably all the way and of its developers.

Members of the Space Research Team at the Faculty of Electrical Engineering of the Technology University have been pondering about already in the 1980's that the first Hungarian small satellite should be built already. Due to the technical level of the time, the plans of the then small satellite described a space device 30 times the size of Masat-1. And although from 1976 a series of space devices constructed by the Space Research Group entered space and operated flawlessly, the plans of an own satellite have not been realized for decades. Finally, in 2006, after so much work and perseverance, good fortune accompanied them. ESA launched its Cube-Sat program, and – by invitation from András Gschwindt, leading the BME Space Research Group at that time – professor Klaus Schilling visited BME and demonstrated UWE-1, the satellite of the University of Würzburg. By their example, several electrical engineering Department groups got passionate about building the first Hungarian satellite.

By 2009, one of the teams succeeded in establishing the necessary internal and external conditions under which this great endeavour could be embarked upon. Under the professional leadership of András Gschwindt

The BME Masat-1 team

of the VIK Department of Broadband Infocommunications and Electromagnetic Theory and the operative management of Gyula Horváth of the Department of Electron Devices, a team of youth (mostly students), with exuberant enthusiasm and months of highly organized work, commenced building the first Hungarian satellite. As the ESA



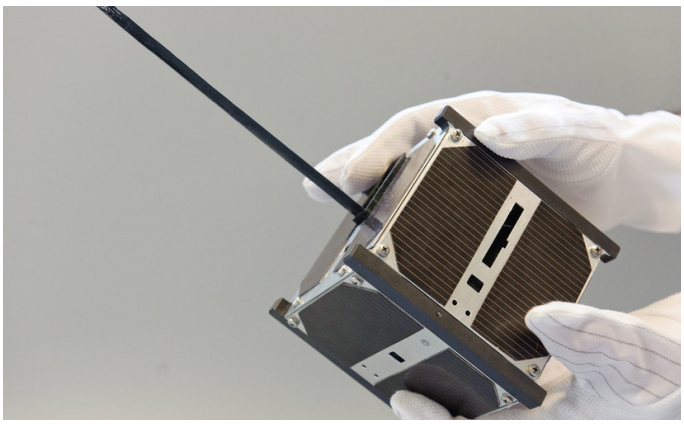
Masat-1 below 1000 grams (995.1)

Cube-Sat program was nearing its end, this was a timed race: enterprising universities had to build a 10cm side edge, cube shaped, weighing maximum 1 kg, space qualified satellite. The last condition meant that they had had the tests for space qualifications of the satellite prepared by the deadline. Tight budget meant that they had to relinquish purchasing space qualified international devices, and had to realize everything on their own. This demanded creativity and extensive innovation from each member of the team. It turned out, that there are domestic small and medium sized companies that are capable of meeting high technology requirements; that by proper quality control, retail materials can be used to create devices that pass exceptional specifications, for example, a metal tape measure may well serve as a space qualified antenna.

By the time of the ESA judgement, despite being a latecomer, Masat-1 got on the reserve list besides the nine already selected. The team boarded this opportunity. In the final period, they 'camped' in the lab, and did the test day in, day out. And because many of the selected teams could not complete their project, but we did, finally, we got the green light!

Masat-1 became the first Hungarian made satellite that was offered the possibility to go up into space, and after the successful launch, this became Hungary's first Earth-orbiting artificial celestial body.

With its three-year successful mission, Masat-1 enhanced the international reputation of the Budapest University of Technology and Economics. Its success was achieved by the colleagues and students of two Departments, the Department of Electron Devices and the Department of Broadband Infocommunications and Electromagnetic Theory, of BME's Faculty of Electrical Engineering and Informatics, by the further Technical University colleagues they got involved, and the unmatched collaboration and support of the Hungarian Space Office, and more than 60 domestic and international businesses.



Masat-1 satellite

Memorable moments of the successful mission of the first Hungarian satellite, 2012-15

The Vega launch, with Masat-1 in its radome, Kourou (02.13.2012)

LAUNCH

The launch of Masat-1 took place on February 13, 2012, at 11 hours Hungarian time at the ESA equatorial space base near the city of Kourou in French Guiana, a region of France in South America. VEGA, carrying Masat-1, another 6 CubeSats, and a larger satellite, was a new rocket of ESA, also a first launch. Following nearly two hours the successful launch, Masat-1 was deployed from the carrier and Masat-1 started its own orbit.

FIRST TRANSMISSION

It was only 45 minutes after the first Hungarian satellite started its elliptical orbit around Earth, the first message arrived from an enthusiastic radio amateur on the American continent to the Masat-1 ground control station located on the top level of Building E of the Technical University. It meant the satellite successfully started operation. Soon the transmission of the pico-satellite passing over us was received in Hungary on the 70 cm wavelength radio amateur band. Masat-1 continuously measured its status and transmitted the date towards the ground radio receiver stations.

GROUND STATIONS

Masat-1 was controlled from the primary ground station located at Technical University (Building E) and the secondary in Érd city. The continuous reception of data packages was ensured by 200 radio amateur stations worldwide that were sending the data to Masat-1 ground station via the internet.

THE FIRST HUNGARIAN SATELLITE IMAGE

March 8, 2012 – Masat-1 snapped its first own space image, showing a section of Africa. The 640x480 pixels resolution camera weighing a few grams was installed on the satellite in the final months.

UNEXPECTED HAZARDS

On October 4, 2012. the satellite's orbit was intersected by debris approx. 20 cm of size, coming from an inoperable satellite. The encounter would probably have caused the destruction of Masat-1, but luckily, the collision did not take place. (In the course of the three-year orbit, in another two cases, May 2 and August 1 2013, did larger debris pass near by Masat-1.)

The team it the Masat-1 Ground Control Station at the BME building E monitors the Masat-1 transit.

MEMORIAL STAMP AND MEDAL

On April 12, 2012, Cosmonautics Day, Hungarian Post issued memorial stamp, while Hungarian National Bank a memorial medal celebrating the success of the first Hungarian satellite.

THE FIRST 'BIRTHDAY

Presenters at the 'Second birthday' (from left): Gyula Horváth, Masat-1 project manager, László Vajta, BME VIK Dean, Zoltán Cséfalvy, NFM secretary of state, András Gschwindt professional lead, Gábor Péceli BME rector, Kálmán Kovács Space Forum chair, and members of the Masat-1 team

On February 13, 2013, celebrated the first birthday of the Masat-1 mission (time spent in space) with an event titled 'Masat-1, the first Hungarian small satellite is one-year-old'

TEN THOUSAND ORBITS

On January 10, at eighteen hundred hours, the Hungarian satellite passed over Hungary, orbiting Earth the ten thousandth time.

THE SECOND ‚BIRTHDAY'

On February 13, 2014, the second anniversary of the successful operation of the first Hungarian satellite, BME VIK Federated Innovation and Knowledge Centre (EIT) together with the Hungarian Astronautical Society (MANT) celebrated with an event where junior researchers gave account of their space related researches. At the event, EIT issues a call for proposals titled 'Satellite mission 2014' with the topic of researching future small satellite experimental opportunities.

THOUSANDTH DAY IN SPACE - FIRST DAY IN THE NATIONAL MUSEUM

On the 1000th day of the Masat-1 mission, November 10, 2014, the creators of Masat-1 ceremoniously handed over the certified model of Masat-1 for the permanent exhibition of the history of science of the Hungarian National Museum. A few days later, on November 21, in the frame of the Hungarian Science Festival, the second model of Masat-1 was handed to the TIT Budapest Planetarium.

END OF MISSION

The last signal from Masat-1 satellite was received on January 9, 2015, at 21:21 Hungarian time. Soon after this, the small satellite entered the denser layer of air under 100 km altitude, where it could not continue orbiting Earth due to increased friction. The continuously increasing friction resulted in the rapid increase of satellite temperature. The structural elements of the first Hungarian satellite melted, the satellite fell apart, and on January 9, 2015, between 23:15 and 0:45 it was destroyed.

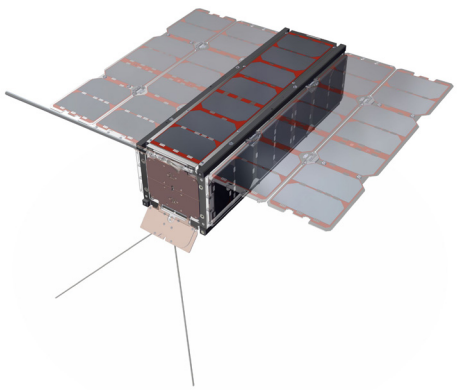
Masat-1 and the proud team in the National Museum

Future of the Masat program

Regarding current and future developments in the small satellite arena, there are two unfolding trends at the BME Faculty of Electrical Engineering and Informatics: a more education oriented, novelty seeker research (SMOG), and a more application or market oriented development trend utilizing the technologies and methods proven by Masat-1 (Masat-2).

MASAT-2

Masat-2 developers aim at a mission that realizes scientific and technological experiments building on the Masat-1 satellite experience. It is the strength of the next satellite generation that it builds on technology that flew, which is an important criterion as regards reliability. The satellite with the size of even 10x10x30 cm3 can serve a fundamentally wider spectrum of applications should it be university, or industrial development projects. This step forward will be due to the advanced situation stabilization system, the increased volume and mass, the significantly more collectable energy and the considerably more amount of data to be transmitted to Earth.



The unit CubeSat platform of C3S

SMOG-1

The development of a small (5x5x5 cm3) satellite is nearing completion. In the project, a new, the space readiness of a Hungarian developed insulation material will be also tested. The scientific objective is to measure human electromagnetic pollution (hence the name of the satellite) in the near Earth region. Parallel to satellite developments, the operation and development of automated and remote controlled ground station capable of serving satellite contact is among the tasks.

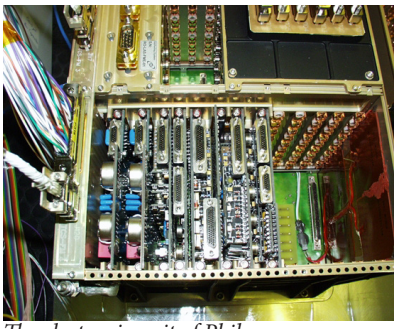
Masat-1 website: cubesat.bme.hu
Ground station website: gnd.bme.hu

SMOG-1, the small satellite with the size of 1/8th of Masat

Rosetta project – Hungarian space devices on a comet core

On the side of BME, a most significant contribution was the participation of the Department of Broadband Infocommunications and Electromagnetic Theory in the ESA Rosetta program.

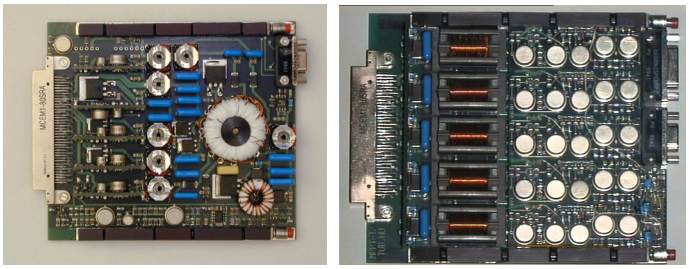
One of the greatest scientific undertakings in the history of ESA, the Rosetta program, was commenced in the early nineties in wide international cooperation. The nearly 100 kg Philae landing unit of the Rosetta spacecraft researches the 67P/Churyumov–Gerasimenko comet. Rosetta, launched in 2004, approached its final destination in a complicated course – using the gravitational slingshot of Earth thrice, of Mars once - in January 2014. While the satellite spent most of its voyage hibernated, on approach to the Lutetia and Steins asteroids it was activated to make pictures of them. Rosetta, after flying in space for nearly 10 years, closed in on and by way of Philae, a first in the history of space research, sent measurement instruments to the surface of a comet.



The electronic unit of Philae

One of the key service units of the Rosetta spacecraft, the power supply system, was designed and built by researchers of Department of Broadband Infocommunications and Electromagnetic Theory. This system operated reliably during the mission, and provided power to on-board equipment following the successful landing on the comet on November 12, 2014.

Philae – similar to Rosetta – spent most of its journey in passive state; therefore, it needed to be activated before landing on the comet. The 'wake up' unit controlling thermic and power conditions is part of the power supply system, which under proper conditions, revives the on-board computer, which steps in as responsible for the control of the landing unit.



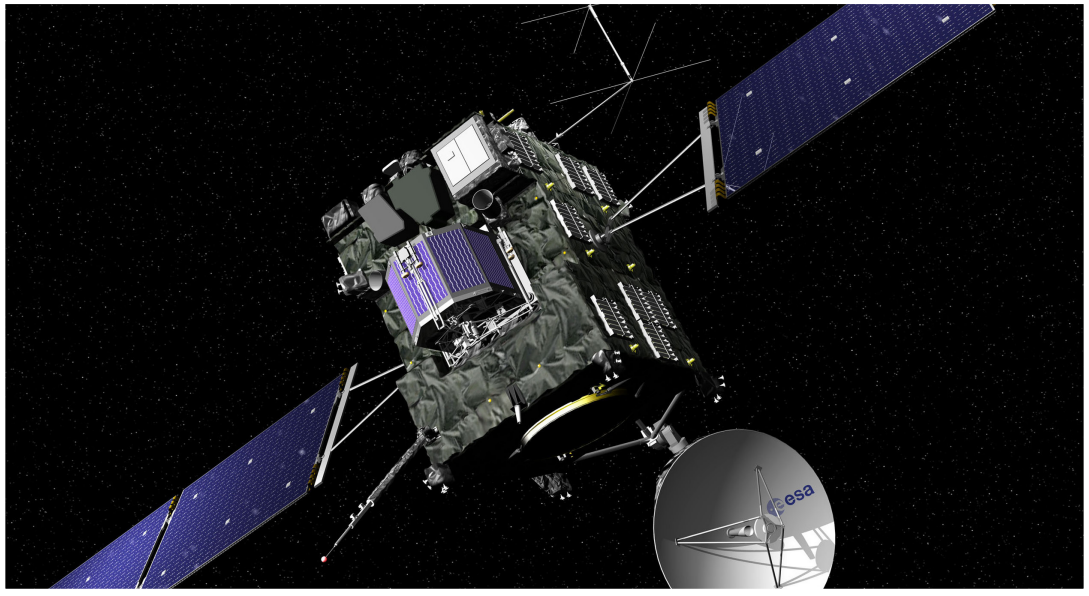
Philae power supply system in the electronic unit

The complete power system is located on ten main and further 79 sub-panels, among which control units, power distribution panels, various power supplies, solar panel controllers and a multiband A/D converter unit are located. The mechanical and thermic construction was also part of the design. Electronics was built using high reliability, space certified, radiation-proof components.

The Rosetta program continues following a year after landing, and the evaluation of the results of the scientific measurements collected by the orbiting unit and Philae is performed continuously.

Rosetta timeline of major events

March 2, 2004 – Launch at 8:17 Hungarian time (7:17 UT)
March 4, 2004 – First planned close swing-by of Earth, altitude above surface was 1,954 km.
February 25, 2007 – Mars flyby.
July 3, 2008 – The probe was activated to prepare for the asteroid rendezvous, instrument calibration was commenced. Then the path of the asteroid was refined so the probe could fly by at the planned distance, final light curve was taken to determine the approximate shape of the celestial body.
August 4-September 4, 2008 – Optical navigation: the location of the planetoid is refined with probe instrumentation, and then probe path is corrected.
September 5, 2008 – Flyby of asteroid 2867 Šteins at a distance of 800 km.
July 10, 2010 – Flyby of the asteroid 21 Lutetia at a distance of 3,170 km.
June 2011 - January 2014 – Hibernation
January – May, 2014 – Approaching the comet.
November 12, 2014 – Philae landing on comet surface. The message of the landing unit can be read on Twitter in Hungarian: Touchdown! My new address: 67P!
November 2014 - December 2015 – Follows the comet on its Sun orbit.
The table was compiled on the basis of Wikipedia.



IV. BME SPACE FORUM ORGANISATIONS AND ACTIVITIES

This compilation is based on data service from Space Forum members.

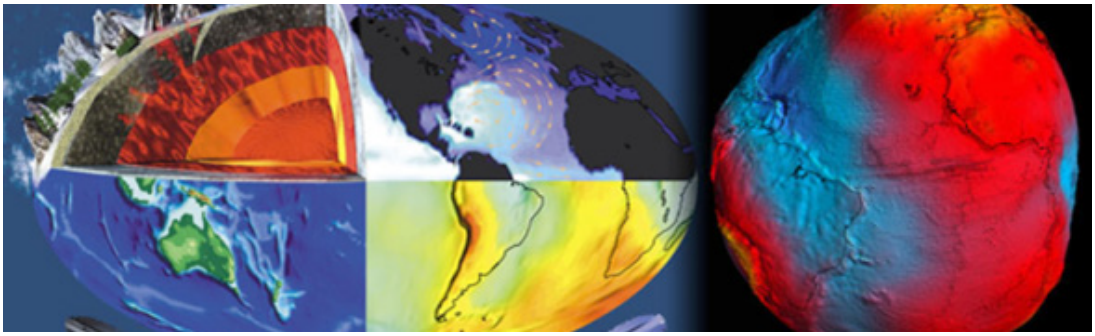
Faculty of Civil Engineering

Department of Geodesy and Surveying

www.geod.bme.hu

Space Forum representative: Dr. Szabolcs Rózsa, associate professor, head of department, rozsa.szabolcs@epito.bme.hu
Further Space Forum representative: Dr. József Ádám, professor, jadam@epito.bme.hu.

The task of the Department is to teach the theoretical and practical aspects of geodesy, surveying, land administration and cartography, including the high-precision national (continental, global) geodetic reference frames and the research of geodetic engineering, geodynamics, deformation analysis, positioning and navigation topics with traditional geodetic and modern satellite technology.



Space activity of the Department is marked by satellite positioning system theory and the research of its application for Earth observation, navigation and the maintenance of geodetic reference frames. The Department operates a GNSS (Global Navigation Satellite Systems) continuously operating reference station since 2000, which observes GPS, GLONASS, Galileo and EGNOS satellites. Further key topics include the modelling of the gravity field of the Earth with space gravimetry and space gradiometry, and the examination of recent crustal motion and deformations with satellite navigation systems.

General faculty data:

- Education and R+D: 12 FTE lecturers (2 HAS professors, 7 PhD), 3 PhD students; Main areas: geodesy, surveying (including satellite positioning), Earth observation (e.g. gravity satellites, GNSS)
- Laboratories: GNSS laboratory, Measurement certification laboratory, Open source GIS software systems laboratory
- Research Groups: HAS-BME Geodesy and Geophysical Research Group (operated between 1996 and 2012, planned to be restarted)

Space activities related information:

Fields of specialization by ESA terminology and classification:

- Ground Data Processing [2.4]
- Earth Observation Payload Data Exploitation [2.5]
- GNSS Systems and Ground-related technologies [10.2]

Main service:

- Continuous operation of GNSS ground station
- Operating EGNOS remote monitoring station

Educational activities:

- Satellite positioning (BSc)
- Satellite geodesy (MSc)
- Global navigation satellite systems (GNSS) theory and applications (MSc)

Main projects and partners:

- EGNOS monitoring SBAS project – Integricom, EuroControl
- GALILEA Project – Space Engineering S.p.A (leader), NavPos System GmbH, CISAS Univ. Padova, BKG
- TROPSY Project – Teleconsult Austria (leader), TU Wien, ZAMG
- INTRO Project – BME (leader), National Meteorological Service, Integricom.NL
- GOCE AO Level-1b/2 - ESA

Planned projects and partners:

- Monitoring of crustal deformations using InSAR technology – KIT Karlsruhe
- Development of QDaedalus zenith camera system for determining vertical deflections – ETH Zurich
- Satellite Positioning of UAV – SZTAKI, ELTE

Department of Photogrammetry and Geoinformatics

www.fmt.bme.hu

Space Forum representative: Dr. Árpád Barsi, professor, head of department, barsi.arpad@epito.bme.hu

The Department has been actively using and researching the cartographic and other engineering application of remotely sensed images since the 1970's. For GIS system applications, these images can be regarded as essential sources of information both for altitude conditions of the Earth surface and land cover analysis.

It comes from the above that space remote sensing, processing of satellite images are an integral part of the Department's teaching and research work. Our key research areas are the development of digital image processing and automatic evaluation processes, and - in cooperation with partner researchers - agricultural, urban development and climatology

analyses. In education, we perform the theoretical and practical presentation of remote sensing methodologies and applications on BSc-MSc-PhD levels.

General faculty data:

- Education and R+D: 10 FTE lecturers (2 HAS professors, 7 PhD), 6 DSc students; Main areas: remote sensing, GIS, photogrammetry, Earth observation, intelligent transport systems, information technology (databases, artificial intelligence, graphics)
- Laboratories: Photogrammetry Lab
- Research Groups: Laser scanning group, Satellite-based positioning group

Space activities related information:

Fields of specialization by ESA terminology and classification:

- Spaceborn remote sensing [26.2]
- GNSS systems and ground-related Technologies [10.2]
- Processing Space Images [26.1]

Main product or/and service:

- Digital surfaces and displacement tests,
- WEB-based GIS databases and services,
- Image processing procedures

Main projects and partners:

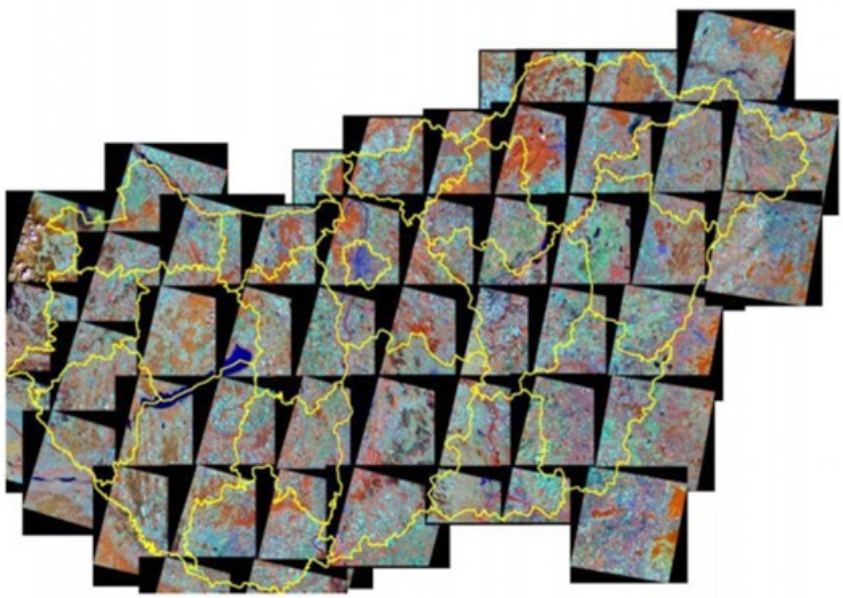
- Safe TRIP – bidirectional satellite communication to serve intelligent transport systems (EU FP7)
- GDACS – disaster management systems (DG JRC Ispra)

Major partners:

- EUTELSAT, DLR-Berlin, FÖMI

Planned projects:

- Satellite image services
- IfSAR (interferometric synthetic aperture radar) data services



Faculty of Mechanical Engineering

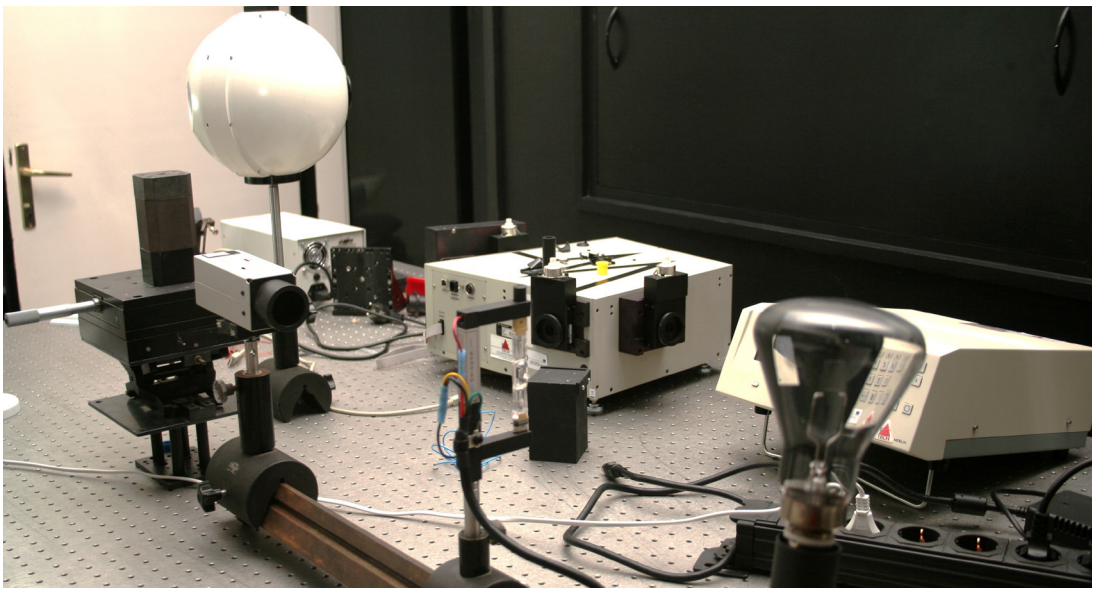
Department of Mechatronics, Optics and Engineering Informatics

www.mogi.bme.hu

Space Forum representative: Dr. Krisztián Samu, associate professor, deputy head of department, samuk@mogi.bme.hu

Key education and research areas of the Department are mechatronics, optics (with related human sight and imaging systems), and the technology of robotics, remote control and submicronial measurements.

Space activities have increased at the Department in recent years, mainly in the field of joint development and manufacturing – in cooperation with the German Max Planck institute – of space quality optical imaging tools, and in the area of development of NIR spectroscopic tools and electromechanical devices.



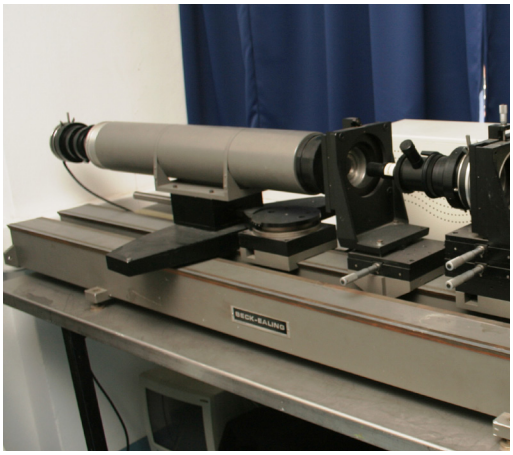
General faculty data:

- Education and R+D: 12 FTE lecturers (2 HAS professors, 7 PhD), 3 DSc students; Main areas: mechatronics, optics, imaging systems, human sight, robotics, remote control and submicronial measurement technology
- Laboratories: Mechatronics lab, Spectral optics lab, Vision systems lab, Measurement laboratory

Space activities related information:

Fields of specialization by ESA terminology and classification:

- Automation and Robotics components and Technologies [13.3]
- Optical system engineering, component technology and materials, equipment and instrument technology [16.1-3]
- Detector Technologies [17.2]
- Processing Space Images [26.1]



Educational activities:

- Optical systems design (BSc)

Main projects and partners:

- VEGA – Halley - Optical testing and alignment (1986)
- ROSETTA - optical testing, calibration, image processing, stray light reduction, Partner: Max Planck Institute for Solar Systems Research
- DAWN - Optical testing and calibration, image processing, stray light reduction, Partner: Max Planck Institute for Solar Systems Research
- OPTASENS - Combination and evaluation of different optical and tactile sensors and measuring methods for the analysis and global form-measurement on optical surfaces. (Hochschule für angewandte Wissenschaften Deggendorf, Institut für Werkzeugmaschinen und Betriebswissenschaften - TU München, Forwiss - Universität Passau, Budapest University of Technology and Economics MOGI)

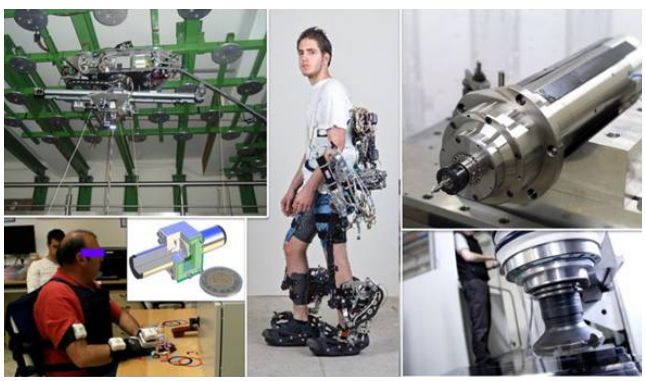
Department of Applied Mechanics

www.mm.bme.hu

Space Forum representative: Dr. Gábor Stépán, professor, head of department, stepan@mm.bme.hu

Space Forum contact: László Bencsik, assistant research fellow, bencsik@mm.bme.hu

Priority teaching and education topics of the Department include transient chaotic movements, stability and nonlinear vibrations of dynamical systems with time delay, multi-body dynamical systems and mechanisms, finite elastic-plastic deformations, finite element techniques, microcontinuum deformation, strength analysis of micro-electro-mechanical structures. Beyond domestic and European Union projects and industrial orders, the Department participates joint projects and exchange programs with Singapore, Chinese, Canadian and American partners.



The Department performs space research activities in the following areas: space vehicle navigation and orientation control (gyroscopic control), development of special robotic systems and special need mechanisms, planning of reconnaissance and landing units and planetary surface vehicles (rovers).

General faculty data:

- Education and R+D: 19 FTE lecturers (4 HAS professors, 12 PhD), 8 DSc students; Main areas: solid mechanics, nonlinear dynamics, vibration theory, the stability of movements
- Laboratories: Computer lab (ANSYS, ADAMS, Catia, MATLAB, Wolfram Mathematica); Robotics Lab; Machine tools vibrations and vibration measurement Lab
- Research Groups: HAS-BME Research Group on Dynamics of Machines and Vehicles

Space activities related information:

Fields of specialization by ESA terminology and classification:

- Space segment Guidance Navigation and Control [5.2]
- Automation & Robotics Systems [13.2]
- Mechanism core technologies [15.1]
- MEMS technologies [15.5]
- Planetary vehicles design [20.7]

Educational activities:

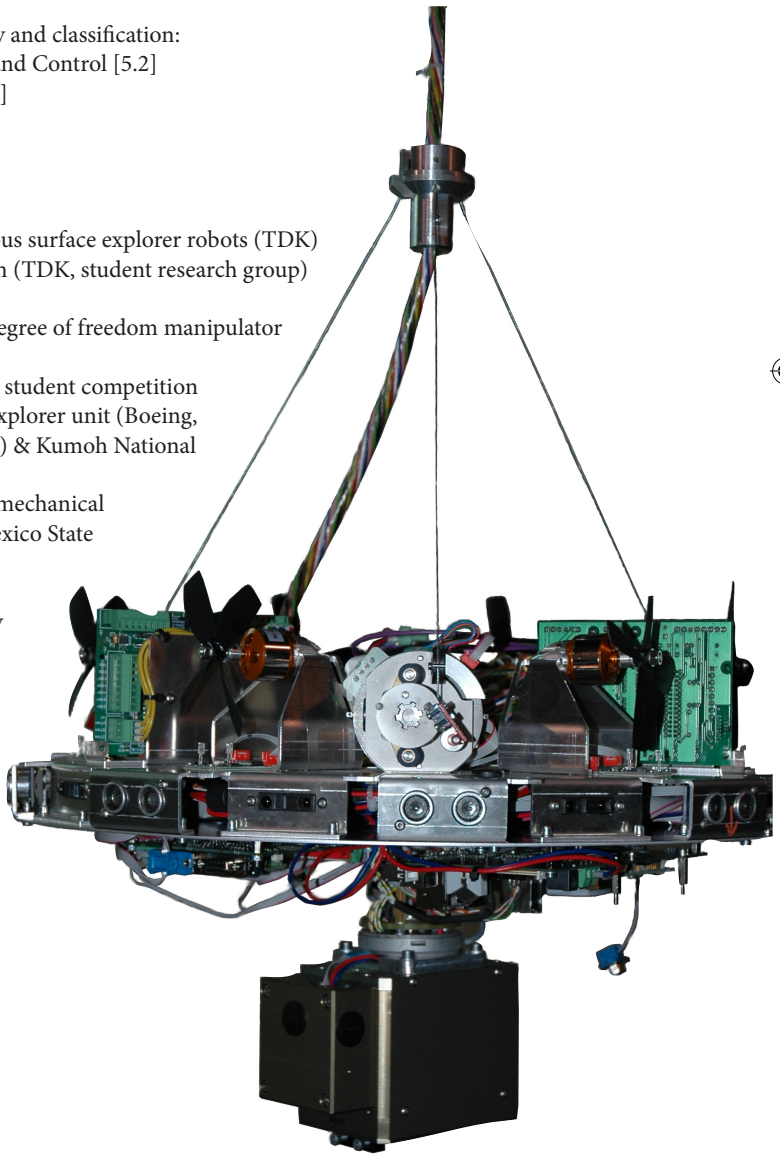
- Design and manufacture of autonomous surface explorer robots (TDK)
- Small satellites directional stabilization (TDK, student research group)

Main projects and partners:

- ACROBOTER – control of multiple degree of freedom manipulator (EU),
- RESCUEBOT – ARLISS international student competition to develop autonomous landing and explorer unit (Boeing, Georgia Institute of Technology (USA) & Kumoh National Institute of Technology (Korea)),
- NASA Student Exchange – analytical mechanical analysis of planetary motion (New Mexico State University).

Planned projects:

- In cooperation with McGill University and Canadian Space Agency

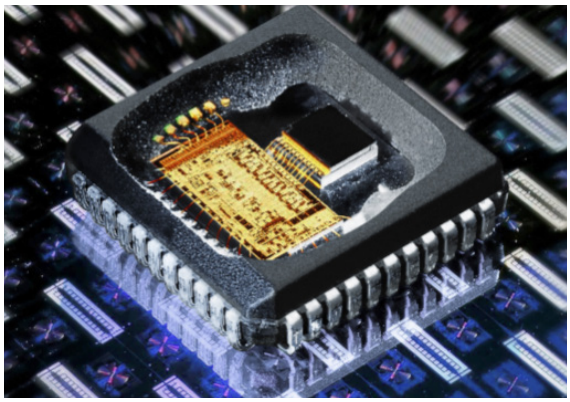


Faculty of Transportation Engineering and Vehicle Engineering

Department of Control for Transportation and Vehicle Systems

www.kjt.bme.hu
Space Forum representative: Dr. Péter Gáspár, head of department, professor, corresponding member of HAS, gaspar.peter@mail.bme.hu
Space Forum contact: Dr. Dóra Zsófia Meyer, senior lecturer, meyer.dora@mail.bme.hu

The education and research activity of the Department builds on the achievements of the domestic and international scientific community and further develops these in an innovative approach, in cooperation with HAS SZTAKI and a number of other professional platforms. Our key areas are control theory, vehicle mechatronics, safety–critical systems, automation, and driverless vehicles.



Competences at the Department currently include GNSS systems appearing in the areas of education and research, but our experiences cover applied missile control theory implementation, as well.

General faculty data:

- Education and R+D: 15 FTE lecturers (3 HAS professors, 15 PhD), 8 PhD students;
- Main areas: Component level design, Integrated control design, Vehicle control system to coordinate with the driver and infrastructure; Closed-loop simulation framework, Automatic incident detection, Development of security critical systems, Control engineering
- Laboratories: Control engineering and air control Lab, Vehicle mechatronics lab, Road traffic lab, Railways automation lab, Electrical engineering lab
-

Space activities related information:

Fields of specialization by ESA terminology and classification:

- On-Board Data Systems (TD1)
- Flight Dynamics and GNSS (TD10)
- Ground Station System and Networks (TD12)
- Quality, Dependability and Safety (TD25)

Educational activities:

- Automatic on-board control systems
- Intelligent Transport Systems (for ERASMUS students)
- Design of transport automation systems
- Air traffic control and communication systems I., II.
- Safety critical systems

Department of Aeronautics, Naval Architecture and Railway Vehicles

www.vrht.bme.hu

Space Forum representative: Dr. Dániel Rohács, associate professor, Head of Department, drohacs@vrht.bme.hu

Topics of education-research activities of the Department cover from traditional solutions for aerial, water and railway vehicles to the transportation tools (e.g. flying cars) of the future.
For decades, the education of space dynamics has been successfully conducted in the area of space research, but research in the areas of propulsion and flight dynamics, as well as autonomous aircraft are also significant.

General faculty data:

- Education and R+D: 22 FTE lecturers (2 HAS professors, 8 PhD), 4 DSc students; Main areas: Aero-Thermodynamics, Fluid Mechanics, Railway Vehicles, Naval Architecture, Aircraft Design
- Laboratories and knowledge centre: Aero-thermodynamics Laboratory, Flight Simulator Laboratory, CFD Computational Fluid Dynamics Laboratory, Small scale naval vessel test channel, UAS Unmanned Aerial Vehicles Laboratory

Space activities related information:

Fields of specialization by ESA terminology and classification:

- Flight Dynamics [10.1]
- Computational tools [18.1]
- Multi-Disciplinary tools [18.4]
- Processing Space Images [26.1]

Main product or/and service:

- Computational Fluid Dynamics and Finite Element Method (ANSYS) investigation, optimization

Educational activities:

- Space Dynamics (BSc / MSc)
- Special Propulsion (Rockets, Ramjets, Scramjets) (BSc)
- Aerodynamics and Flight Mechanics (hypersonic) (MSc)

Main projects and partners:

- Numeric methods in space dynamics - TU Delft, Cranfield University, TU München, Deutsche Luft- und Raumfahrt (DLR), NRL

Planned projects and partners:

- Numerical simulation of vehicle aerodynamics, flight mechanics
- Optimization of propulsion system elements

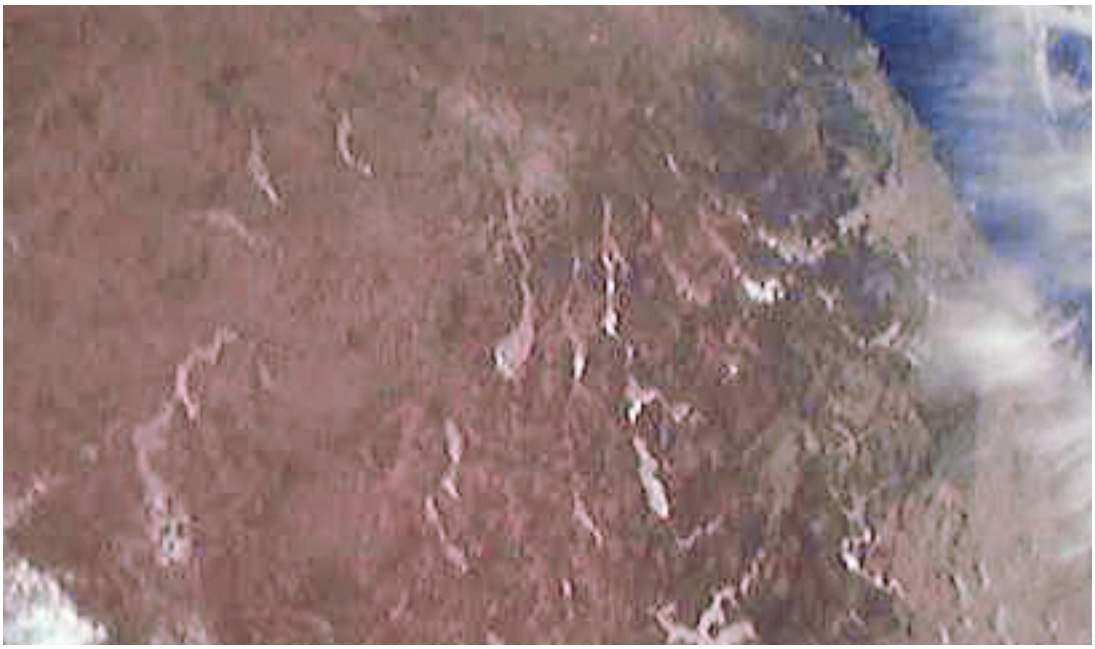
Faculty of Electrical Engineering and Informatics

Department of Electron Devices

www.eet.bme.hu

Space Forum representative: Dr. András Poppe, associate professor, Head of Department, adm@eet.bme.hu

As a unique range in Hungarian education-research, the activity of the Department covers areas from semiconductors through nanotechnology tools to the theory and practice of encapsulated systems, all these supported by computerized design systems.
In the area of space activities, the superior proportion of participation in the manufacturing of Masat-1, the first Hungarian produced satellite, is an outstanding achievement of the Department. Following the success of Masat-1, the Department is engaged in continuing the Masat program, building and testing (e.g. heat load) satellite subsystems.



The first Hungarian satellite image: Coastal East Africa - Masat-1 12.03.2012.

General faculty data:

- Education and R+D: 23 FTE lecturers (4 HAS professors, 14 PhD), 5 DSc students; Main areas: Micro-electromechanical systems (MEMS), Solar cell manufacturing, LED and OLED characterization, thermic analysis, space technologies
- Laboratories: 'Clean Room (class 6/7)' – satellite (CubeSat) assembly, IC and solar cell manufacture; Thermal analysis and tests Laboratory

Space activities related information:

Fields of specialization by ESA terminology and classification:

- Thermal Analysis Tools (21.5)
- Control electronics technologies [15.4]
- Microelectronics for digital and analogue applications [1.3]
- MEMS technologies [15.5]

Main product or/and service:

- Clean Room (class 6/7) services
- Small satellite (CubeSat) integration,
- Thermic analyses and tests for small satellites.

Main projects and objectives:

- Masat-1 integration and tests (BME own project)
- Masat-2 – smart on-board sensors, Si-based detectors,
- Electro-thermal analysis of small satellites (components as well),
- Design and characterization of microfluidic systems for space related applications,
- "Lab on a Chip" services for small satellites

Dressed to test - the Masat-1 team

BMEETT
ELEKTRONIKAI TECHNOLÓGIA TANSZÉK

Department of Electronics Technology

www.ett.bme.hu
Space Forum representative: Dr. Tamás Hurtony, Assistant Professor
hurtony@ett.bme.hu

The Faculty researches, develops and educates technologies that build electronics parts into systems and creates connections among them, especially in the specialization areas of production technology, quality and reliability theory, error detection and failure analysis, and production informatics that utilizes well in electronics manufacturing industry.

Space activities primarily encompass the areas of micro- and nano-electronic technologies and thermal analysis. Successes were achieved in ESA's educational programs.
To utilize faculty knowledge and to strengthen industrial relations, a spinoff company, EFI Services Ltd. was established.

General faculty data:

- Education and R+D: 17 FTE lecturers (2 HAS professors, 12 PhD), 2 DSc students; Main areas: electronics technologies and materials, quality assurance in microelectronics, reliability assessment, technology processes modelling
- Laboratories: 14 labs, including: Surface Mount Technology (SMT) Lab, Quality assurance and Failure analysis laboratory, Nanotechnologies laboratory, Laser technologies Laboratory, Climate Lab
- Spin-off company: EFI Services Ltd.

Space activities related information:

Fields of specialization by ESA terminology and classification:

- MEMS technologies (15.5)
- Structural design and verification methods and tools (20.1),
- Materials Processes (24.2)
- Thermal Analysis Tools (21.5)
- Heat Transport Technology (21.1)

Major projects:

- BEXUS 14-15, ESEO, REXUS - ESA educational projects
- STRATOS 2 – international university project
- Verification and the quality control of PCBs - SMT assembly line Thermal chamber, thermal shock, highly accelerated stress test

Major partners:

- ESA Education Office, SSC, SNSB, DLR
- AlmaSpace, TU Delft
- Space Dosimetry Research Group of Centre of Energy Research at the Hungarian Academy of Sciences (HAS)

Department of Networked Systems and Services

www.hit.bme.hu

Space Forum representative: Dr. László Bacsárdi
bacsardi@hit.bme.hu

Education and research topics of the Department encompass landed and mobile communication, from multimedia systems through network safety, acoustics and studio technology to quantum computing and communication, as well as business information systems. Space research activities include high-reliability sensors moving autonomously on remote celestial body surface under extreme conditions, scarce energy sources and lack of maintenance, as well as secure quantum-based satellite communication.

General Department information:

- Education and R&D: 40 FTE lecturers (6 MTA professors, 18 PhD), 9 DSc students
- Main areas: Information security, Mobile communication, Green (power saving) networks, Multimedia networks, Quantum communication, UAV
- Laboratories: ICT Systems Analysis, Planning and Development Laboratory, Mobile Communications and Quantum Technologies Laboratory, Crysys Data and System Security Laboratory, Laboratory of Acoustics and Studio Technology, Multimedia Networks and Services Laboratory, Financial Computing and Signal Processing Laboratory, Electronic Systems Planning Laboratory;

Space activities related information:

Fields of specialization by ESA terminology and classification:

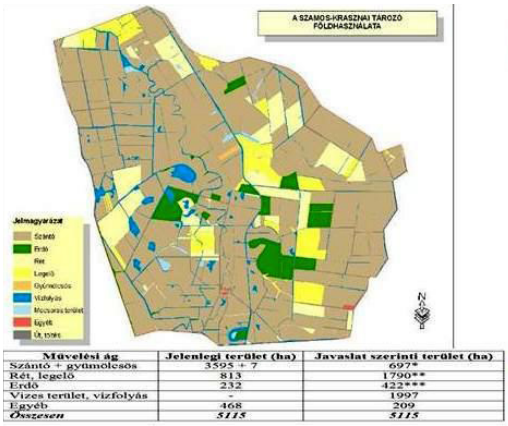
- Analysis, Design and Development of ICT Systems [1.3]
- Mobile/Wireless Communications [6.1]
- Quantum communications [6.1]
- GIS applications [26.3]

Main service:

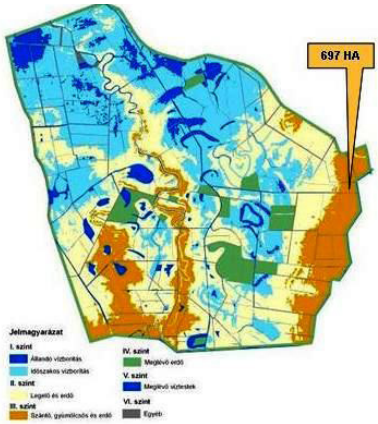
- Digital radio transmission and reception, signal processing
- Quantum communications procedures
- Network and cloud based services

Major project:

- Design of HW with high reliability for measurement data collection and wireless transmission



Művelési ág	Jelenlegi terület (ha)	Javaslat szerinti terület (ha)
Szántó + gyümölcsös	3595 + 7	697*
Rét, legelő	813	1790**
Erdő	232	422***
Vizes terület, vízfolyás	-	1997
Egyéb	468	209
Összesen	*5115*	*5115*



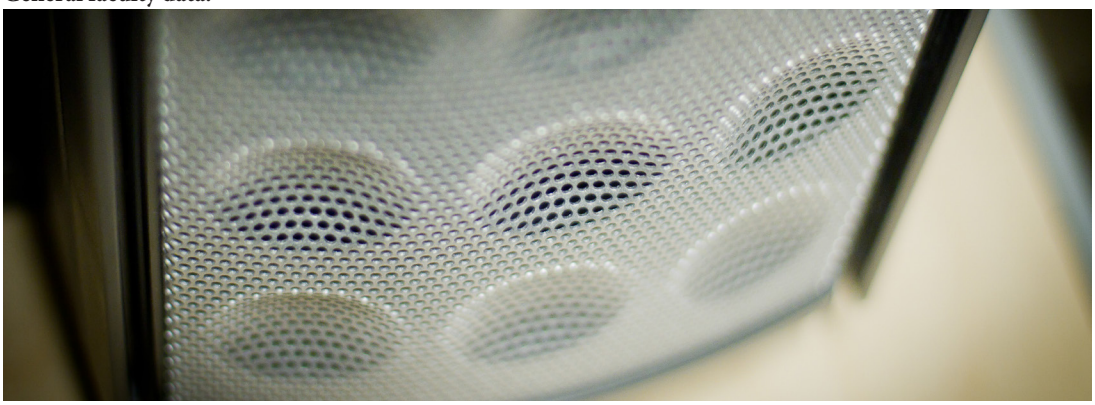
Department of Measurement and Information Systems

www.mit.bme.hu

Space Forum representative: Dr. Ákos Horváth research fellow, ahorvath@mit.bme.hu

Main education-research areas of the Department include embedded, intelligent and dependable information systems. Related to these, Department colleagues are internationally recognized experts and project participants in the design and implementation of software, equipment and systems that are necessary to perform tasks in the various areas (e.g. digital technology, medical device technology, artificial intelligence).
The Department participates space activities primarily via software technologies and secure systems operation areas.

General faculty data:



- Education and R+D: 50 FTE lecturers (6 HAS professors, 19 PhD), 18 DSc students; Main areas: embedded, intelligent and dependable systems, sensor networks, Fault Tolerant Systems
- Research Groups: Embedded Systems Research Group (Medical Devices Technology Lab, Digital Signal Processing Lab), Intelligent Systems Research Group, Fault Tolerant Systems Research Group

Space activities related information:

Fields of specialization by ESA terminology and classification:

- System Dependability and Safety [25.1]
- Advanced Software technologies [2.1]

Educational activities:

- Critical embedded systems (MSc),
- Cyberphysical systems (MSc)

Major projects:

- DIANA Distributed Equipment Independent Environment for Advanced Avionic Applications
- TTTech (Austria),
- Critical Software (Portugal),
- ResilTech srl (Italy)

Further partners:

- Embraer (Brazil), Itemis AG (Germany), Univ. of Coimbra, LAAS-CNRS and IRISA (France)

Department of Broadband Infocommunications and Electromagnetic Theory

www.hvt.bme.hu
Space Forum representative: Dr. Lajos Nagy, associate professor, Head of Department, nagy@mht.bme.hu
Further Space Forum representative: Dr. László Csurgai-Horváth, associate professor, csurgai@hvt.bme.hu

Space research activity has benne an organic part of the educational-research activity of the Department, which covers communications, telecommunications, remote sensing, optical and broadband communications and space technologies.

Space research at the Department has a history 40 years that saw equipment developed here entering space in more than 20 space missions. Our major partners are ESA, NASA, AMSAT and several domestic and international space technology companies. Major research-development directions: power supply/distribution systems of space vehicles, on-board telemetry transmitters and receivers, measurement-data collection, ground service equipment, ground receiver and control stations, space technology construction and thermic problems, and testing of millimetre wavelength radio wave propagation and application for communications.

Levente Dudás (Team Masat-1) installs the ground station antenna atop BME building 'E

Connecting to ESA's education al programs, our students can take part in a number of space research programs that include high altitude rocket and balloon experiments, and the development of on-board systems and experiment instrumentation of educational satellites. Following the recent successful completion of the Rosetta comet research program, the Department currently participates a wave propagation and a communication experiment in the ESA Alphasat program, and - also in the coordination of ESA, as well as ALMASpace - the development of the power distribution unit and a plasma diagnostic instrument of the ESEO small satellite. In a cooperation project, our Department takes part in the radar image processing of the ESA Sentinel-1 space probes.

General faculty data:

- Education and R+D: 38 FTE lecturers (5 HAS professors, 12 PhD), 4 DSc students; Main areas: communications and telecommunications, remote sensing, optical and broadband telecommunications and space technology
- Laboratories: 8 labs, including: Antennas, EMC and wave propagation Laboratory, Digital and Optical Communication Systems Laboratory, Electromagnetic Field Simulation Laboratory, Rohde & Schwarz Reference Laboratory, Space Technology Laboratory
- Research Groups: Electromagnetic Theory Group (neural networks, material forming with magnetic field, laser engraved codes, non-destructive materials testing and nanowire modelling), Broadband Communication Group (optical and microwave telecommunication, antennas and radio locators, satellite telecommunications and broadcasting).

Space activities related information:

Fields of specialization by ESA terminology and classification:

- Satellite power subsystems [3.1,3.4]
- Onboard data collection systems [1.1,1.2]
- RF transmitters and receivers up to Ka band (onboard and ground stations) [6.1,6.4,6.5]

Main product or/and service:

- Ground control station (radio transmitter-receiver station, small satellite ground control station)
- Satellite power supply systems (PSS)
- On-board data collection systems (ODCS)
- Scientific experiment payloads

Educational activities:

- Space technology theory (BSc)
- Space technology practice and lab (MSc)

Main projects and partners:

- Rexus/Bexus programme - ESA (continuous)
- ESEO programme – development of Power distribution system, Plasma diagnostic instrument – ESA, ALMASpace
- Alphasat – experimental communication in Ka and Q bands - ESA
- Sentinel-1A – radar image processing - ESA

Future ambitions:

- Participation in ESA educational programs - ESA
- Development of Fail-safe digital systems - BHE Bonn Hungary

Departmental instruments in space

The below table shows the operating space assets of BME VIK Broadband Infocommunications and Electromagnetic Theory Department that entered space in the last four decades:

Colours identify organisations implementing the 'Program':

Intercosmos AMSAT ESA NASA BME (magyar)

Felbocsátás	Program/Műhold neve	Tanszéki eszköz megnevezése
06. 19. 1976	INTERCOSMOS-15	Telemetry System PS, A/D Converter
09. 24. 1977	INTERCOSMOS-17	Telemetry System PS, Power Subsystem (PSS)
10. 24. 1978	INTERCOSMOS-18	PSS
02. 27. 1979	INTERCOSMOS-19	Onboard Data Collection System (ODCS) PSS
11. 01. 1979	INTERCOSMOS-20	ODCS PSS
05. 23. 1980	Phase III / A	PSS
02. 04. 1981	INTERCOSMOS-21	ODCS PSS
03. 02. 1983	Phase III / B AO-10	PSS
12. 15. 1984	VEGA-1 & 2	ODCS , TV-PS, PLAZMAG-PS, TÜNDE-PS
06. 15. 1988	Phase III / C AO-13	PSS
09. 28. 1989	INTERCOSMOS-24 ACTIVE	ODCS, SAS Experiment, SAS–TX
12. 18. 1991	INTERCOSMOS-25 APEX	ODCS
08. 02. 1995	INTERBOL-1 TAIL	ODCS
04. 23. 1996	MIR-PRIRODA	MOS-Obzor spectrometer PS
06. 02. 1998	STS-91	Alpha Magnetic Spectrometer PS
11. 16. 2000	Phase III / D "AO-40"	PSS, RF-MONITOR
03. 02. 2004	ROSETTA	Roland-PSS
13. 02. 2012	MASAT-1	RF, PSS
09. 25. 2012	"BioDos" Balloon exp.	Experiment + Data collection system
10. 08. 2013	"Daemon" Balloon exp.	Experiment + Data collection system
06. 06. 2013	"Gekko" Rocket experiment	Experiment + Data collection system
07. 25. 2013	AlphaSat TDP5 experiment	Beacon receiver
2016, TBD	ESEO	PDU, LMP experiment

Department of Telecommunications and Media Informatics

www.tmit.bme.hu

Space Forum representative: Dr. Klára Vicsi scientific advisor,
vicsi@tmit.bme.hu

The Department is involved in the research of convergent telecommunications, information and media technologies, and the university level education of related knowledge. Main areas are the technical issues of information value chain, content - transmission – visualization, the issues of managing and network availability of various contents by IT devices.

In the area of space research, the most significant activity is performed by the Speech Acoustics Group of the Department in the COALA program. The object of the experiment is to work out and test methods for the continuous monitoring of psychological and neuro-physiological effects of isolation. The experiment organized by ESA is underway at the Concordia South Pole research station operated in French and Italian cooperation.
Our Department performs psychological status monitoring by computerized analysis of language phenomena.

General faculty data:

- Education and R+D: 36 FTE lecturers (6 HAS professors, 30 PhD), 21 DSc students; Main areas: infocommunications, Internet applications and services, Big Data, data mining, Smart City
- Research and development: Infocommunications systems, Media Information systems
- Laboratories: 6 labs, among them High Speed Networks Laboratory, Data Science and Content Technologies Laboratory, Speech technologies and Smart Interactions Laboratory)

Space activities related information:

Fields of specialization by ESA terminology and classification:

- Next gen. telecomm. systems [6.1]
- Data/media mining [14.4]
- Media content recognition [12.2]
- Decision support [2.4]
- Speech technology [14.3]

Main project and professional target area:

- COALA-Phonetics - Psychological Status Monitoring by Computerised Analysis of Language phenomena – ESA, Concordia Antarctic Station, Institute of Cognitive Neuroscience and Psychology at HAS
- Spontaneous crew talks detection with advanced speech technology algorithms for speaker diarization (separation of acoustic streams of individual speakers).

Firms spun-off from BME Space Activities

The spin-offs bound to BME usually operate on a special area of expertise and perform high value-added activity. Two of these does significant space activity: the activities of C3S company related to the Masat program are 100 per cent, while only a smaller proportion of the large scale volume orders of EFI Services Ltd. are related to space.

C3S Electronics Development LLC

COMPLEX SYSTEMS & SMALL SATELLITES

A company established by young colleagues at the Department of Electron Devices of BME Faculty of Electrical Engineering and Informatics playing significant role in the success of and related to the continuation of the Masat-1. Major areas of activity: 1 unit (1U) CubeSat platforms, Masat-1 mission flight results, One-point fault tolerance of critical systems, Redundant OBC, COM and EPS equipment.
The company has already been performing ESA-finance activity, primarily in the areas of telemetry transceiver, on-board computer and configurable structure.

EFI-labs (Electronic Failure Investigation)

The foundation of EFI Services Ltd. was decided by the colleagues of the Failure Analysis Laboratory at the Department of Electronics Technology in 2011. Due to strong scientific and industrial relations, and instrumentation, soon the company became market leader in the area of failure analysis and validation of electronics products. Because of the special and individual know-how, the majority of multinational electronics companies are among their Customers primarily but not exclusively from automotive field.

Based on their experiences in the production technology of safety critical systems and testing they have participated several space related researches and projects. They cooperate with MTA Centre of Energy Research Dosimetry Laboratory in high altitude balloon and rocket experiments, and in the development of student satellite ESEO.

V. THE ORGANISATION OPERATING BME SPACE FORUM - EIT

The Federated Innovation and Knowledge Centre (EIT) was created at the Faculty of Electrical Engineering and Informatics of Budapest University of Technology and Economics in 2009 to stimulate the research and development activity and to assist the exploitation of research achievements at the Faculty. To achieve these objectives, EIT basically operates as an R&D service centre. Its key tasks include initiating cooperation with other Faculties of the University, with other tertiary institutions, industrial companies and international organisations; furthermore, supporting the successful participation of Faculty Departments and Research Groups in domestic and international tenders, and in industrial RDI activities with project preparation and project management services. Organisationally, VIK Knowledge Centres are under EIT. EIT has two locations outside Budapest: the Debrecen and the Szeged Research Groups.

Professional coordination role of EIT

EIT performs Departmental and University level coordination activity in various areas, where it evaluates the results, research and networking potential of the professional workshops planning to cooperate in then given area; assist forming joint objectives, and the creation of tender and business projects. Major professional areas: Space activities, Smart City, Danube Region Strategy programs (VIK), Future Internet (BME, National platform), Future ICT, and EU KIC Digital.

Project management activity of EIT

Since 2010, EIT has provided project management for 12 larger projects (6 of these have been successfully completed), the managed funding exceeds HUF 6 billion. In the Research University project (HUF2.8 billion funding), EIT managed 4,000 contracts of 1,500 researchers, the usual number of researchers in the other projects is around 50-150.

EIT dissemination and result utilization activities

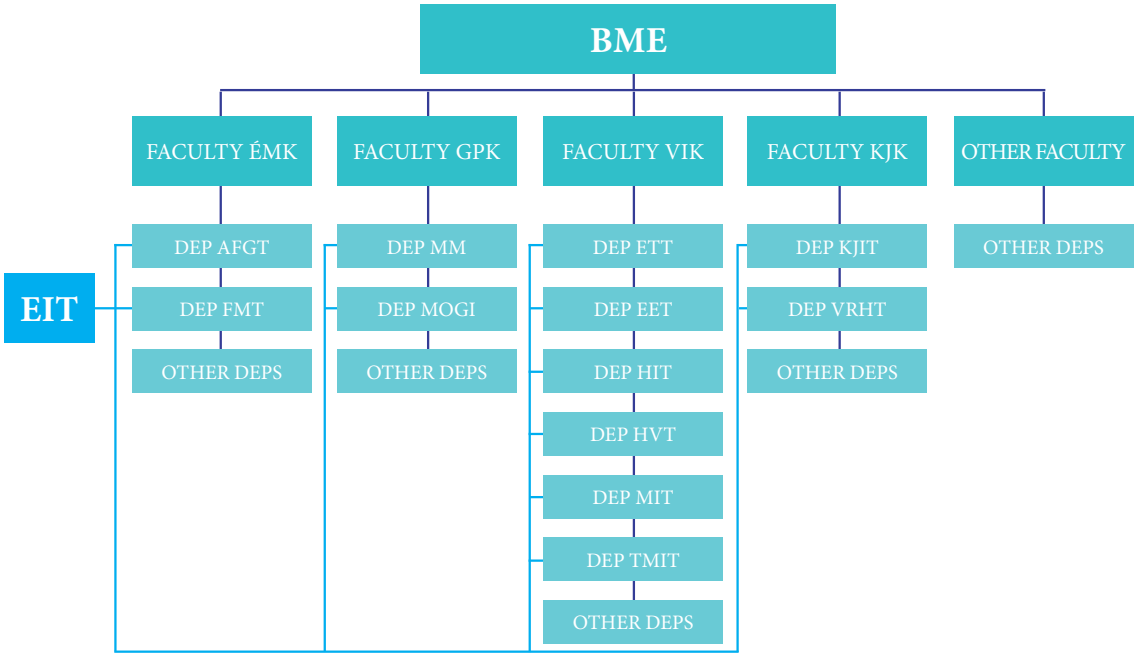
EIT assists the patent and industrial utilization of project results, the establishment of spin-offs. Besides these, the H-SPACE international space conference series is outstanding, just as the leading roles played in Future Internet National Platform and Smart City Section.

The coordination role of EIT in BME space activities

At the Faculties and Departments of the Budapest University of Technology and Economics various research workshops perform space research related activities in several areas, from theory research to the practical manufacture of different on-board systems. Recognizing the lucrative opportunities in harmonizing the work of the numerous individually operating research groups, Technical University leadership regarded it expedient that the various space activities are joined under EIT as an umbrella organization is capable of uniformly representing the fragmented organisation before BME's current and potential partners, and is capable of initiating cooperations that could significantly contribute to the more efficient utilization of the university research capacity. To perform this task, EIT operates a Technical University space activity coordination forum.

In harmony with the above, in the course of the ESA membership process evaluation, BME space activity was introduced to ESA professionals in the coordination of EIT in a unified structure.

SPACE FORUM – the coordinatory activity of EIT



VI. BME SPACE FORUM EVENTS

Space Forum sessions

A fundamental objective of the BME Space Forum to promote the sharing of information, results related to intra-university space activities, and to make domestic and international space research organisations known among Space Forum members. Therefore, EIT invites significant space research related organisations to Space Forum sessions in order to get introduced to each other and for networking purposes, which may create the basis of future successful project cooperations.

Jean-Jacques Dordain ESA CEO and Kálmán Kovács president of Space Forum at the preparatory meeting of the accession of Hungary (2014)

BME EIT operates two space forums:

- the BME EIT Space Coordination Forum, the 'internal forum' where representatives of member BME Departments and Research Groups, involved colleagues and invited guests participate,
- The 'open forum', that is the BME Space Forum events that are open to all.

Dean of BME VIK László Vajta greets the participants of BME Space Forum in the Neumann Room (2014)

The two fora are held alternately, in accordance to actual issues and needs, usually by every one or two months.

At the Space Forum sessions, joint strategy and objectives are regularly discussed, which are then jointly represented at domestic and international meetings.

Conferences

BME Space Forum (the open session) is often organized as a conference.
At the occasion of the February 2013, then at the February 2014 session, we held conference about the first, then the second successful year of operation of the first Hungarian satellite MAsat-1, built at BME. We welcomed those Hungarian radio amateur enthusiasts who received and transmitted the most Masat-1 signal to the BME ground station.

Rector of BME János Józsa opens H-SPACE 2016,
the 2nd International Conference on Research, Technology and Education of Space

The gala session and technical conference in 2015 organized jointly with the Hungarian Space Office (NFM MŰI) on the occasion of the 35th anniversary of the first Hungarian space flight was a unique opportunity, where Bertalan Farkas and distinguished Hungarian researchers held presentations, and the audience had the chance to meet astronauts from 6 countries.

Our annually held – organized jointly with MANT – conference:

- Space Day – Technical day of Hungarian space research for decades, the organization of which was taken up by BME Space Forum in recent years.
- H-SPACE – BME Space Forum, commemorating the successful mission of the first Hungarian satellite built at the Technical University, initiated this annually held international conference series on the topics of space research, space technology and education in February 2015 (see page 44.)

H-SPACE conference series

The publication of H-SPACE 2015 conference, that contains abstract of the presentation as well (in English and Hungarian)

The Federated Innovation and Knowledge Centre (EIT), within the Faculty of Electrical Engineering and Informatics at the Budapest University of Technology and Economics (BME) – in cooperation with the Hungarian Astronautical Society - organizes an international conference on space research under the name of International Conference on Research, Technology and Education of Space (H-SPACE).

The organization of the conference comes at a time of growing opportunities arising from ESA recently granting membership to Hungary and the need for a joint presentation of space activities pursued at BME. The selection of the date of the event pays tribute to the successful deployment to orbit and mission of the first Hungarian satellite.

The agenda of the conference addresses scientific, technological and educational aspects of space research and space activities. The conference is open to both international and local professionals. It also provides an opportunity to showcase Hungarian scientific, technological, educational and outreach activities, related to space. The conference consists of three main sections, related to Science and Technology, followed by Education and Outreach.

The first conference was held on February 13, 2015. Our keynote speaker was Tibor S. Balint (NASA JPL).

The second conference was held on February 25-26, 2016. Keynote speakers: Franco Ongaro (Director of Technical and Quality Management (D/TEC), and Head of ESTEC in Noordwijk, the Netherlands), Tibor Balint (Royal College of Art, London), Richard Jones (Flow Chemistry Society), Rainer Sandau (International Academy of Astronautics). After the conference, the Space Generation Advisory Council (SGAC) organized its first European Space Generation Workshop.

The 3rd International Conference on Research, Technology and Education of Space' will be held on February 9-10, 2017.

H-SPACE 2017
3rd INTERNATIONAL CONFERENCE
ON RESEARCH, TECHNOLOGY AND EDUCATION OF SPACE

VII. MAJOR ESA PECS PROJECTS:

Name of project	Short summary of the programme (participating department)	Status (completed/ ongoing)	Amount awarded (EUR)
TROPSY	Assessment techniques of tropospheric effects for local augmentation systems of global navigation satellite systems (ÉMK AFGT)	completed	31,472
INTRO	Integrity analysis and modelling of troposphere models used for global navigation satellite systems (ÉMK AFGT)	ongoing	129,706
Computerized Analysis of Language phenomena – Phonetic Analysis (COALA-Phonetics)	BME's research task is the Psychological Status Monitoring by Computerised Analysis of Language phenomena (COALA-phonetics). This is part of a large ESA Program: For Medical, Physiological and Psychological Research Using Concordia Antarctic Station as Human Exploration Analogue (AO-13-Concordia). (VIK TMIT)	ongoing	149,940
BEXUS 14	Stratospheric balloon experiment for university students. BME was involved in the development of the radiometric measurement platform, which performed a successful mission onboard of BEXUS 14 balloon. Project leader MTA-EK Space Dosimetry lab. (VIK ETT)	completed	no funds awarded/ received for this work
REXUS 17	Stratospheric rocket experiment for university students. Under the supervision of MTA-EK, BME participated in the development and testing of a cosmic radiation measurement device for sounding rocket experiment. The mission was successful. (VIK ETT)	completed	no funds awarded/ received for this work
ESEO	BME supports the MTA-EK Space Dosimetry lab in the development and testing of silicon based radiometric measurement device for satellite application. The appliance is planned to measure cosmic radiation on LEO trajectory onboard of ESEO Student Satellite. (VIK ETT)	ongoing	no funds awarded/ received for this work
Participation in the AlphaSat Technology Demonstration Payload Experiment ESA/4000109841	Beacon receiver development for Alphasat propagation experiment. (VIK HVT)	completed	98,000
Ground Station for the Alphasat Q/V Band Communications Experiment, ESA/4000114582	Satellite communication experiment in Q/V band. (VIK HVT)	ongoing	198,000
ESEO ESA/98107	Power subsystem and Langmuir-probe experiment development for the ESEO satellite. (VIK HVT)	ongoing	310,000