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László Bacsárdi and Kálmán Kovács

MANT 2024

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Welcome from the Organizing Committee

Welcome to the 8th edition of our H-SPACE conference series!

We are happy to welcome you at the 8th International Conference on Research, Technology and Education of Space. Special welcome to those participants who are joining the H-SPACE conference for the first time.

The event is organized by the Faculty of Electrical Engineering and Informatics at the Budapest University of Technology and Economics (BME) – in cooperation with the Hungarian Astronautical Society (MANT), which is the oldest space association in Hungary. The organization of the conference series started in 2015, 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 for the first occasion of our conference series was a tribute to the successful mission of the first Hungarian satellite, Masat-1, launched on February 13, 2012.

A lot has happened in space since our last conference in 2022. We would like to highlight a few Hungarian achievements.

Our companies and research institutions are actively participating in different European and international space programs. The recently published Hungarian Space Kaleidoscope 2023/2024 contains more than 60 companies, research institutions and university departments working in the Hungarian space sector.

Our national astronaut program – the Hungarian to Orbit (HUNOR) – selected four astronaut candidates and one of them will conduct experiments on the International Space Station with Axiom Space.

Researchers from the HUN-REN Astronomy and Earth Science Research Center (HUN-REN CSFK) are participating in the PRIDE (Planetary Radio Interferometry and Doppler Experiment) experiment of the JUICE (Jupiter Icy Moons Explorer) program, one of the most important interplanetary missions of the European Space Agency (ESA). The spacecraft was launched in April 2023 towards the largest giant planet in our solar system, Jupiter.

The newest satellite of the Budapest University of Technology and Economics (BME) has been launched in June 2023. The MRC-100 is named in honor of the university's radio club (Műegyetemi Rádió Club) 100th anniversary in 2024. MRC-100 is a 5*5*15 cm size PocketQube satellite. One of its tasks is to measure electrosmog, but it also carries instruments for experiments of teams from University of Debrecen, Széchenyi István University (Győr) and the University of Szeged.

In September 2022, BME started the first class of its space engineering MSc program, and the first students will graduate this June.

In line with the objectives of Hungary's Space Strategy adopted by the Hungarian government in 2021, 17 Hungarian universities have entered into a consortium agreement to launch 4 separated but coordinated space related postgraduate training program under the national UniSpace education program. These includes Space Technology Specialist, Innovative Nutrition and Health Sciences Specialist, Space Science Specialist and Space Policy Advisor Training Program. The 3-semester program started in September 2022 and the first class graduated this February.

In this Aprill, Iván Almár, honorary president of the Hungarian Astronautical Society became the first Hungarian who has been recognized with the IAF Hall of Fame award by the International Astronautical Federation.

The topic of this year's H-SPACE conference is "Cooperation in the space sector". The agenda of the conference addresses scientific, technological, and educational issues of space research and space activities. The conference is open for both local and international professionals and provides an opportunity to showcase Hungarian scientific, technological, educational and outreach activities related to space.

The Organizing Committee has internationally recognized members: Dr. Balázs Bartóki-Gönczy, Dr. Tibor Bálint, Ferenc Horvai, Prof. János Lichtenberger, Dr. Lóránt Földváry, Prof. László Pap, Dr. Andrea Pődör, Prof. Gábor Stépán, Dr. Szabolcs Rózsa. We are grateful for their contributions to the success of the conference.

On the first day, we will host in person presentations which will be live streamed for online participants. The second day we will host online presentations (oral and posters). The conference will have four main sections: a Plenary with invited presentations. Session Science and Technology I-II and Session Education and Outreach.

This book contains the abstracts of the presentations. In the coming months, selected full papers will be published in the official conference proceedings which will be available on our website, http://space.bme.hu . On this website, the proceedings and selected papers of the previous issues can be found as well.

We hope you will enjoy your time in Budapest and the H-SPACE conference could help to learn about new scientific and technological results and strengthen your network. We hope to welcome you again at the next edition of H-SPACE, at the H-SPACE 2026, which will be organized in the spring of 2026.

Dr. László Bacsárdi
co-chair
Vice President of MANT

Dr. Kálmán Kovács
co-chair
President of MANT

Final Conference Program

In this program, the name and affiliation of the presenter author is listed.
For detailed information about authors and their affiliations, see the abstracts.

April 25, Thursday

Location: Building I, ground floor, IB.027
Budapest University of Technology and Economics
Magyar tudósok krt. 2., Budapest, H-1117

The first day will be live streamed for online participants.

Master of the ceremony: László Bacsárdi

14:00 Opening ceremony
Orsolya Ferencz, Ministerial Commissioner, Ministry of Foreign Affairs and Trade
Hassan Charaf, Dean, Faculty of Electrical Engineering and Informatics, BME
Kálmán Kovács, President, Hungarian Astronautical Society

14:20 Keynote talk
Small satellites - Finnish road from education to science and business
Jaan Praks, Aalto University, Finland

14:50 Keynote talk
PocketQubes: A New Frontier in Space Education
Caius Reza, Alba Orbital, Glasgow, United Kingdom

15:20 Poster highlight talks

16:00 Coffee break and poster session

Session Chair: Lóránt Földváry

16:45-18:45: Technical presentations – Session Science and Technology I

The future of satellite frequency usage satellite agenda items for WRC-23 and WRC-27
Péter Vári, National Media and Infocommunication Authority, Budapest, Hungary

Hungarian participation in the Comet Interceptor mission
Ákos Kereszturi, Konkoly Observatory, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary

Radio interferometric observations of the JUICE spacecraft en route to Jupiter
Judit Fogasy, Konkoly Observatory, HUN-REN Research Centre for Astronomy and Earth Sciences, Hungary

SPECTRE, a self-deploying bi-stable composite tape-spring mechanism for future nanosatellite missions
Sara Sanchis Climent, KTH, Royal Institute of Technology, Stockholm, Sweden

FOTEC's Testing and Qualification Capabilities for Small Satellites
Laura Bettiol, FOTEC Forschungs-und Technologietransfer GmbH, Wiener Neustadt, Austria

Thermal performance characterization of battery insulation on ATL-1 picosatellite mission
Zoltán Tóth, H-ION Research, Development and Innovation Ltd., Budapest, Hungary

Fast and flexible developments of digital logics: applications in the first Hungarian astrophysical satellite, GRBAlpha
András Pál, Konkoly Observatory, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary

Testing remote clock synchronization with GPSDO-s and a free space laser communication system
Máté Galambos, Budapest University of Technology and Economics, Hungary

18:45: Wrap up of the first day - *László Bacsárdi*

April 26, Friday

Location: online
Registered participants will receive the link for online participation.

Session Chair: Kálmán Kovács

9:00: Welcome of the second day

9:05: Highlight talk

Hungarian participation in the European Space Agency's JUICE (Jupiter Icy Moons Explorer) mission
Pál Gábor Vizi, HUN-REN Centre for Energy Research, Budapest, Hungary

9:30-12:00: Technical presentations – Session Science and Technology II

The Space Weather Monitoring and Data Service at HUN-REN Institute of Earth Physics and Space Science (EPSS)
Árpád Kis, HUN-REN Institute of Earth Physics and Space Science, Sopron, Hungary

Reproduction of the Lunar Radar experiment failure and success during implementation
Péter Pataki, Széchenyi István University, Győr, Hungary

Review of Lagrangian Points and Scope of Stationary Satellites
Joel Eldo, Amity University Dubai, UAE

Space Debris: Overview and Mitigation Strategies
Mohammed Vaseeq H. Khan, Amity University Dubai, UAE

The Expected Impact of SysML v2 to Cooperation in the Space Sector
Vince Molnár, Budapest University of Technology and Economics, Hungary

EON: The first year of the re-started optical tracking of artificial satellites at Baja
Tibor Hegedüs, Baja Observatory of the University of Szeged, Baja, Hungary

Study of Microwave Electrothermal Propulsion System
Rhea Ranjit Mulki, University of Southern California, Los Angeles, USA

Aether S, a Student-Developed Supersonic Sounding Rocket as a Carrier for Scientific Payloads
András Illyés, BME Aerospace Team, Hungary

Assessing Natural and Anthropogenic Ground Deformation Using Sentinel-1 PSI in the Region of Cluj-Napoca, Romania
Péter Farkas, Geo-Sentinel Kft., Hungary

11:45: Highlight talk

Innovation at the European Union Agency for Space Programme
Christina Giannopapa, European Union Agency for Space Programme (EUSPA)

12:05 Lunch break

Session Chair: Dorottya Milánkovich

13:15: Opening of the afternoon session

13:20: Invited talk

Educational and incubation practices in the emerging space - an association perspective
István Arnócz, Hungarian Astronautical Society, Budapest, Hungary

13:40-15:00: Presentations – Session Education and Outreach

Assessment of Cooperation in the Space Sector
Don Koulaouzos, Skytrek Ltd, London, United Kingdom

Engineering and Management of Space Systems (EMSS) - an International Joint Master's Double-Degree Programme
Jasminka Matevska, City University of Aplied Sciences, Bremen, Germany

Space Science in the Classroom
Annamária Komáromi, Balassi Bálint Eight Grade Secondary Grammar School, Hungary

The educational and awareness-raising activities of BME Suborbitals
Bence Csaba Kováts, Budapest University of Technology and Economics, Hungary

Introduction of space science in higher education: space science in BSc engineering
Szilárd Takács, Széchenyi István University, Győr, Hungary

15:00 Closing remarks

April 25 – Poster presentations

Probing Low Mass Neutrinos in Gravitational Wave Environments: A Novel Approach with Feynman Diagrams & Applications In Space Sciences
Panta Sasikanth, N.B.K.R Institute of Science and Technology, Nellore, India

Fast Routing in Entanglement-based Satellite Networks
András Mihály, Budapest University of Technology and Economics, Hungary

Circular food production in space environment – Insect protein production by supplementing green biomass in feed
Orsolya Meier, University of Debrecen, Debrecen, Hungary

Thermal properties of heterogeneous materials using extended heat equations
Anna Fehér, Budapest University of Technology and Economics, Hungary

Spectral instrument optimization for asteroid missions by space weathering simulation
Ákos Kereszturi, Konkoly Observatory, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary

RTK GNSS monitoring under high ionospheric activity
Bence Takács, Budapest University of Technology and Economics, Hungary

High-redshift radio quasars from ground and space
Máté Kreizinger, Eötvös Loránd University, Budapest, Hungary

Investigation of Glass-foam systems as Insulation materials for Space applications
Kinga Tamási, Ludovika University of Public Service, Budapest, Hungary

MAUVE – UV-Vis Spectroscopy of Stars by a 16U CubeSat
Gergő Mezőhegyi, C3S Electronics Development LLC., Budapest, Hungary

Comprehensive analysis of the ionospheric response to the largest geomagnetic storms from solar cycle 24 over Europe
Kitti A. Berényi, ELKH-ELTE Space Research Group, Budapest, Hungary

Proposal of a Hybrid CSNN-PSO Algorithm For Improving Space Debris Identification and Classification
Hanga Katreiner, Technische Universität Berlin, Berlin, Germany

Transparent Planetary Polished Thin Section Rock Sample Maker for Hungarian Hunveyor Educational Space Probe
Pál Gábor Vizi, HUN-REN Centre for Energy Research, Budapest, Hungary

Remote sensing of hydrological parameters by GNSS reflectometry
János Gaskó, Budapest University of Technology and Economics, Hungary

Development of GIS software based spatial ejecta estimation algorithm to support the NASA-ESA Artemis program
Richárd Krisztián Tomka, Konkoly Observatory, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary

Distributed Intelligence and Sensor Network in the Power Systems of MRC-100 Satellite
Péter Püspöki, Budapest University of Technology and Economics, Hungary

The Hungarian contribution to the T-FORS Horizon Europe project
Kitti A. Berényi, ELKH-ELTE Space Research Group, Budapest, Hungary

Application of Rain Sensor Device in Reliable Attenuation Statistics Calculations on Satellite and Terrestrial Radio Connections
László Csurgai-Horváth Budapest University of Technology and Economics, Hungary

Simulating Solar Particle Events: New advances in Proton irradiation techniques for biological samples at ATOMKI
Máté Szarka, HUN-REN Institute for Nuclear Research

Radiation characteristics measurement on a sounding rocket near the Kármán line
Bence Csaba Kováts, Budapest University of Technology and Economics, Hungary

CubeSim - A Simulation Framework for small Satellites
Bernhard Seifert, FOTEC Forschungs- und Technologietransfer GmbH, Wiener Neustadt, Austria

An event-based hydrological model for arid/hyper-arid and Martian environments
Vilmos Steinmann, Konkoly Observatory, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary

The role of entanglement in the development of satellite-based quantum internet
Kitti Oláh, Budapest University of Technology and Economics, Hungary

Preliminary design of payload for sounding rockets
Ádám Dobay, Budapest University of Technology and Economics, Hungary

Fuel consumption optimization for suborbital solid fuelled rocket engines
Gergely Márk Tölgyesi, Budapest University of Technology and Economics, Hungary

Numerical investigation of the spanwise mean velocity gradient method for transition delay
Márton Kulcsár, Budapest University of Technology and Economics, Hungary

Radiocommunications with the International Space Station (ISS)
Katherine Cazco, Széchenyi István University, Győr, Hungary

Class-Space: From the classroom to space!
Anna Pántya, HUN-REN Centre for Energy Research, Budapest, Hungary

The perspective of launch capacity and strategic sovereignty of European space activity
Bence Kertész, Ludovika University of Public Service, Budapest, Hungary

Space Awareness: latest fireball events and the independent allsky7/8 network of Hungary
Tibor Hegedüs, Baja Observatory of the University of Szeged, Baja, Hungary

Data processing from weather satellites
Benedikta Rédling, Széchenyi István University, Győr, Hungary

The first module in space by SZESAT
Barnabás Zoltán Baranyai, Széchenyi István University, Győr, Hungary

Daytime Optical Background Radiation
Dóra Borbála Kovács, Budapest University of Technology and Economics, Hungary

Abstracts

Aether S, a Student-Developed Supersonic Sounding Rocket as a Carrier for Scientific Payloads

András Illyés[1,2], Barbara Matécsa[1,3], Ádám Oláh[1,4], Katalin Princz[1], András Szilágyi-Sándor[1,3]

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Sounding rockets are single- or multistage rockets that usually use solid propellant rocket motors and are used to launch scientific experiments into the atmosphere. The BME Aerospace Team was established to build such rockets and also to pave the way for future generations of rocketeers.

In 2023, BME Aerospace Team, as an innovative student rocketry team, reached an altitude of 7,000 meters with its Aether S sounding rocket. The Aether S achieved a maximum speed of 750 m/s (Mach 2.2) during its ascent. The Team participated in the European Rocketry Challenge (EuRoC) in Portugal in late 2022 with Aether S, where the rocket had to comply with the competition's guidelines beyond the team's own design requirements. In our work we are going to dive into the development of Aether S, especially its scientific payloads and flight simulations.

Two scientific experiments have been carried out by Aether S: a biomedical experiment and an atmospheric physics measurement. The two scientific payloads were placed in the payload bay, between the motor bay and the avionics bay of the rocket. These experiments were carried out with the Semmelweis University and the Eötvös Loránd University Space Research Group.

During the biomedical experiment MG-63 cells were used, which are laboratory-grown replacements to human bone tissue cells, more precisely osteoblast cells. The aim of the experiment was to analyze the vitality of these cells. These cells were suitable for this experiment, as they are particularly sensitive to mechanical effects, so it was appropriate to measure the biological effects of physical factors occurring during flight.

The aim of the atmospheric physics experiment was to verify the plane wave approximation near the lower boundary condition (i.e. in the region close to the surface) of the Earth-Ionosphere Waveguide (EIWG). By performing continuous measurements up to the rocket's apogee, information was obtained in the most distorted, thus the most important range of the EIWG.

Other than the commercially available softwares, two open-source softwares were used to simulate the flight of Aether S: OpenRocket and RocketPy. The use of multiple softwares provides the possibility of cross-validation and the use of open-source softwares ensures that the shortcomings of the available softwares can be supplemented with some proprietary codes.

In this work we are going to describe the BME Aerospace Team, the development, construction and flight performance of the Aether S, and the scientific experiments it has carried out.

An event-based hydrological model for arid/hyper-arid and Martian environments

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Understanding hydrological processes in extreme environments, such as arid and semi-arid areas, is crucial for studying the evolution of Martian valley systems as part of planetary exploration. The aim of this research is to develop a raster-based hydrological model for this type of environment, capable of estimating the steady-state flow characteristics of the area under study. The model has been tested on the Zafit watershed, which is a sub-basin of the Zin basin in the Negev desert, Israel. This part of the Negev desert can be a potential Mars analogue field due to its low vegetation cover and arid climate.

The model, which is built into and runs under the open source geoinformatics software QGIS, uses the kinematic flow-based flow accumulation tool and surface-related environmental variables such as slope and aspect, as well as precipitation data for the study area. In addition, the model is able to estimate surface erosion and accumulation, which are crucial factors influencing landscape evolution and sediment transport processes. By taking into account the dynamics of erosion and deposition, the model is able to estimate the relative position of the deposited material and the possible sources of erosion. The erosion-deposition estimation is based on the SIMWE model, which is a process-based (physical) model for determining linear erosion. In the future development of the model, we would like to simulate the flow conditions under unsteady conditions and complement it with a long-term surface evolution model to simulate the long-term surface changes. By studying the long-term surface evolution, it will be possible to determine how long it takes for the water to erode and form the current topography of the area. Developing the model in this way can help us to understand the morphology, evolution and surface variability of the former wet Martian valleys.

Application of Rain Sensor Device in Reliable Attenuation Statistics Calculations on Satellite and Terrestrial Radio Connections

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In the case of satellite and terrestrial radio connections operating in the millimeter wavelength range, it is well known that fading phenomena are primarily caused by precipitation, especially the liquid water (rain). As a result, when planning these radio connections, a sufficient amount of fade margin must be included in order to ensure that the availability of the connection is adequate. The sizing of the fade margin is supported by rain attenuation models based on long-term measurements, both for terrestrial [1] and satellite [2] connections.

The above models take into account the geographical location of the installation of the connections, the frequency range used and other characteristics of the transmission, such as the polarization and the elevation angle of the received satellite. At the same time, even in the case of small geographical distances, varied meteorological conditions occur, so statistics based on specific, local measurements are also of great importance. In the case of satellite connections, the Q (33-50 GHz) and V bands (40-75 GHz), which are intensively researched today, still have relatively little measurement data, and during the processing of the measurement data, it is particularly difficult to identify fading phenomena, which is necessary for the production of accurate statistical data.

In our article, we present the attenuation measurements of the Ka (19.7 GHz) and Q-band (39.4 GHz) beacon signals of the Alphasat satellite [3], as well as a terrestrial 57.725 GHz connection [4] installed in the same location. We also describe a signal detection based on a rain sensor device, and a fading phenomenon selection method, which is suitable for accurately identifying rain events and thus forming reliable attenuation statistics (distributions). The method greatly speeds up rain event detection, which is traditionally done mostly by manual work, and makes the results of attenuation statistics more accurate.

References:
[1] ITU-R Rec. P.530-18. Propagation data and prediction methods required for the design of terrestrial line-of-sight systems. ITU, 2021.
[2] Recommendation ITU-R P.618-14. Propagation data and prediction methods required for the design of Earth-space telecommunication systems. ITU, 2023.
[3] Kelmendi, A., Csurgai-Horvath, L., Svigelj, A., Mohorcic, M., Javornik, T., & Hrovat, A. (2023). Site Diversity Experiment in Q-Band Satellite Communications in Slovenia and Hungary. IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS, 22(8), 1967–1971. http://doi.org/10.1109/LAWP.2023.3270839
[4] Andrea Farkasvölgyi, László Csurgai-Horváth, Attila Hilt (2024). High Resolution Rain Intensity Sensing with Millimeter Wavelength Radio Link, IEEE Antennas and Wireless Propagation Letters, (under review)

Assessing Natural and Anthropogenic Ground Deformation Using Sentinel-1 PSI in the Region of Cluj-Napoca, Romania

Péter Farkas[1], Gyula Grenerczy[1], Eduárd András[2], Florin Borbei[2]

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The continuous analysis of ground deformation is essential for both the assessment of natural hazards and the monitoring of human-induced activities. In this study, we present the results of a PSI analysis of ground deformations in the region of Cluj-Napoca, Romania.

Cluj-Napoca is the second most populous city in Romania, located in a hilly environment, built on the banks of the river Someșul Mic is ideal for such an assessment. The urbanization of the city has rapidly progressed in the recent decades, more than doubled the area of the city in 30 years, as the boundaries of the city reached the neighboring hills with slopes up to 26% steepness, which are prone to landslides.

The PSI was performed using more than 8 years of Sentinel-1 descending data via the Interferometric Point Target Analysis module of the Gamma software. For the interpretation, we used GIS to integrate the local geological information and include a geotechnical viewpoint as well. The thorough analysis is indeed necessary as many types of deformations are present, often superimposed, related to mass movements, groundwater pumping, sediment compaction, industrial operations, mining, earthworks related to road construction, etc. Results expected to show significant movements on recently built areas at the edges of the city, often caused by the combined effect of anthropogenic activities and geological conditions. This study is also a proof of the necessity of local studies, although country and continent-wide maps are useful tools for mapping of large areas: results are more up-to-date, processing details are more specifically tailored to the region and the user needs, e.g. by using locally selected reference and adjusting parameters to the goals of the research. Furthermore, our detailed analysis involving local knowledge, local experts and auxiliary data provides information regarding the risks, the interpretation, origin and characterization of the detected movements. By doing so, we demonstrate the necessity of collaboration between remote sensing and local geotechnical experts to maximize the potential and operative effectiveness of InSAR data.

The accurately mapped and quantified ground deformations can be used for the better understanding of the geological processes and assessing the risk of the urban development in the area. The detected slope instabilities, subsidence or uplift can have significant impacts on the built environment, and it is also important to take them into account in the planning and design of new buildings and infrastructure.

Assessment of Cooperation in the Space Sector

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The phrase *"united we stand, divided we fall*" is often quoted to inspire unity and cooperation.

The celebrated Apollo programme relied on over 20,000 different organisations to put humans on the moon. Fifteen nations from five space agencies cooperated to build and maintain the International Space Station. The European Space Agency is another exemplar of successful cooperation at an international level.

Can we apply lessons from these and other historic achievements to the *New Space* era? Are there more advantages than disadvantages to cooperation, and what are the key factors that determine success? What are the barriers to entry for SMEs who try to grow alone?

Large enterprises are often reluctant to accept risk purchasing from small or startup companies held back by their size, restricted capital or limited history.

Some of the benefits from cooperation include reduced costs and risks, sharing of financial and human resources, greater buying power, and improved supply chain assurance (especially for scarce components), as well as the efficiency benefits from economies of scale and market reach.

One of the main challenges competing companies face is determining whether growing the whole pie cooperatively will generate greater financial and strategic benefits than just their segment of the pie.

It is possible for firms to simultaneously exist as competitors and partners through a *Coopetition* framework. Analysing the strengths and weaknesses within a country or industry using Porter's Diamond model can help determine if there is a competitive advantage or disadvantage. Business clusters are one method for competing companies to work together to achieve goals that would not be possible independently. However, to achieve any measurable impact, clusters need to be more than just a passive catalogue of entities and capabilities.

Examples of successful cooperation in the space sector between emerging and well-established companies include the European *New Symphonie* consortium, led by UNSEENLABS and EUROCONSULT which has 22 members from 8 countries. *UNIO Enterprise* operates with 14 companies including SES. Large conglomerates such as Airbus and Thales have grown through effective cooperation.

It is important to adopt the most appropriate collaborative model to be effective in the space sector. However, success will depend on having a clear common purpose, with well-structured and managed governance working with a true spirit of trust and employing effective communications.

Circular food production in space environment – Insect protein production by supplementing green biomass in feed

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As humanity discovers more and more remote parts of the universe, the food supply for long-term space missions becomes an increasingly critical issue, and thus the need for sustainable food systems becomes more obvious. In space environments, where resources are limited and recycling is essential, insects can play a vital role as valuable actors in a circular food system.

This study aims to assess the effect of combining semolina with dried green duckweed, alfalfa, and green pepper as feeding substrate for yellow mealworm larvae (*Tenebrio molitor*). The weight ratio of wheat semolina: green mustard was constant (75% : 25%) throughout the different feed treatments. During the feeding experiment, the samples were kept in a programmable incubator at 23°C, 60% relative humidity, and 0% light intensity for 20 days. The research extended to examining production parameters (individual body weight, growth rate, survival rate, feed conversion ratio - hereinafter FCR) and the dry matter, carbon, sulfur, nitrogen, and crude protein content of the larvae.

The results show that all feed supplements used had a positive effect on the protein content of yellow mealworm larvae. The highest protein content was realized in the larvae fed the alfalfa supplemented diet. In addition to increasing the larvae's protein content, the plant substrates also increased their organic carbon content compared to the control group. Larvae fed with the pepper supplement with the lowest mean individual weight were associated with the highest FCR, whereas larvae fed with the duckweed supplement with the highest mean individual weight were associated with the lowest FCR. In terms of survival rate, all treatments achieved a value above 90%. Our experiment also suggests that a high protein content in feed does not necessarily ensure high protein content in the larvae.

This research highlights the potential of integrating innovative agricultural techniques and entomophagy to increase the efficiency and sustainability of food production in terrestrial and possibly extraterrestrial environments.

Class-Space: From the classroom to space!

Anna Pántya, Dorottya Jakab, Márton Zagyvai, Tamás Pázmándi

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Scientific experiments conducted parallel in classrooms and at the International Space Station.

The HUN-REN Centre for Energy Research is one of the longest-established space research centers in Hungary. Over the past decades, nearly 100 instruments and experimental devices have been launched into space from here.

The "Class-Space: From classroom to space!" project aims to develop and implement an experimental programme to enhance understanding of space characteristics. This initiative creates national-level cooperation, and the experimental programme will be implemented in collaboration between the Hungarian astronaut planned to spend 30 days on board the ISS in 2025 and groups of students from Hungarian schools. Within the project, 10 experiments will be developed and executed simultaneously by students in classrooms and the astronaut aboard the International Space Station. Schools across the country will have the opportunity to participate by conducting the experiments in parallel with the astronaut at their own facilities, for which the "Class-Space: From classroom to space!" project will provide the necessary equipment. Following the completion of the experiment series, students will be tasked with interpreting and evaluating the observed phenomena and publishing the results. Lessons learned will be thoroughly discussed, with a focus on applying the gained experience in future educational endeavors.

The overall aim of the project is to raise awareness and interest in scientific activities and to promote science, particularly among young people. The project will place a strong emphasis on developing students' skills, including creativity, individual and collaborative problem-solving and strategic thinking, which will prove beneficial not only in their scientific careers but also in various other aspects of life. Furthermore, establishing a network that facilitates professional connections between researchers and teachers is deemed crucial for laying the foundations for long-term cooperation.

Comprehensive analysis of the ionospheric response to the largest geomagnetic storms from solar cycle 24 over Europe

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A multi-instrumental analysis of the meridional ionospheric response is presented over Europe during the two largest ICME-driven geomagnetic storms of solar cycle #24 maximum. Data from 5 European digisonde stations, ground-based Global Navigation Satellite System, Total Electron Content (GNSS TEC), the ratio of the TEC difference (rTEC), as well as Swarm and Thermosphere, Ionosphere, Mesosphere, Energetics and Dynamics (TIMED) satellite observations have been used for the investigation of selected intervals (11–17 November, 2012, and 16–25 March, 2015). The storm evolution is monitored by digisonde foF2 critical frequency (related to the maximum electron density of F2-layer) and GNSS TEC data. Moreover, Global Ultraviolet Imager (GUVI) measurements from the TIMED satellite are used to investigate the changes in the thermospheric O/N_2 ratio. Our main focus was on the main phase of the geomagnetic storms, when during the nighttime hours extremely depleted plasma was detected. The extreme depletion is observed in foF2, TEC and rTEC, which is found to be directly connected to the equatorward motion of the midlatitude ionospheric trough (MIT) on the nightside. We demonstrate a method (beside the existing ones) which allows the monitoring of the storm-time evolution of the disturbances (e.g., MIT, SAPS, SED) in the thermosphere-ionosphere-plasmasphere system by the combined analysis of the worldwide digisonde system data (with the drift measurements and the ionospheric layer parameters with 5–15 min cadence), with rTEC and GNSS TEC data, and with the satellite data like Swarm, TIMED/GUVI.

CubeSim - A Simulation Framework for small Satellites

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In recent years, CubeSats have become increasingly popular for scientific, communication or observation missions. Extensive hardware testing, as required for Attitude and Orbit Control System (AOCS) algorithms, is often beyond the capabilities of low budget or University projects. In order to be able to test the attitude determination and control software, multiple sensor signals would have to be emulated in real time. At least a three-axis rotational table, multiple solar simulators, three Helmholtz coil pairs and a GPS simulator would be required to verify the attitude determination algorithm. The interaction between the magnetorquers being driven by the attitude control algorithm and the present magnetic field is even more complicated to test. So-called air tables are commonly used to allow the spacecraft to move at reduced friction along two axes or to rotate around one axis. An extension to three axes and therefore a complete hardware-in-the-loop test setup for the verification of these algorithms is not possible.

The purely software-based simulation framework CubeSim [1] uses the laws of mechanics to propagate celestial body and spacecraft movement. This also includes the torque generated by the applied magnetic moment of the spacecraft and the ambient magnetic field. The black body radiation of stars and the albedo reflection are simulated using raytracing. CubeSim allows the computation of all spacecraft sensors at any time such as photo diodes, gyroscopes, magnetometers, accelerometers, GNSS transponders. Actuators such as reaction wheel, magnetorquers and thrusters are simulated to compute orbital maneuvers or to verify sophisticated AOCS algorithms. This allows to simulate the spacecraft in various mission scenarios and orbits which is beneficial for system engineering, margins definition and mission planning.

The open-source software is programmed in C++. This allows the direct execution of the on-board computer software on a PC. The ADCS algorithm of Austria's first CubeSat PEGASUS [2], [3] was developed and fully tested in CubeSim.

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Data processing from weather satellites

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In my poster presentation, I would like to give an overview of the receiving data from different weather satellite systems by our ground station. I would like to present the technical planning process that served to create the ground station. I would specifically address the practical technical experiences that have an influence on the reception of the given GEO satellite's signal. I would like to draw attention to the separation of terrestrial and satellite systems (physical, spectrum) through our own example. After that, by choosing the right tools, we can get the raw data, which provides impressive images after proper processing.

In the course of the processing, I will specifically refer to the Eumetsat GEO system, which is based on DVB technology and operates in several frequency bands. I would like to give an overview of why it is important to choose the appropriate technical parameters of the receiving equipment and to agree with the service provider (Eumetsat) in order to ensure proper operation on our ground station.

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Daytime Optical Background Radiation

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Since the advent of the internet at the user level, networks have evolved rapidly, and in less than three decades, we have gone from dial-up modem solutions to stable wireless networks. However, the demand to communicate at the highest possible data rates in the most secure way has driven the need to research and develop quantum-based solutions. These technologies would revolutionize data transmission compared to current solutions. Satellites capable of optical communication and quantum key distribution (QKD) are becoming the key infrastructure of the near future. Optical background radiation determines the quality of the free-space optical QKD links. That was the motivation to investigate the optical background radiation. This parameter determines the transmission quality of quantum-based free-space communication with a special focus on the wavelengths of the 810 and 1550 nm bands (two common wavelengths in optical communications).

In the BME laboratory on top of building „I", we have measured background radiation daytime on the above-mentioned wavelengths. The device suitable for daytime measurements was previously developed in the laboratory to measure the daytime background radiation. It is also capable of graphically displaying and analyzing the results of the measurements with the help of mathematical software called Matlab.

During the day, the main factor is the weather. Clear weather conditions result in low background radiation. On the displayed graphs, the data appears to follow the Sun's path, meaning values rise gradually, peaking around noon and then falling back to the noise level. Broken clouds cause serious fluctuations in the noise levels as a function of time.

When the Sun is behind the clouds, light is scattered, reflected, refracted, and absorbed over a wider range of wavelengths. Where the Sun comes out, it falls back to the level measured under clear skies. In heavy darkness, it falls back to almost nighttime conditions, where the instrument is not sensitive enough to measure relevant data.

Heavy rain and dark clouds reduce noise levels; however, they make communication with satellites impossible due to extremely high noise levels and electromagnetic interference. According to previous knowledge (Given the Sun's spectrum), the background radiation in the C-band is much lower than on 810 nm due to Rayleigh scattering, and this is clearly visible in the graphs visualized from the measured data. However, further measurements are required to confirm the theory and the results that have been evaluated so far.

Development of GIS software based spatial ejecta estimation algorithm to support the NASA-ESA Artemis program

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GIS software are designed to collect, manipulate, analyse and visualise spatial data both for Earth and other planetary bodies. Collaborating with the NASA-ESA Artemis project, the landing site of CP-22 unmanned mission was supported by the author's PhD project. Using planetary GIS methods allow to use raster data (linked to pixels and resolution (m/px) including numerical values); and vector data types (point, line and polygon, linked to numerical and text data) together with SQL selection methods; the southern polar hemisphere of the Moon was analysed. With such a software environment raster type elevation model was used to identify craters and their ejecta thickness with areal distribution. The Lunar Orbiter Laser Altimeter (LOLA) instrument provided 60 m/px detailed elevation model for the research. During the method I developed crater ejecta profiles were measured along polylines first, then elevation values were extracted from pixels cross the polylines. Using these profiles a sixth order polynomial equation was generated that describes the ejecta profile also considering the subsurface induced structural uplift at the inner part of the crater rim. The removal of this structural uplift is necessary, what makes around 70% of the total rim height based on previous measurements. The extension of the structural uplift is approximately 85% of the crater diameter where the inflection point (considering the topographic profile) marks that part where only ejecta contribute of the profile. Based on the diameter of the craters, the extension of the ejecta layer with and without the inner structural uplift were calculated with the euclidean distance tool. In the next step the raster calculator tool was used to estimate the thickness of the ejecta, and finally cell statistics tool was used to aggregate the two raster datasets to remove the structural uplift and provide a final ejecta thickness map. Using the developed Python based numerical algorithms, the spatial distribution and rough stratigraphy of the crater ejecta layers could be estimated supporting other missions too beside CP-22 for the Artemis Connecting Ridge area, the CraterTools software was also applied for dating these craters and their ejecta. This project is supported by the H82 POLICETECH project of ESA and the KKM of Hungary.

Distributed Intelligence and Sensor Network in the Power Systems of MRC-100 Satellite

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The MRC-100 is a three unit PocketQube satellite which was developed at the Budapest University of Technology and Economics by students and lecturers. It has been launched into space in June of 2023 and it is currently in a Sun Synchronous Low Earth Orbit. It utilizes distributed intelligence in its central power system. Each subsystem onboard has its own protection circuit, which includes a current limiter switch circuitry that monitors power consumption and can act independently in case of malfunction. The limiter switch has three main structural components. These are the switching MOSFET, the sensors to monitor the load current and output voltage and the microcontroller which controls the circuit to manage the main functions and collect telemetry data about the status of the load. Besides the protection of the subsystems and the energy bus, the intelligence in the limit switches also provided additional features. They can act as a controllable switch to turn on or off the subsystems. This can be controlled by the On Board Computer, selected subsystems can be turned on or off by commands from the ground station based on what measurements or experiments are desired to be conducted. This solution simplifies the complex task of managing the satellite's power distribution system and gathering telemetry data.

Engineering and Management of Space Systems (EMSS) - an International Joint Master's Double-Degree Programme

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Dynamic development of the European space sector results in a necessity for suitable Higher Education Institution graduates.

Current study programmes of Aerospace Technology are focused on the field of mechanical engineering. Although engineering methods for design, construction and assembly of mechanical systems are covered, interdisciplinarity and life cycle aspects are not considered in a sufficient degree.

Due to the increasing digitalization, interconnection and distribution of technical systems, there is a high necessity to consider the systems with their interdisciplinarity during the entire life cycle from the initial idea through conception, design, production, integration, verification and validation to operation, maintenance and disposal in such a way that it best meets the expectations of the stakeholders and successfully accomplish the planned mission. Current systems consist of various hardware and software components, thus require different competencies depending on the characteristics of the application domain. The increasingly dynamic market requires an adaptation of traditional approaches and the introduction of agile methods in order to meet the requirements for greater flexibility and creativity. This, supplemented by management and social competencies, forms a future-oriented basis for mastering the ever-growing complexity of technical software-intensive systems.

Our international interdisciplinary joint Master's double-degree program - Engineering and Management of Space Systems (EMSS) established as a cooperation of Bremen City University of Applied Sciences, Germany and Gdańsk University of Technology, Poland addresses all the above-mentioned systems engineering aspects and imparts competencies necessary to comprehend complex space missions as a "system of systems" during their entire life cycle. It is conducted in cooperation with the local space industry, in particular OHB, Airbus Defence and Space, and Ariane Group.

The curriculum includes three study semesters with 90 ECTS in total. Due to the interdisciplinary orientation, it is possible to specialize in the disciplines Computer Science, Electronics Engineering and Space Technologies. The course takes into account the international standards of systems engineering, based on the certification programs of the International Council on Systems Engineering (INCOSE) and its German Chapter, Gesellschaft für Systems Engineering (GfSE). The proof of academic equivalency and certification are planned as next steps. After three pilot runs and a successful accreditation, the first official run is going to be launched in the summer semester 2024. With this programme we offer an innovative and future-oriented study programme that has a unique selling point throughout Germany and Poland. Thus, we can make an important contribution to securing skilled staff for the space industry.

EON: The first year of the re-started optical tracking of artificial satellites at Baja

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Upon to an invitation of a Polish space company, who had an ESA-supported project of establishing a new whole Earth European Optical Network (EON) for satellite tracking, Baja Observatory and AstroTech joined to this, as its Middle-European station (2021). As a part of this project, a new optical sensor (designated as PAN-8 within the EON system) was installed at Baja during late Summer of 2022, and soon, the optical observations of the artificial satellites has been restarted after 35 years long pause. The results and experiences of the first year activity are presented. The station is automated, remote-controlled, and its full automatization is planned during 2024. It is capable to perform customer-ordered satellite observations as well, thus, for the possible future domestic applications we present the technical parameters and limitations of PAN-8.

Fast and flexible developments of digital logics: applications in the first Hungarian astrophysical satellite, GRBAlpha

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Field-programmable gate arrays (FPGAs) are fundamental parts of digital electronics and can provide a flexibility in the interconnect and processing capability of scientific instrumentation, mixed-signal driven components and platform-side electronics on a satellite bus. However, the related learning curve of such solutions are rather shallow, compared to another forms of embedded parts like microcontrollers or classic application processors. In this presentation we demonstrate the capabilities of a soft system-on-a-chip design concept that allows us to attain a fast development cycle, rich communication interfacing and the exploitation of high-level language programming at the same time. Re-usable building blocks are therefore not limited to IP/CPU cores but bootstrap routines, peripheral and interrupt controllers, power management controllers at operating system level and hardware accelerator libraries, where all of these are sharing the same level of extensibility. This design also allows in-orbit upgrades of the cores with customizable separation of address spaces for software components ranging from boot ROMs and real-time OS's, up to application-level software run from random-access memory blocks. These technologies have successfully been demonstrated and utilized in GRBAlpha, Hungary's first space mission devoted to astrophysical research. This 1U-sized satellite [1] investigates and characterizes the most violent explosions of the Universe known as gamma-ray bursts [2]. Operations of this satellite are continuous since its launch, March 2021, while various parts are underwent several times such architectural-level upgrades. In addition to further in-flight improvements on the data acquisition pipeline of the gamma-detector units, this soft system-on-a-chip is expected to take part in related satellite components. These components include but not limited to transceivers based on software-defined radio, forward error correction layers or power supply drivers.

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Fast Routing in Entanglement-based Satellite Networks

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With the advent of quantum computers capable of handling thousands of logical quantum bits coming closer and closer, there is an increased need for high-security communication protocols. The need for increased security is thanks to a clever algorithm developed by Peter Shor. Thanks to Shor's algorithm, we can factorize primes in logarithmic time complexity instead of exponential, as with the best classical algorithms. The speedup of factorization is crucial in breaking today's most used public-key cryptographies, such as the RSA scheme. The RSA scheme is a vital part of modern Internet security and is used by many actors, from banks through virtual private networks to shopping websites. Using quantum communication, we can not only facilitate secure key exchange, whose security is backed by physical laws, but also provide a way for quantum computers to exchange non-classical information.

Two main mediums for optical quantum communication networks are fiber-based and free-space optics (FSO). Both mediums have advantages and drawbacks. In the case of larger systems, FSO systems are better because of their more extensive coverage and dynamism. Using satellites as intermediary nodes can bring out even more the advantages of FSO systems. Most modern research on satellite-based quantum networks focuses on Low-Earth Orbit (LEO) satellite-based systems. The main factor that makes LEO satellites attractive for quantum systems is their high coverage and relatively low Earth-satellite link attenuation. Not considering the cost of technology development, which is needed for high-reliability satellite-based quantum systems, one of the highest cost drivers for these networks is the cost of launching and maintaining satellites. Thus, reducing the number of satellites needed for maintainable quantum communication is a top priority in the field of satellite-based quantum communication.

In our research, we developed a new algorithm based on our old REBSAN (Routing in Entanglement-Based SAtellite Networks) algorithm. With the use of our novel algorithm, it is possible to calculate all possible paths from a starting ground node to all other available ground nodes in O(deg(v)*O(V2)) time. This algorithm uses a novel approach in satellite-based quantum communication utilizing the unique properties of entanglement-based systems. Using these properties, we are no longer bound chronologically or in space in pathfinding. This means we could have routes where the first edge is the last chronologically or have paths like A → B ← C connecting A to C. This newfound freedom means we can find routes where previously it was impossible.

FOTEC's Testing and Qualification Capabilities for Small Satellites

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FOTEC Forschungs- und Technologietransfer GmbH, the research subsidiary of the University of Applied Sciences Wiener Neustadt, has been active for decades in the development of electric and chemical propulsion systems for small satellites [1–2] as well as space hardware, such as ion sources for potential control (ASPOC), sensors or mechanical parts. In order to test or qualify the equipment and to characterize their performance under certain conditions, FOTEC has developed extensive testing competences and capabilities, which include thrust balances [3] to measure the force generated by the thrusters, ion current density and ion energy distribution measurement systems respectively with highly accurate Digital Faraday Cups (noise floor of ±5 pA/cm^2) [4] and Retarding Potential Analyzers to measure the energy distribution of an ion plume [5]. Moreover, a mass efficiency balance was developed to allow in-situ measurement of the propellant consumption over time.

In addition to this, FOTEC offers its customers and partners the possibility to test their equipment, ranging from individual components to entire CubeSats, and supports them with many years of experience in the planning and execution of tests in the space domain. Environmental testing (vibration, shock) and thermal vacuum testing both in a compact climate chamber and in a larger thermal shroud are available in FOTEC's Aerospace Laboratory.

This paper shall give a summary of FOTEC's testing capabilities and shows typical results and performance figures of systems that have been tested and qualified in FOTEC's laboratories so far.

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Fuel consumption optimization for suborbital solid fuelled rocket engines

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This study introduces a MATLAB-based motor optimization program developed by the BME Suborbitals Rocketry Team, tailored for suborbital rocketry applications. The program tackles the intricate task of identifying optimal grain geometries within a predefined size range, crucial for achieving diverse apogees efficiently. It is designed to handle both Bates and conical grains, chosen for their structural stability and ease of remanufacturing, enabling consistent performance due to relatively low tolerances. Furthermore, the program's flexibility allows for the exploration of various thrust curves, a result of the unique combination of Bates and conical grain geometries. This code can serve as the baseline for competent rocket engine development. Due to this, emphasis is placed on minimizing hardware costs, achieving the lowest rocket launch rail leaving velocity, and maintaining the rocket's acceleration within predefined limits. Engine parameters such as maximum pressure, average pressure, and minimum thrust are also considered, enhancing the program's adaptability to specific mission requirements. This research not only contributes to advancing propulsion systems for suborbital rockets but also underscores the significance of optimization methodologies in achieving cost-effective and efficient solutions. The findings hold implications for both academic research and practical applications within the aerospace industry, offering insights into the intricate balance between performance, cost, and manufacturability in rocket motor design and optimization.

High-redshift radio quasars from ground and space

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High-redshift radio quasars are distant and luminous extragalactic objects. They are unique probes of the early Universe and provide insights into the formation and evolution of the first galaxies and supermassive black holes. It is now evident that fast accretion of material was needed for assembling such black holes seen already in the first ~1 billion years of the history of the Universe. Accretion can lead to the ejection of powerful relativistic plasma jets. Even from these enormous distances, the technique of very long baseline interferometry (VLBI) can reveal the compact innermost parts of the radio-emitting relativistic jets on millarcsecond-scale. However, the list of known quasars observed with VLBI at redshifts z>5 is still rather limited. Here we present the results of the 1.6-GHz European VLBI Network (EVN) observations of 10 faint z>5 radio quasars with different radio-loudness indices, to significantly extend the VLBI sample available at z>5 to date, and to investigate how radio loudness affects the jet physical parameters. The radio loudness (i.e. the radio-to-optical luminosity ratio) characterises the dominance of the radio emission for a given object. Together with the ground-based VLBI observations, we analysed the available measurements for our sample obtained from various astronomical space missions that operate in different wavebands. Gaia in the optical, WISE in the mid-infrared, and Chandra in the X-ray band observed some of our targets. The combination of ground- and space-based astronomical observations across multiple electromagnetic wavebands enables a more complete understanding of the nature of radio quasars.

Hungarian participation in the Comet Interceptor mission

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Comet Interceptor is an exciting new mission that will be launched before its target is known. The mission is foreseen for launch together with ESA's ARIEL spacecraft, both to be delivered to the Sun-Earth Lagrange point L2. Comet Interceptor will wait there in space until a new Long Period Comet (LPC) is identified on its way into the inner Solar System.

Previous comet missions encountered short-period (less than 200 years) comets. These comets have approached the Sun many times along their orbits and as a consequence have undergone significant changes: Rosetta's comet, 67P/Churyumov-Gerasimenko has 6.5 years while Comet 1P/Halley, visited by VEGA & Giotto, has 76 years period. LPCs are different because they will tell us about how the solar system formed even an interstellar object that is only just starting its journey into the inner Solar System.

Comet Interceptor mission was approved by ESA in June 2019, and being developed in cooperation with the JAXA. Planned launch is in 2029. It will be a multi-element mission comprising a primary platform (A), which also acts as the communications hub, and two sub-spacecrafts (B1 by JAXA and B2 by ESA), allowing multi-point observations around the target. The spacecraft will remain connected to each other at L2. The mission cruise phase will last months to years. Before the encounter, the spacecrafts will separate from each other. The three probes will be equipped with a complementary scientific payload, providing different perspectives of the comet's nucleus and its gas, dust, and plasma environment. Measurements will greatly improve the 3D information needed to understand the dynamic nature of a pristine comet.

The Comet Camera (CoCa) imaging system will be on Spacecraft A, provided by a consortium led by the University of Bern in Switzerland including DLR Adlershof, LAM Marseille, CSFK CSI (HUN-REN) and industrial partners REMRED Ltd. and SGF Ltd. in one consortium, while Admatis Ltd. from Hungary. Researchers of HUN-REN Wigner RCP are involved in the evaluation of the measured data. CoCa is designed to provide high resolution imaging of the selected comet with 4 filters at broadband optical wavelengths. For a 1000 km fly-by, CoCa will provide 8 m per pixel images at most with a rate of 2 images per second. The REMRED Ltd. (hardware) and SGF Ltd. (software) develop CoCa's Digital Processing Modul. SGF Ltd., resemble to the DPM of the CaSSIS camera of the ExoMars mission using similar software.

Hungarian participation in the European Space Agency's JUICE (Jupiter Icy Moons Explorer) mission

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JUICE - JUpiter ICy moons Explorer, ESA's (European Space Agency) first large-scale mission to Jupiter, which was launched in April 2023, will arrive at the planet in 2031 and spend at least three years exploring the gas giant and its three largest moons, Ganymede, Callisto and with detailed observation of Europe. Our group, the MTSzSz Space Technology Group of the Energy Science Research Center, developed the power supply for the PEP (Particle Environment Package) instrument. PEP and its sensors explore the plasma environment in the Jupiter system. PEP measures the density and flux of positive and negative ions, electrons, exospheric neutral gases, thermal plasma, and energetically neutral atoms.

The nominal on-board voltage is 28V on the space probe, in addition, several other voltages are required for each experiment, including PEP. The task of our space technology group was to develop the DCC (Direct Current Converter) power supply for the PEP sensors. Many tests had to be passed during the design and control phases, as well as after production, to prove long-term reliability. In our publication, we present the creation and process of the DCC. For the DCC tests, it was necessary to develop a special ground control device, a test device called Electronic Ground Support Equipment (EGSE). EGSE was developed by SGF Ltd. and supported the inspection of the DCC. Also, during the spaceflight, we are expected to be available throughout to answer questions that arise with simulations, and we have also been asked for additional development.

PEP is powered by solar panels. The application of solar power generation at a large distance from the Sun, in the worst case with a solar constant of 46W/m2, results in large-area solar arrays, typically 60-75m2, and finally 85m2. The on-board voltage for experiments is 28V, provided by a 28V nominal line and a redundant line, also 28V.

The task was very challenging due to the high reliability required by ESA, and reliable operation has to be ensured even under extreme conditions.

Introduction of space science in higher education: space science in BSc engineering

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Space science is a fascinating and powerful field in which our country has now become an important part. From an educational point of view, several universities now offer some kind of specialised training in space science, and there are already master's degrees in space engineering. Under the UniSpace programme, 17 Hungarian universities are cooperating to offer advanced training in space science at four universities. However, at bachelor's level, a prospective engineer is unlikely to encounter a subject related to space science outside of basic physics, or it is only available in a few specialisations. Future professionals should be introduced to this discipline as soon as possible. This is why it may be important to offer space science courses at undergraduate level, to help students if they wish to pursue their studies in this field.

The Széchenyi István University of Győr has already taken several steps to promote space technologies, including the SZESAT student group, where students can work on space telecommunications, the Mobilis summer children's camps, where students give lectures on the topic every year, and the University of Győr is also a member of the UniSpace Hungary consortium.

The study seeks to answer two questions: first, how interested students are in a similar subject that introduces them to space science and the basic space technology opportunities. The second is what majors are interested in the new subject, and which segments of the discipline might be the most interesting to them. In addition to the two main orientations, another important consideration is how students might integrate it into their studies and what prior learning would be required to start such a new subject.

Investigation of Glass-foam systems as Insulation materials for Space applications

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The foam glass has the properties of low thermal conductivity, high compression strength, high frost resistance, and better durability.This material can be used to build walls, regulate heat in refrigerating equipment, or used as floating and filtering material. But the space environment is very different from the classical terrestrial environment.Our study has produced glass foam samples made from recycled materials (natural based filler additives as: banana peel (B), eggshell (ES), coffee grounds (C) and oak powder (O) on 900°C sintering heat digestion temperature. The matrix of all samples was based on ordinary float glass (FG) waste, which was combined with the above-mentioned filler-additives in different amounts. The following properties were investigated at the University of Miskolc:compressive strength, density, porosity, thermal conductivity, and water absorption. In conclusion, it was found out that bio-waste materials combined with glass could produce foam glasses at a temperature of 900°C which have low densities, low thermal conductivities, with high porosity rates. These materials can be used for thermal insulations. On the other hand, the materials which could not foam but maintain their shapes after sintering have high thermal conductivities, high compressive strength, and high densities more than 1g/cm^3. They have very low water absorption and porosities, and therefore can be used for load bearing activities. Since the combination of the two materials (float glass and bio-wastes used in this project could produce foam glass, it means that the objective of decreasing environmental pollution can be achieved, when such products are utilized. Since the bio-waste materials are bound in the environment and relatively cheaper, combining them with waste glass will help to produce foam glass at a cheaper cost. However, easy manufacturability is not enough for space suitability, the material must be REACH-compatible and resistant to extreme space environment effects such as UV, particle radiation, ATOX, thermal cycling and climate effects during ground storage.They must also be free of volatile organic compounds (VOCs) and other particles resulting from fragmentation, including critical cleaning.As these samples are essentially designed as insulating materials, they must of course also meet other requirements such as fire and flame resistance, etc.A further complicating factor is the brittleness of the materials, which are expected to become mechanically unstable after thermal cycling, so it is recommended that in the future, additives should be combined with some kind of plasticising co-agent.

MAUVE – UV-Vis Spectroscopy of Stars by a 16U CubeSat

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M-dwarfs are currently of great interest due to the prevalence of small planets, including rocky ones, within their habitable zone. As the best candidates to host life, rocky planets may be impacted by the behaviour of their host stars. The MAUVE project [1] aims to build, for the first time, a CubeSat in a rapid timescale with the ultimate purpose of observing such stars via ultraviolet spectroscopy.

The state-of-the-art 16U satellite will prove a configuration for delivering excellent science data, while developing the key technologies in the interface with the detector, the thermal design and high-performance pointing accuracy. The concept is in a sweet spot of technology access and performance which, unlikely many other complex astrophysical missions, avoids the need of large mirrors, cryogenic detectors and suppression of thermal emitted stray-light. The platform subsystems, except the pointing system, own heritage from the ESA funded RadCube mission [2]. Beside the redundant subsystems solutions, the platform will include the novel Intelligent Payload Controller (IPC) module, providing an advanced interface unit between the platform and the payload.

The project will demonstrate the capability of the European industry in delivering innovative and ambitious scientific satellites at a radically faster pace and lower costs than traditional science satellites. MAUVE is being developed with the ambition to provide scientific data highly complementary to existing and upcoming exoplanet related space and ground-based observatories, including the James Webb Space Telescope and ESO's Extremely Large Telescope.

The MAUVE Satellite, targeted to launch in Q2 2025, is being built in the frame of an international cooperation among space dedicated SMEs. The scientific work is led by Blue Skies Space (IT/UK), the innovative CubeSat technology is delivered by C3S (HU), and the advanced pointing system with the Attitude Determination and Control System (ADCS) is developed by ISISPACE (NL).

The aim of this presentation is to give an insight to the main scientific and technology challenges of the project, focusing on the key satellite components being built, the scientific results expected and also the impact of the mission on exoplanet observation by CubeSat solutions.

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Numerical investigation of the spanwise mean velocity gradient method for transition delay

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In the proximity of a streamlined body's surface a boundary layer will develop. At first the boundary layer is thin and laminar, but as the flow moves further downstream, it becomes a thick turbulent layer. Laminar flow is characterized by parallel streamlines, while in turbulent flow, streamlines interact with each other, altering the interactions between the flow and the body. One of the effects of transition from laminar to turbulent is that turbulent flow enhances heat transfer because it promotes mixing and increases the convective heat transfer coefficient. This effect can be detrimental when spacecraft are reentering the atmosphere, as it promotes heat transfer from the stagnation point to other parts of the craft. Another effect of the laminar-turbulent transition, which our work is focused on is that the friction generated by the flow, is higher in turbulent flow, causing higher losses. With these in mind, it can be seen that delaying the laminar-turbulent transition can have positive impacts, such as lowering the fluid dynamic losses, or keeping the heat transfer low.

The transition can occur in two main ways: the first is the growth the instabilities, while the other is the bypass-transition, which is not widely understood. In the first case, the exponential growth of the instabilities can be described by linear stability theory until a given amplitude, after which the non-linear mechanisms take over. One of the most understood instabilities in the boundary layer are the so-called Tollmien-Schlichting (TS) waves. It has been shown both numerically and experimentally that by reducing the growth of these, the laminar-turbulent transition can be delayed. One of the mechanisms which can achieve this is the spanwise mean velocity gradient (SVG) method. This method delays the transition by attenuating disturbances such as the TS-waves of the boundary layer flows. These SVGs can be created by a multitude of methods; our investigation is focused on their creation by roughness elements and discrete suction using numerical means.

The aim of this study is to create a methodology via numerical means to serve as a foundation for further investigation of the phenomena such as finding the optimal parameters for a given geometry and velocity.

Preliminary design of payload for sounding rockets

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Many prominent academy and industry players have the desire to experiment under high acceleration, and elevated radiation within the uppermost troposphere. This demand can be satisfied with sounding rocket satellites developed by university groups.

BME Suborbitals is a team of STEM students, who develop their rockets for various competitions, including our low-cost solid-propellant motor. Recently our team began developing scientific and technological experiments for payload applications.

As each member of the group has a different domain experience, we set up our learning platform based on available open-source knowledge to educate each other, while incorporating the gained skills in a hands-on experience. Following ECSS-M-ST-10C standard in satellite development, the group began with an outline of the payload being developed; a System Requirements Review. Subsequently, we devised various ideas with a focus on space application with each member writing their Preliminary Design Review associated with the idea.

The payload will be encapsulated in a CubeSat format of 10x10x10cm (1U) design conforming to CP-CDS-R14.1. The frame has been designed by the team to specifically comply with the experiments on-board, which include a Radiation Measurement Experiment (RME) in collaboration with Ephermersys Inc. There will also be a Fungal Sporulation experiment (FSE) in collaboration with Szeged Biological Research Centre (SZBK) to aid space mycology, an Aeronautical-Ground channel (AGC) study with OFDM link for channel characterization, an AI-based fault predictor for the On-board Computer (OBC) developed by the University of Neumann János to enhance the dependability of payloads and finally a monocromator to study greenhouse gas concentration at various altitudes. The CubeSat will also be capable of filming the entire descent with an on-board down-facing camera, which will be analyzed as its' secondary purpose of terrestrial observation.

Besides the payload, the main subsystems are the OBC, which is responsible for task scheduling and the realization of data persistence, an Electrical Power System (EPS) with an experimental photovoltaic system, a Communication board (COM) to send telemetry to the ground station and a Sensor board (SEN) to measure temperature, pressure and humidity.

Probing Low Mass Neutrinos in Gravitational Wave Environments: A Novel Approach with Feynman Diagrams & Applications In Space Sciences

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Our research pioneers a novel exploration into the elusive properties of low mass neutrinos. Utilizing Feynman diagrams, we delve into their interactions within gravitational wave environments, employing a powerful methodology for visualizing and calculating particle dynamics.

The study's innovation lies in the integration of quantum field theory with gravitational wave, astrophysics, offering a distinctive approach to unraveling the nature of low mass neutrinos. By examining the interplay between gravitons and neutrinos, we aim to unearth unique signatures distinguishing these interactions from background noise.

Our investigation conducts a comprehensive analysis of relevant Feynman diagrams,considering gravitational wave-induced perturbations on the neutrino field. This approach enables the prediction of distinctive observational outcomes, which can be validated through experimental data from gravitational wave detectors.

The research extends beyond theoretical exploration, addressing potential implications for astrophysical phenomena like supernovae and neutron star mergers, where low mass neutrinos field influence. Discerning their impact amid gravitational waves holds promise for groundbreaking insights into the dynamics of these cosmic events. In conclusion, our study presents a unique and innovative approach to studying low mass neutrinos through the lens of gravitational wave astronomy.

The integration of Feynman diagrams provides a robust framework for interpreting experimental data, pushing the boundaries of our understanding of fundamental particle properties and their connection to the broader cosmic landscape. We investigate the intricacies behind low energy field. It revolves around the distinctive nature of our methodology in exploration of deep space & microbiological studies in lower g environment. It provides test bed for exploration and intersection of particle physics & astrophysics.

Proposal Of A Hybrid CSNN-PSO Algorithm For Improving Space Debris Identification And Classification

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Clean space is becoming a more severe problem due to the evolving number of Earth-orbiting debris, especially in LEO. Mitigation starts with identification and classification. A more traditional method, like clustering is widely used for this purpose, however, it has its limitations like outlier handling difficulties and often struggles with high-dimensional datasets. To handle such scenarios and improve accuracy a hybrid concept, neuromorphic swarm intelligence is being introduced.

Neuromorphic computing is a third-wave AI approach to computing that works similarly to a human brain by using artificial neurons and synapses. It provides the hardware framework for implementation of Spiking Neural Networks (SNN) which offer a biologically realistic model of computation. Spikes refer to signals or impulses that neurons propagate to each other. They do not transmit information at each cycle, only once the threshold is reached, making the network's energy consumption low. A variation for neuromorphic algorithms is a Convolutional spiking neural network (CSNN) that combines traditional Convolutional Neural Networks (CNN) with spiking layers, thus introducing rapid learning rates and the feasibility of extracting spatio-temporal features efficiently. However, the additional layers do not prevent the network from low convergence and overfitting. To overcome these pitfalls, such as getting stuck in local optima, a hybrid solution is proposed by using Particle Swarm Optimizer (PSO), a Swarm Intelligence (SI) technique which is a collective behaviour-based subfield composing individual agents, using decentralized control and self-organization.

This study evaluated the CSNN-PSO hybrid approach aiming to address Space Situational Awareness (SSA). The outcome of the comprehensive analysis showed that the merged algorithm has the potential to increase effectiveness and accuracy in identifying and classifying space debris.

Radiation characteristics measurement on a sounding rocket near the Kármán line

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With the ongoing progress in the space industry, space travel has become more cost-effective and popular. However, it comes with inherent risks, particularly concerning radiation exposure during ascent through the atmosphere. Data on the radiation field in the altitude range of 30 km to 90 km is limited due to challenges with sustained balloon flights and the lower reach of Low Earth Orbit (LEO) satellites. With the increase in human spaceflight and the launch of complex space devices, the knowledge of radiation conditions in the atmosphere has become a more pressing issue.

A new scientific payload will be implemented on board a sounding rocket to investigate the issue. Our project called TELLER (Three-axis Experimental Low-altitude Laboratory for Exploring Radiation) is an experiment developed by a team of students from the Budapest University of Technology and Economics in Hungary. The aim of the project is to assess the energy, density, and directional patterns of ionizing radiation in the atmosphere and to explore their correlation with altitude. The experiment will be launched up to the Kármán Line in the spring of 2025 to perform measurements, thanks to the Swedish-German student programme called REXUS/BEXUS.

Our methodology involves integrating multiple measurements to enhance precision, utilizing a spatial arrangement of GM tubes and scintillator detectors. With this spatial placement, we are able to determine the direction of the incoming radiation. In the following article, we would like to describe the experimental set-up and the measurement process, the development and the progress so far.

Radio interferometric observations of the JUICE spacecraft en route to Jupiter

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The European Space Agency's (ESA) large-class mission JUICE (Jupiter Icy Moons Explorer) launched towards the Jovian system on 14 April 2023. The primary science targets of JUICE are the icy Galilean moons of Jupiter (Ganymede, Callisto, and Europa), which show signs of liquid water under their crusts based on previous observations. PRIDE (Planetary Radio Interferometry and Doppler Experiment) is one of the JUICE science experiments, which enables highly accurate position determination of the spacecraft relative to compact reference sources in the sky, by observing the carrier signal of its radio transmitter with a global network of radio telescopes, using the technique of very long baseline interferometry (VLBI).

In the framework of ESA PRODEX (Programme de Développement d'Expériences scientifiques), we have been working on defining the optimal phase-referencing strategy, assembling an inventory of suitable reference objects, and densifying the network of celestial radio sources with new observations along the spacecraft trajectory. As part of the project, we participated in the planning of several VLBI experiments using the European VLBI Network (EVN), the Australian Long Baseline Array (LBA) and a global VLBI network. Our group's main roles in these projects are to provide assistance in observation planning by identifying suitable primary and in-beam reference sources, and data reduction, in particular, the assessment of the quality and accuracy of spacecraft lateral position determination. The aim of one of these VLBI experiments is to visit potential VLBI calibrator sources well before the Venus flyby of JUICE. The Venus flyby, scheduled for 31 Aug 2025, provides a unique opportunity to test the PRIDE technique and to evaluate the improvement that PRIDE observables can make to planetary ephemerides, in this case for Venus. Thus, the Venus flyby serves as a full end-to-end test in preparations for JUICE operations in the Jovian system, where VLBI data will be used to improve the Galilean satellites' ephemerides during the many flybys JUICE will encounter. Here we briefly introduce JUICE, PRIDE, and present some details of our work in the project.

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Gurvits, L. I. et al. (2023): Planetary Radio Interferometry and Doppler Experiment (PRIDE) of the JUICE Mission. Space Science Reviews, Vol. 219, Issue 8, article id.79

Radiocommunications with the International Space Station

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The conquest of space has been made possible thanks to technologically advanced telecommunications means. A great example is Earth-Moon-Earth communication, also known as lunar bounce. (It also reminds us the fact that Zoltán Bay carried out a Moon radar experiment in 1946).

Our paper intends to study and summarize the knowledge that is necessary to establish radio transmission services between ISS and the Earth Station of the university. This communication will become important for us when we can welcome Hungarian astronauts on the board of ISS.

It is our task to analyze the question whether the connection can be technically established from the roof of the university and the dormitory. We need to define the technical conditions which can guarantee the establishment of the connection with high reliability. In order to achieve this high reliability value, we need to design a geo-redundant earth station.

By the input technical parameters and expectations, we will have to carry out calculations in order to be able to determinate the adequate value of the power level. Apart from the calculations we need to explore the area where we want to establish the earth station examining whether the technical conditions are given like power supply, line of sight etc. In the chosen frequency band, we will measure the level of the noise, so that we can decide whether the given area is appropriate for the project.

Given the conditions, we will commence the planning of the scheme of the system of the station, including hardware and software elements. Following planning, we will commence the phase of implementation. As a first test, communication with a selected radio amateur satellite (repeater station) will take place. Using the results, we will continue the construction of the station so that we should be able to communicate with ISS in a similar way.

Based on scientific knowledge and utilization of engineering skills we would like to be the first to communicate with the astronauts on the board of ISS from the top of the University Győr.

Remote sensing of hydrological parameters by GNSS reflectometry

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There is an increasing interest in the remote sensing applications of the Earth's surface environments with GNSS reflectometry (GNSS-R) including river gauging, ice sheet and snow cover analysis and soil moisture measurement. It provides a new, highly precise, continuous, all-weather and near-real-time remote sensing tool that can greatly increase the available data's spatial and temporal resolution, while providing redundancy for traditional methods. Existing GNSS-R methods for such measurements are often done with expensive or cumbersome equipment that require a significant investment of time, resources, and skilled workforce to install and evaluate data. During GNSS-R measurements the direct signal from the GNSS satellite and the reflected signal from the surroundings form an interference pattern. Changes in the environment and the satellites' positions result in a time dependent signal at a given receiver position, that is a source of noise under everyday use of GNSS positioning, but also carries relevant information about the environment that can be extracted.
We have developed an easy to install, cost efficient measurement solution that automatically collects and evaluates GNSS-R data and determines water level and surface roughness. Via the prototypes installed on the Danube and around Lake Balaton, this solution is proven to be able to provide such data with sufficient reliability and precision.

Reproduction of the Lunar Radar experiment failure and success during implementation

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The first lunar radar experiment was carried out in Budapest by Zoltán Bay, a Hungarian physicist, engineer and inventor, who and his team carried out a unique experiment at the time: he successfully measured the Earth-Moon distance using radio frequency signals. The resulting distance measurements made our knowledge of distances in the solar system much more accurate. This meant that Zoltán Bay not only launched radar astronomy, but also gave birth to a new discipline. Students at the Széchenyi István University of Győr set themselves the goal of repeating the radar measurement to commemorate the experiment. Given the possibilities of the present day, the instruments and settings had to be modified. After many challenges and trials to overcome, the Győr lunar radar experiment was a success, a fitting tribute to our forefathers. Communication via the Moon has become accessible and commonplace in Győr thanks to the revival of old technology. Future plans include overcoming the noisy environment and conducting the experiment in other frequency bands.

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Review of Lagrangian Points and Scope of Stationary Satellites

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The Lagrangian points represent zones of gravitational equilibrium in a two-body system, where objects can theoretically remain in position with minimal external force. These points, known as L1, L2, L3, L4, and L5, play crucial roles in the field of astronautics, offering strategic locations for satellites and space stations due to their unique gravitational properties. This paper aims to elucidate the nature and stability of the Lagrangian points, focusing on their significance in space exploration and the positioning of spacecraft. In particular, it investigates the stability by comparing the relatively unstable collinear (L1, L2, and L3) with the more stable triangular points (L4 and L5). In addition, the paper analyses the dynamics and requirements for maintaining spacecraft in these positions by reviewing existing missions utilizing Lagrange points. It thoroughly examines the trajectories needed for moving a spacecraft between the Lagrange points within the Sun-Earth system, emphasizing the minimal delta-v (ΔV) and fuel requirements for station-keeping. The findings highlight the comparative stability and viability of L4 and L5 as potential locations for long-term space installations. It discusses the practical applications of the points in current and future astronaut missions, including the deployment of satellites and the theoretical potential for hosting megastructures. The Lagrange points offer significant opportunities for advancements in space exploration and the strategic positioning of space infrastructure. By leveraging the natural stability of L4 and L5, space missions can achieve more efficient station-keeping and mission planning. This research paper underscores the importance of these equilibrium points in astronautics, suggesting avenues for further research and application in bringing hypothetical space structures to reality.

RTK GNSS monitoring under high ionospheric activity

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RTK GNSS technique has gradually become one of the primary tools in a wide range of professions over the past two decades. GNSS infrastructure in the background can support a large number of users to use just a single rover receiver and get a few cm accurate positions almost everywhere in the covered area, having just a few clicks on the receiver. The efficiency is beyond doubt; however, users partly depend on external factors, such as the RTK service providers or mobile internet connection.

The Earth's atmosphere, especially its upper part, the ionosphere, plays an instrumental role in the performance of GNSS positioning. Now that we are approaching the next maximum of solar cycle 11-year periodicity, the ionosphere effect on RTK GNSS positioning has come again into the focus of attention. According to recent experience, ionospheric activity is getting significantly higher than during the previous solar maximum.

It comes from these that monitoring the available accuracy of RTK positioning is of utmost importance these days. This paper presents the main results of deploying a fully automated RTK monitoring service in Hungary based on monitoring stations equipped with professional or, in other cases, low-cost GNSS receivers. Accuracy, initialisation time and their correlation to ionospheric activity are investigated.

Simulating Solar Particle Events: New advances in Proton irradiation techniques for biological samples at ATOMKI

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Solar Particle Events (SPEs), characterized by energetic solar particles, predominantly protons, pose acute risks. Irradiation experiments, simulating SPEs, have been conducted to decipher biological responses to space-like radiation. Ionizing radiation, a prominent challenge in space, induces various detrimental effects including enzyme inactivation, DNA-damage, and oxidative stress. Microbial metabolism undergoes substantial alterations when exposed to the challenging conditions of space, necessitating thorough studying, particularly as human space exploration ventures beyond Low-Earth-Orbit (LEO). Understanding the adaptive mechanisms of human-associated microbes, notably advanced fungi, to the space environment is crucial to mitigate potential risks to astronaut health. Increased metabolic-activity in space may lead to elevated virulence and secondary metabolite production, necessitating comprehensive simulations and studies. Achieving complete microorganism absence in a space-habitat is impossible, inadequate understanding of altered microbial behavior poses significant threats to astronaut health, especially on other celestial bodies (e.g. the Moon), where ionizing radiation environments differ substantially from LEO. At ATOMKI, cultures of *Aspergillus nidulans* as a model organism of filamentous fungi underwent proton irradiation using a specially designed radiobiology setup aimed at simulating SPEs. State of the art molecular biology techniques were employed to analyze biological responses. Optimal irradiation fluence ensured survival of studied cultures, facilitating transcriptome analyses to elucidate physiological responses. Resilience mechanisms employed by surviving cultures were examined, revealing intricate molecular pathways triggered by irradiation. Transcriptional changes indicated upregulation of genes associated with DNA repair, telomere maintenance, and mitotic DNA integrity checkpoint signaling, alongside downregulation of genes related to vegetative growth and most unexpectedly production of antioxidant enzymes. The cultures were subjected to proton irradiation at the vertical beamline of the MGC-20 cyclotron facility. Protons, accelerated up to 17 MeV kinetic energy within the cyclotron, were transported to the irradiation site containing the cultures. The protons, having lost energy passing through the vacuum window and the polystyrene petri dish lid, possessed kinetic energy of approximately 13 MeV upon reaching the biomass surface. As protons traversed the biomass, a portion of their energy was transferred, quantified as the absorbed dose per unit mass of the biomass. Beneath the biomass layer, protons were fully stopped by the agar plates. The methodology provided precise control over proton irradiation parameters, ensuring uniform and reproducible conditions for investigating biological responses to space-like radiation. Such studies are vital for understanding the impact of space-radiation on biological systems and developing strategies to mitigate potential risks to astronaut health during prolonged space-missions.

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Space Awareness: latest fireball events and the independent allsky7/8 network of Hungary

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Owing to the personal financing and maintenance efforts, the Hungarian Meteoritical Society operates an independent allsky7/8 camera network since 2021. The 6 stations are maintained by local astronomical associations, institutions or private persons. There were several promising blowing bolides in 2023, some of which could cause meteorite falls, too. This poster shows some examples of the latest records of this system, the main information about the hardware, and the experiences of the last year's operation, as well as the possible further applications in space awareness activity. Future contributors are welcomed.

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Space Debris: Overview and Mitigation Strategies

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The space industry has grown explosively since humanity's first venture into space over 65 years ago. While this marks the coming of a new age of technological advancements and scientific achievements, it presents underlying risks, foremost of which is space debris. Rocket technology is advancing rapidly, leading to reduced launch costs, with an estimated 8,350 active satellites orbiting the Earth. There are 12000 trackable space debris objects, including decommissioned satellites, and an estimated 1 million non-trackable space objects. These objects orbit the Earth at hypervelocities, posing hazards to satellites, spacecraft, and astronauts. Space collisions are uncommon and lead to further fragmentation, exacerbating space debris accumulation. As nations worldwide invest billions in advancing their presence in space, an increasing number of organizations have plans to place constellations in orbit in upcoming years. However, with no clear strategy to tackle the issue of space debris, the likelihood of triggering the Kessler Syndrome significantly increases. This scenario would result in collisions that ultimately render the Low Earth Orbit (LEO) unpassable and confine human activities to Earth. This paper reviews existing literature on space debris, examining its sources, threats, and the current legal framework surrounding space debris mediation. Additionally, it emphasizes the necessity of international cooperation to ensure the sustainability of our space environment and reduce the strain caused by the planned mega-constellations. This paper investigates various Active Debris Removal Methods (ADS), such as Laser Orbital Debris Removal (LODR), Net Capture System, and Harpoon method. The study also explores the applicability of passive debris removal mechanisms, including drag-augmented sails. Considering current technological capabilities, each removal method's effectiveness, feasibility, relevance, and associated challenges are examined. Furthermore, the paper investigates the regulatory ISO standards in place. It emphasizes the importance of a multifaceted approach that integrates regulatory measures, international collaboration, and technological innovation to address the escalating threat of space debris and ensure a sustainable space environment. In conclusion, this paper provides a comprehensive overview of the current space debris landscape, the threats and dangers it presents, and a range of mitigation methods to reduce the impact of Space debris on space exploration.

Space Science in the Classroom

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In this decade there is a huge progress in the development of using space science in elementary and secondary education in Hungary. This is one of the efforts, which tries to promote a higher proportion of students choosing STEM (Science, Technics, Engineering, Math.) careers. I present different versions of using space science in education.

In 2024 January, the ESERO (European Space Education Resource Office) was also established in Hungary. The ESERO office organizes and supports, among other events, the various competitions, events, and projects announced by ESA for elementary and secondary school students. As an example, I will present the Moon Camp, in which the Hungarian team already achieved great international success last year, and the CanSat competition, the domestic round of which has been successfully organized by the Hungarian Astronautical Society (MANT) for several years, with the participation of about 100 high school teams every year. ESERO also directly organizes trainings for teachers to facilitate and support the formal education of STEM-related subjects.

The SpaceBuzz Erasmus+ programme (2020-2023) was a successful international project for students aged 10-12. The programme will continue at a national level. The SpaceBuzz project is a free, experiential education programme using the STE(A)M (Science, Technics, Engineering, Art, Math.) learning method. It prepares and takes children on a virtual space trip, raising their awareness of the importance of climate and environmental protection, among other things.

There is also a personal proposal for using space science in education: I will mention the low-cost classroom experimental setup I developed to demonstrate the GRACE-FO twin satellites used laser interfetometer. This setup will be showcased by me at this year's Science on Stage festival in Turku.

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Spectral instrument optimization for asteroid missions by space weathering simulation

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Asteroid surfaces are heavily influenced by space weathering effects. These cause darkening and reddening of the targets and diminishing of the infrared spectral bands of local minerals. Artificial simulation of meteorites was conducted by proton irradiation tests provided ATOMKI (by the support of NKFIH K_ K_138594 project) to mimic the space weathering consequences, with specific focus on mineral band changes of the irradiated NWA 10580, NWA 11469, NWA 5838, NWA 4560, Dho 007 meteorites. Changes of olivine, pyroxene feldspar and some further minerals was surveyed, and infrared, Raman, SEM and optical analysis were realized before and after the irradiation actions. Amorphization and Mg loss have been identified beside various changes in peak positions and FWHM values. The observed gradual degradation of crystalline lattice influences the optimization of multi- or hyperspectral band positions in future detectors. Survey of the related changes and suggestions for detector band position optimization will be presented at the meeting.

SPECTRE, a self-deploying bi-stable composite tape-spring mechanism for future nanosatellite missions

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SPECTRE (SPacE proof of Composite Tape-springs boom on REXUS Experiment) is an experiment developed by a multinational team of students from the KTH Royal Institute of Technology in Sweden. Its aim is to validate a self-deploying rigid boom mechanism in space. This includes withstanding a rocket launch and subsequently deploying in microgravity under vacuum conditions. SPECTRE seeks to contribute to the development of this technology and provide a significant improvement that will benefit its application in future nanosatellite missions. It is scheduled to fly aboard REXUS33 as part of the Cycle 15 of the Swedish-German programme REXUS/BEXUS. The REXUS/BEXUS programme allows students to fly an experiment of their own design by providing sounding rockets and high-altitude balloon platforms. This programme is realised under a bilateral Agency Agreement between DLR and SNSA through collaboration with ESA, EuroLaunch, SSC and MORABA.

SPECTRE comprises two main units: a Free-Falling Unit and a Rocket Mounted Unit. The FFU will be ejected from the REXUS rocket, comprising the boom deployment mechanism, a Recovery Unit, 3 cameras, and 2 Inertial Measurement Units to record the boom deployment dynamics, capturing essential data such as initial oscillation amplitudes and damping times. The collected information will be stored in the Recovery Unit, which will transmit its position using GNSS for precise location tracking. Upon recovery, the data from these sensors will undergo a detailed analysis to quantify the performances of the boom and enable benchmarking. From this benchmarking, SPECTRE will analyse the prospective application of this boom deployment mechanism in nanosatellite missions and space exploration.

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Study of Microwave Electrothermal Propulsion System

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Since 1960, numerous varieties of techniques for propulsion have come about to meet the propulsion needs of satellites and spacecraft. Chemical rockets currently dominate space exploration, navigation, and research. However, alternative rocket propulsion methods, such as nuclear power, electrostatic and magnetic drives, have been explored since the sector's inception to enhance efficiency by increasing exhaust velocities and reducing the required fuel for rocket vehicles. A notable category within rocket propulsion is beam-powered propulsion, also known as directed energy propulsion. This innovative class of aircraft or spacecraft propulsion involves the transmission of energy produced by ground-based power plants to the spacecraft or aircraft. Electrothermal thrusters are a type of beam-powered propulsion system where electrical energy is utilized to heat the propellant, which causes thermal expansion that results in the production of thrust. Some of the electrothermal thrusters are resistojets and arcjets rockets currently in use. The gas is heated using a heater element and DC or AC arc in resistojets and arcjets respectively. Certain shortcomings of arcjets and resistojets are eliminated in Microwave Electrothermal Truster (MET) by employing a plasma rather than an electric arc or heater element for heating the propellant. Converting a resonant cavity to the heating chamber of the propulsion system is the objective of the microwave electrothermal thruster, and the working fluid to be expelled is heated by plasma-induced using the microwave. This paper talks about the experiment conducted by the Bogazici University Space Technologies Laboratory (BUSTLab) on the prototype of MET. They have used Helium gas as the working fluid to produce thrust. This experiment measured and assessed chamber pressure and temperature, propellant mass flow rate, power levels, thrust, and specific impulse (Isp). For the experiment conducted at 500 W power, the highest Isp of 347 s & 266 mN thrust is assessed.

HSPACE2024-ABS-30

Testing remote clock synchronization with GPSDO-s and a free space laser communication system

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Precise clock synchronization is a cornerstone of many applications. An example is entanglement-based quantum key distribution, where knowing the precise arrival times of heralding photons at the transmitter side and arrival times of signal photons at a remote receiver side allows us to select the corresponding photon pairs even through a lossy and noisy channel. Here we report on testing various methods of clock synchronization between two ground stations. We used GPS disciplined oscillators (GPSDO-s) and a free-space laser communication system to synchronize remote clocks. We tested our system at various distances, from 60 meters to 500 meters and even 3 km. We found that our optical transmission system can be very precise, especially at short distances, although it is highly sensitive to optical turbulence. GPSDO-s on the other hand had larger phase noise at short distances yet remain operational even under less than ideal weather conditions.

The educational and awareness-raising activities of BME Suborbitals

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BME Suborbitals, an initiative by the Budapest University of Technology and Economics, exemplifies the integration of practical aerospace projects into higher education, bridging the gap between theoretical knowledge and real-world application. This paper presents an in-depth analysis of BME Suborbitals' flagship projects: Project Prometheus, a high-altitude rocket designed to reach the stratosphere; Kratos, a breakthrough in rocket propulsion technology; and Project Athena, an endeavor to enhance satellite communication capabilities. Each project embodies the innovative spirit and technical prowess of the team, providing students with invaluable hands-on experience in aerospace engineering.

Moreover, the organization of the CanSat competition by BME Suborbitals in Hungary serves as a cornerstone for promoting space science and engineering among high school students. This competition challenges participants to design, build, and launch a miniature satellite within the constraints of a soda can, fostering a practical understanding of satellite technology and mission design. Through this initiative, BME Suborbitals not only contributes to the academic enrichment of participants but also stimulates a broader interest in aerospace careers.

The team's participation and achievements in the European Rocketry Challenge (EuRoC) 2022 further underscore their role as pioneers in amateur rocketry. Their performance at EuRoC, marked by innovative design and engineering excellence, highlights the practical impact of their projects on the global stage, offering a testament to the value of project-based learning in fostering next-generation aerospace professionals.

This comprehensive exploration of BME Suborbitals' projects, educational initiatives, and competitive accomplishments reveals a multifaceted approach to enhancing space science education. By merging hands-on project work with competitive engagement and outreach activities, BME Suborbitals not only advances the technical skills of its members but also plays a crucial role in inspiring a new generation of engineers and scientists. The success of these initiatives advocates for a broader adoption of experiential learning models across the educational spectrum, ensuring future professionals are well-equipped to address the challenges and opportunities of the space industry.

The Expected Impact of SysML v2 to Cooperation in the Space Sector

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The next major version of the Systems Modeling Language (SysML) is in the process of finalization. SysML v2 promises to revolutionize model-based systems engineering, addressing many challenges of the space domain as well, including the management and V&V of design artifacts, cooperation with suppliers and subcontractors, and the integration of subsystems. The standard not only comes with the language specification but also a standardized API for tools, as well as conformance criteria that are expected to ensure interoperability between different tools and allow engineers to build an open software ecosystem.

The language has dedicated and powerful elements for requirements engineering, and new constructs like verification and analysis cases provide the opportunity to include V&V activities and artifacts in a unified system design model, taking traceability a large step further. A mathematical foundation ensures that models have precise semantics, facilitating automatic consistency and correctness checks to amplify the benefits of model-based systems engineering. With these capabilities, an executable system model would be suitable for conducting early analyses to assess different variations, the effect of configurations, or the consequences of certain faults, as well as to be used directly in different in-the-loop simulations and tests.

We will highlight the expected benefits of new features of SysML v2 that enable a more productive model-based systems engineering process in the space domain and showcase the potential impact of an open software ecosystem that will now finally be possible with a standardized exchange format, tool interface, and conformance criteria to make sure tools are interoperable. We argue that these capabilities are crucial to support cooperation in the space sector, where different suppliers must be able to collaborate closely to ensure a successful mission.

The first module in space by SZESAT

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The MRC-100 is a picosatellite created by Hungarian students. The owner of the idea is the Budapest University of Technology and Economics, other universities helped of the creating of the satellite.

It is a great honor that the Széchenyi István University were one of them. The students of the Széchenyi István University could designed a payload for the MRC-100 satellite. The satellite reached the space in 12 June 2023. Then, on 22 June 2023, MRC-100 began operating in space. With this success the creator universities, among them the Széchenyi István University reached the TRL 9 level. Thanks to this, they joined the small circle of those who designed a unit that is out in space and works properly.

In my poster presentation, I will present the purpose of the satellite module, its design and testing phases. I will also cover the design and building of our ground station. Nevertheless I would like to describe the technical difficulties that occurred in the planning and operational processes.

The future plans are that Széchenyi István University will deve its own picosatellite, which will also be able to go into outer space.

The future of satellite frequency usage satellite agenda items for WRC-23 and WRC-27

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The ITU held its World Radiocommunication Conference in December 2023. The priority and investigated area of radio communication was the frequency bands required by future space communication and space research services.

We would like to share the result of ITU WRC 23 with the conference participants.

In the presentation, we will summarize the results of the conference that determine future development directions of space research and space communication.

In the course of the review, we cover ESIM (40/50 GHz), space weather sensors, connections between satellites, radio astronomy, and the central ground station of NGSO systems.

Due to the technological development, the value of low-satellite orbits has increased, but their coordination is an increasingly difficult task for national administrations.

The Hungarian contribution to the T-FORS Horizon Europe project

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The Earth's ionosphere is known to be a very dynamic medium. Its plasma density at any location can change significantly even on a short timescale, for example due to wave-like disturbances, called traveling ionospheric disturbances (TIDs), mainly related to atmospheric gravity waves (AGWs) propagating in the neutral atmosphere which could be caused by the geomagnetic and lower atmospheric forcing. AGWs can transfer energy and momentum between different layers of the atmosphere, e.g. from the troposphere up to the thermosphere/ionosphere, and change their properties due to the coupling between neutral and ionized particles. The presence of TIDs can cause serious issues in the high accuracy positioning of the navigational systems, like GPS or GNSS networks. Furthermore, their impact on HF signal propagation and, through it, on civil air traffic control (on Over The Horizon Radars) is also significant.

The main objective of the T-FORS project is the development of new validated models able to issue forecasts and alerts for TIDs several hours ahead, exploiting a broad range of observations of the solar corona, the interplanetary medium, the magnetosphere, the ionosphere and the atmosphere. Machine Learning techniques are used to train models based on existing databases developed in the frames of past Horizon 2020 projects, to estimate the occurrence probability of medium scale TIDs and to forecast the occurrence and propagation of large scale TIDs. Prototype services are developed based on specifications from the users' community and following harmonized standards and quality control similar to the best practices of meteorological services. On ground demonstration tests are organised, by aerospace and civil protection agencies, to validate the performance of the T-FORS prototype services. A comprehensive architectural concept is proposed, including the densification of ground instrument networks, and new space missions, and possible future adjustments in order to develop a real-time operational service fully compliant and complementary to the ESA Space Weather services.

Within the project, the Geospace Ionosphere Research Group of the Institute of Earth Physics and Space Science (Sopron, Hungary) is mainly involved in the development of climatological models of medium-scale TIDs (MSTIDs) by manually processing large amounts of ionograms and they play a main role in the determination of preliminary indicators and alert criteria for the increased MSTID activity and in the validation of the models. In the current poster, in addition to a general presentation of the project, the activity of the Hungarian group will be presented in detail.

HSPACE2024-ABS-50

The perspective of launch capacity and strategic sovereignty of European space activity

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This research aims to analyse the European space launch capacity and its effects on the strategic sovereignty of European space activity. The analysis starts from the historical perspective of European space launch capacities which gives a brief introduction on the development and technological background of the sector and its potential. The research gives a conclusive review of current European space capacities, revealing the major issue of their temporary absence and analyses the effects of this phenomena on the strategic sovereignty of European space activity. Furthermore, this study provides a brief outlook on the space launch capacities of major space powers, thus giving references for models that can serve as an example for Europe. The aim of the research is not only to analyse the current issue of European space launch capacities, but to draw its possible future perspective, and create proposal with a special emphasis on the need for reusable space launch capacities.

The role of entanglement in the development of satellite-based quantum internet

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Nowadays, there is a growing trend on using the quantum technology in computing and communication. Although the focus is mostly on the development of quantum computers, the importance of quantum networks should not be forgotten. The aim is to connect these devices so they can communicate via a global quantum network, known as the quantum internet, following the protocols of quantum communication. There are two types of transmission channels: optical fibers and free-space systems (including satellites). Unfortunately, in the first case, the physical limitations of fiber over long distances are very significant. The satellite-based system overcomes these limitations and could enable the deployment of global quantum communications.

The quantum bit containing the quantum information is sensitive to environmental influences, so there is a high risk of decoherence, which would damage the state of quantum bit. To maintain their state over long distances, we need devices named quantum memories which preserve them with high efficiency. Quantum memories can take the role of trusted nodes in the network, where their main task is to store quantum information and transmit it to another node.

In our work, we investigated the application possibilities of quantum memories in satellite communication. To transmit quantum bits, we used quantum teleportation protocol (to support quantum communication) and E91 protocol (to support classical communication), both of them are based on the so-called entanglement. We investigated several types of quantum memory structures from different viewpoints including coherence time, storage efficiency. Furthermore, we considered which of these technologies can act efficiently as an optical interface, since quantum bits are transmitted between two nodes via optical paths in satellite-based quantum systems. We considered different technological constraints that would need to be overcome to deploy a satellite system. We analyzed the impact of one or more quantum memories in a satellite-based quantum network through a simulation of a LEO satellite constellation.

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The Space Weather Monitoring and Data Service at HUN-REN Institute of Earth Physics and Space Science (EPSS)

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The space weather-related measurements at the HUN-REN Institute of Earth Physics and Space Science embrace a long heritage. Most of the measurements were started in 1957 during the International Geophysical Year, also referred to as the third International Polar Year. In our geophysical observatory, situated in a protected environment, the magnetic and the telluric acitivity is continuously measured. The real-time data are displayed on our website, and it is refreshed in each second. The ionospheric data are also presented in real-time. In our presentation we show the most recent developments in the measurement and data management system that can satisfy the most modern needs of our times, and it can become the basis of multiple targeted data services.

Thermal performance characterization of battery insulation on ATL-1 picosatellite mission

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The ATL-1 2PQ format picosatellite was a collaborative experiment involving two private companies, ATL and H-ION Ltd. and ATL cPlc., along with the Budapest University of Technology and Economics, and the Eötvös Loránd University. This mission spanned approximately 10 months, from December 2019 to October 2020, during which ATL-1 orbited in low Earth orbit at an initial mean altitude of 387 km and a closing stable altitude of 300 km. The aim of the project was the development of functional test used for the thin-layer insulation of the batteries. Three different, aluminium oxide-based, specially structured thermal insulation materials, newly developed and manufactured by the research engineers of H-ION Ltd., along with the research scientists of the Eötvös Loránd Universit, and a reference material were used to insulate the batteries. These three materials were as follows: porous fiber, composite, and cryogelic powder, in addition to the kapton foil used as reference. The primary objective of the study was to investigate the thermal behaviour of these experimental materials in relevant space environment and to identify the most effective insulating material. Before launch, thermal conductivity factors of the materials were determined by ground-based laboratory tests, according to which the porous fiber proved to be the most effective thermal insulator. The temperature cycling resulted in by orbiting the Earth were also investigated, including variations in cycle minimum, maximum, average, and amplitude.

A specially-defined quantity called “thermal insulating intensity” was also determined from the temperature dataset to identify the most effective thermal insulator. Results show that porous fiber consistently outperformed the other materials on each side of the batteries, in agreement with the results of the pre-flight laboratory tests.

The study also includes an analysis of the „response time” of the temperature. This is defined as the temporal difference between the moment of appearance and disappearance of solar irradiation (i.e. exiting from or entering Earth’s shadow) and the time when the temperature variation changes sign. Behaviour of this quantity is also correlated strongly with better thermal characteristics of the materials in the space environment.

Thermal properties of heterogeneous materials using extended heat equations

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Today, engineering practice increasingly demands precision and minimum error, and this is also true for the proper modelling of materials used in practice, which is a major challenge. The actual properties of a material are strongly dependent on its internal structure, composition, size and the properties of its interfaces. The characterisation of materials is usually given by the classical Fourier heat equation, but this is only fully applicable to homogeneous materials. The characterisation of homogeneous materials is straightforward in this respect, but in real life most materials we use contain heterogeneities such as porosity, fractures or contact between several different materials. In our research, we have investigated a variety of materials, including rocks, carbon foams, metal foams and insulations, and experimentally studied their thermal properties.

The experiments were carried out using the so-called flash heat pulse measurement technique, whereby a single heat pulse is measured on the front side of the sample and the temperature is recorded on the rear side of the sample as a response to the pulse using a thermocouple. This is a standard procedure for determining the thermal diffusivity of samples at room temperature. The Fourier equation is used as a first approximation for processing the experimental data, but for most samples there is a discrepancy between the temperature-time series by the equation and the measured data. At the start of the measurement, the temperature increase from the equation starts later and the sample is expected to cool sooner than in reality. For this reason, two other extended heat equations, the Guyer-Krumhansl and Jeffreys equations are used in the evaluations, which can model multiple, parallel heat conduction channels, and experience shows that the extended equations describe the temperature-time series with reasonable accuracy. As a result, a discrepancy of up to 30-40% between the thermal properties given by Fourier and Guyer-Krumhansl and Jeffreys equations is observed. We wish to call attention to the possibility that size-dependent behaviour, or sensitivity on the heat pulse duration, might be present, and these properties are under investigation. In doing so, we provide a toolbox for investigating the corresponding thermal properties of materials.

Transparent Planetary Polished Thin Section Rock Sample Maker for Hungarian Hunveyor Educational Space Probe

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Our plan shows a mechanical instrument that can produce polished thin sections in situ on the surface of a planet with a connected thin section-producing unit for an optical microscope to measure microtexture at high magnification, where microbial life units (mineralized bio signatures leave traces in minerals) found on the Earth, the Moon, the Mars and in chondritic meteorites. The in situ discovery of planetary mineralized microbial microtextures in rocks would be of enormous importance.

The goal is to produce transparent rock samples in space, e.g. in zero gravity, vacuum, etc. that can be examined with an optical microscope.

The structure and main units of the transparent space rock sample maker are a rotating sample holder fork, workstations and appropriate tools.

The steps of the testing procedure are as follows: 1) Provision of the aggregate to be tested (size ~0.5 – 1 cm). 2) Thinning e.g. grinding, sanding and polishing. 3) Optical examinations include fluoroscopy, photography and analysis. 4) Sampling (possibly storage) and preparation for testing the next grain.

The steps of sample dilution: 1) Fixation of the rock grain in the sample holder 2) Cutting a plane-parallel plate (tile) 3) Coarse grinding (thinning) 4) Finishing touches 5) Polishing

Our experimental equipment possibly 1) contributes to the expansion of bioweathering and biomineralization studies to a broad range of UOCs and OCs, 2) provides an alternative model for the homogenization of chondrules through microbial weathering and diagenesis, suggesting that primitive microbial components also contributed to the formation of early planetary accretion, and 3) contributes to the clarification of the assumption that the emergence of life in the Solar System began to develop not at the molecular, but at the microbial level, and 4) initiates not only the exploration of diverse occurrences of microbes on the Earth but in all extreme environments in the Solar System, and 5) suggests that the "microbially contaminated dust" (with dormant microbes) is probably still continuously emanating from presolar objects today.

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Invitation to H-SPACE 2026

The 1st International Conference on Research, Technology and Education of Space was the opening event of the conference series. It was held on February 13, 2015.

The 2nd International Conference on Research, Technology and Education of Space was held on February 25-26, 2016.

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

The 4th International Conference on Research, Technology and Education of Space was held on February 15-16, 2018.

The 5th International Conference on Research, Technology and Education of Space was held on February 27-28, 2019.

The 6th International Conference on Research, Technology and Education of Space was held on February 26-27, 2020.

The 7th International Conference on Research, Technology and Education of Space was held on April 7-8, 2022.

The 8th International Conference on Research, Technology and Education of Space was held on April 25-26, 2024.

H-SPACE 2026, the 9th International Conference on Research, Technology and Education of Space' is planned to be organized in April 2026 in Budapest, Hungary.

The Call for Papers will be available from October 1, 2025 on the http://space.bme.hu website.