MINISTRY
OF EDUCATION, SCIENCE, RESEARCH AND SPORT OF THE SLOVAK REPUBLIC

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Slovakia PECS Activity Achievements

PECS IPL-IPS
Bratislava, Slovakia
19/9/2019

European Space Agency

HamrOptSen: Development of a Supporting Optical Sensor for High-Area-to-Mass-Ratio Objects Cataloguing and Research

Contractor: Comenius University in Bratislava, Faculty of Mathematics, Physics and Informatics (FMPI)

Contract: 4000117170/16/NL/NDe / Proposal: SK1-03	Year of Contract: 2016

TRL	Initial: 2	Achieved: 3	Target TRL: 3 Date: 2018-11-07

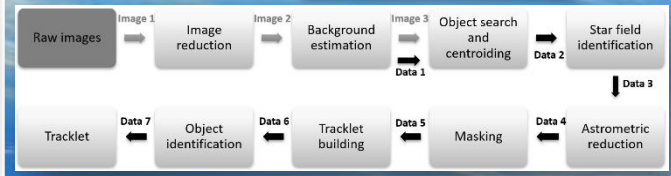
Background and justification: Space debris research aims to understand these objects origins trough studying physical and dynamical properties. Optical observations can provide several different products such as astrometric positions to be used for orbital elements determination/ improvement and cataloguing. Light curves provide information about the rotation properties and reflectivity properties of the surface. Magnitudes in standard filters and color indices provide information about objects size and surface material properties, respectively. The FMPI's background allows to involve astronomers and their well-established techniques to the space debris research. Also new scientific methods are developed.

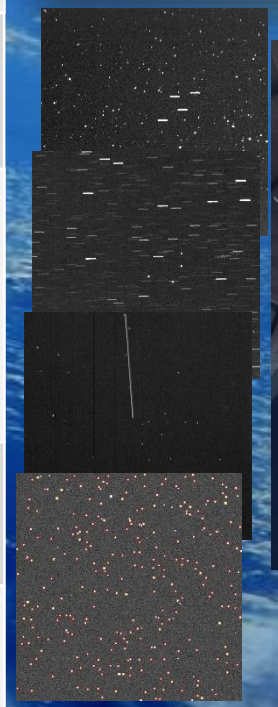
Objective(s): The main objective of this activity is to develop a pipeline processing elements for semi-automated optical sensor for the space debris observations, namely for High-Area-to-Mass-Ratio (HAMR) objects and to Near Earth minor planets, which will be a complementary sensor to the Astronomical Institute of University of Bern (AIUB) Zimmerwald station (Switzerland). A second goal is to develop observation and scientific programs at FMPI for space debris astrometry and photometry (relative and absolute). The third goal is to create interfaces between FMPI and AIUB for real time data exchange to support AIUB's cataloguing efforts for objects discovered during ESA OGS surveys.

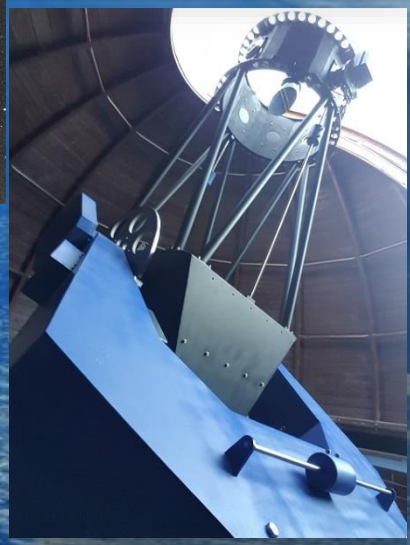
Achievements and status:
The AGO70 has been installed at the FMPI's Astronomical and Geophysical Observatory in Modra, Slovakia (AGO). The low-level telescope control has been adapted to the needs of space debris tracking with focus on accurate timing. For the image processing software we have chosen a modular design. It contains several individual elements performing tasks such as objects search on the frames, centroiding, astrometric reduction and tracklet building. The observation planning has been developed according to the AGO70 system's H/W limitations with focus on GEO, GTO and GNSS like orbits. The output products delivered by the system are astrometric positions in international formats (CCSDS TDM and MPC), light curves and relative color indices obtained by using Johnson-Cousins BVRI filters.
To proof the system capabilities, the whole activity was concluded with an observation campaign measuring AIUB's HAMR (High-Area-to-Mass-Ratio) objects and public TLE objects. The quality of the system's products was monitored by the AIUB via its state-of-the-art epoch bias and astrometric accuracy analysis routines. All the deliverables have been accepted and the activity will be concluded by the final presentation to take place in November 2018.

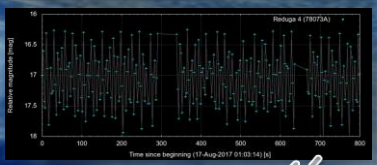
Benefits: The primary benefit is availability of high quality data, astrometric and photometric, which are ready for scientific processing. Telescope is capable of space surveillance tracking of GEO/GTO, e.g., for AIUB cataloguing, ESA or European Union SST support and is also used for educational purposes. New observation/scientific program has been established at FMPI dedicated to the research of space debris, program unique on the national level. The program allows to create new experts in space debris and SST area including observation planning, acquisition and processing, related software and hardware development and improvement. Currently, several master works dedicated to the space debris research are ongoing.

Next steps:
The following phase will consist of improving the system latency by connecting the developed image processing modules with sophisticated interfaces. The time accuracy will be improved and the system will be adapted toward the LEO tracking. The interfaces with outside systems will be extended, e.g. toward ESA's SSA SST's Expert Center, EU SST, SLR stations, and other potential partners.









SURGE: Simulating the cooling effect of urban greenery based on solar radiation modeling and a new generation of ESA sensors

Pavol Jozef Šafárik University in Košice - Košice, Slovakia

Contract: 4000117034/16/NL/Nde / Proposal: SK1-04 | **Year of Contract: 2016**

TRL	Initial: 2	Achieved: 3	Target TRL: 3 Date: 09/2018

Background and justification: This feasibility study is an important step towards spatial modelling of land surface temperature in urban environment for which solar irradiation, surface thermal emissivity and albedo and also vegetation phenology are the key factors. While solar energy income can be precisely calculated using virtual 3D city models the latter aspects require other sources of information. Sentinel 2 multispectral imagery is a potential candidate for its higher spatial and temporal resolution than other similar earth observation missions. Integrated use of the 3D urban geometry and spectral properties of landscape can become a tool for quantified assessment of different urban scenarios where vegetation plays essential role in cooling the urban climate.

Objective(s): The main technical objective is to design an algorithmic approach for simulating the cooling effect of urban greenery by modelling the solar irradia. The goal is to define the relationship between high-resolution 3-D geometry of urban greenery and vegetation metrics in selected periods throughout the year. The 3-D geometry is recorded by repeated terrestrial laser scanning. The vegetation metrics are derived from the laser scanning time series and related to metrics derived from the Sentinel 2 imagery. The area of interest comprises 4 sq. km of the central part of the Košice City ,Slovakia.

Achievements and status: Virtual 3D city model of the study area was generated from airborne lidar and photogrammetric data acquired in a single mission. A time-series of Sentinel 2 data was gathered to be compared with a reference time-series of terrestrial lidar (TLS) data of urban greenery on 4 small sites. Statistical linear relationship was defined between the vegetation metrics derived from Sentinel 2 and TLS data. A geobotanical database of urban trees was generated based on field survey. Algorithmic structure of a toolbox for modelling the land surface temperature in GRASS GIS was developed based on the Stefan-Boltzmann law and Kirchhoff rule. The use of Sentinel 2 data for estimating albedo, emissivity and solar transmittance was demonstrated. Roadmap for implementing the toolbox into the open-source GRASS GIS was proposed.

Benefits: The primary benefits are in the developed algorithm for estimating the land surface temperature in a GIS environment providing a unique platform (i) for integrating various kinds of datasets to become usable in urban planning and (ii) for exploitation of the Sentinel 2 data in mitigation of the urban heat island.

Next steps: The following phase will be in development of a compact specialized software toolbox to be implemented in open-source GRASS GIS. The roadmap suggest a 2-year period for including software design and coding, software testing and verification using validation datasets and implementation in GRASS GIS. We suggest further development based on the Tangible Landscape concept that should improve the communication and data interaction between user and model leading to increased applicability of the model in urban planning and city management

SURGE
Simulating the Cooling Efect of Urban Greenery

ÚSTAV GEOGRAFIE
Prírodovedecká fakulta UPJŠ v Košiciach

Feasibility study to observe ionospheric disturbances by one pixel UV detector (AMON-net)

Contractor: Institute of Experimental Physics, Slovak Academy of Sciences

Contract No.: 4000117740/16/NL/Nde SK1_05			YoC: 2016
TRL	Initial: 1	Achieved: 3	Target TRL: 3 Date: 2018

Background and justification:
The geographical and time variability of night-time airglow light that is produced in lower ionosphere is still among not well understood topics. The influence of the solar cycle, magnetospheric disturbances and changes in Earth atmosphere to the airglow emission are not sufficiently measured and described. Measurements of the variability of airglow light produced in lower ionosphere can provide additional information on ionospheric disturbances to existing and proposed experiments based on different physical principles. To our knowledge there is no complex study of this topic in UV spectral range. Furthermore such study could be essential for detection of extensive air showers induced by ultra high energy cosmic rays with fluorescence telescopes from the Earth orbit.

Objective(s):
The objective of the project is a study of night-time UV background models and data for the estimation of ionospheric disturbances visibility, especially during active years of the solar cycle, in night-time UV airglow light that is produced by upper atmosphere of the Earth. The available UV background models are analyzed and data are compared with the measurements of relatively simple and inexpensive ground-based one pixel UV detector. Feasibility study of ionospheric disturbances observation by one pixel detector is the main objective of this project.

Achievements and status:
Simulations of airglow production on the global scale in few decades including spectra of produced light to find out response of upper atmosphere to magnetospheric disturbances were realized. Simulations include global maps evaluations to find out appropriate points for airglow monitoring during the geomagnetic storms. Simulations of airglow production evolution on hourly scale for selected appropriate points was following. At selected positions radiation transfer of produced light together with other light components (zodiacal light and star light) through the atmosphere to Earth's ground was evaluated. Spectra of light components at the ground allow to evaluate response of ground detectors to incoming light and observability of the changes induced by geomagnetic storms. Optimal observation places were identified and statistical method to estimate changes in night sky UV light intensity was developed. Data provided by detectors in separate non ESA activity at two places with good meteorological condition were analyzed. The response of the monitored airglow intensities to the geomagnetic activity was indicated. But conclusive result, due to very quiet magnetosphere in last 200 days when measurements were done, is missing. On the other hand the variations of airglow intensities that could be related to another processes in Earth's upper atmosphere were detected and are worthy to be studied.

Benefits:
The primary benefit is providing a study of possibility to monitor a ionospheric disturbances in complementary observational channel by monitoring night sky UV light intensity. Specifically for small inexpensive one pixel detector. If this approach work, technology of detector will allow building a world network of such detectors for relatively small budget to observe global dynamics of ionosphere in airglow light.

Next steps:
Another research and measurements in future are needed to clarify average response of airglow production changes induced by geomagnetic storms. As next step we would like to continue in research in project "Follow-up of feasibility study to observe ionospheric distrurbances by airglow monitoring network (AMON-net)" from AO/1-8673/16/NL/NDe.

Space for Education, Education for Space

Contractor: Faculty of Electrical Engineering and Information Technology ,Slovak University of Technology			
Contract No.: 4000117400/16/NL/NDe/ Proposal: SK1-06			Year of Contract: 2nd
TRL	Initial: n/a	Achieved: n/a	Target TRL: n/a Date: n/a

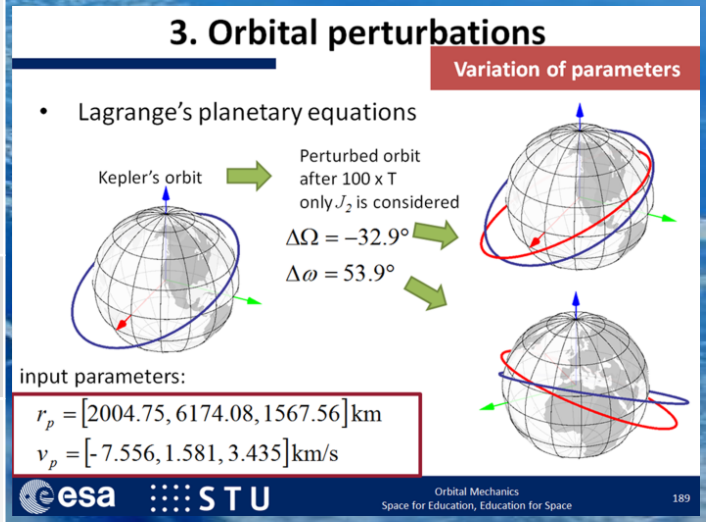
Background and justification:
Slovakia, as ESA European Cooperating State, needs to prepare both private and public sector for possible future full ESA membership. While Slovak universities have only limited influence on private sector, proper education in related subjects is needed to avoid meaningless projects. To prepare properly oriented professionals ready to take part in formation of Slovak space technological sector is the root justification of executed project.

Objective(s):
To prepare educational course related to space technologies and science in Slovakia and prepare students and staff of technologically oriented companies for participation in future ESA projects .

Achievements and status:
During project duration we staged at first 5 motivational lectures for students and broader public which attracted substantial interest. Motivational lectures have been followed by 10 more advanced lectures for genuinely interested individuals. For students from other regions of Slovakia we organized intensive course in the form of summer school. Each activity (lectures and summer school) was organized in two runs (twice). Because space related education in Slovakia is very limited, we invited foreign lecturers universities with established space courses to help us with intensive course subjects. We also prepared space related study program, down to list of subjects and syllabus, and basic textbook for such course.

Benefits:
The primary benefits are broadening of interest in space matters in broader public, introducing proper information channel related to space technologies and raising awareness of emerging opportunities.

Next steps:
The process to introduce space related study program into official Slovak educational system have been started during this project, but outcome is being unclear for now. The need for even broader space and technology in general awareness programmes is clearly badly needed. Ideally, secondary schools pupils should be targeted, i.e. before their choose career orientation.



Radiation Induced Terahertz Wave and Power Generation in Magnetic Microwires (RIT)

Contractor: FEI-STU			
Contract: 4000116936 Proposal: SK1-07			**YoC: 2016**
TRL	**Initial: 1**	**Achieved: 2**	**Target TRL: 2 Date: 2018**

Background and justification:
The conducted feasibility study is an important step in search for new radiation conversion technologies and micro-scale THz power sources

Objective(s):
The project aims to provide evaluation of feasibility of radiation induced THz wave and power generation in magnetic microwires and assess experimental and theoretical efficiency

Achievements and status:
The project provided experimental evidence of power generation using magnetic materials and femtosecond heat pulses, proving fast impulse power conversion using magnetic materials feasible. Most of the generated power was however found to lie in GHz and sub-GHz region for the tested materials and THz-TDS measurement showed no THz waves generated up to detection limits. Conversion efficiency of the test cells did not enable direct confirmation of power generation by ions and alpha radiation. Simulations of the H-field distribution around loop inductors and antennas showed a possible reason for low performance of antennas to be low sensitivity to H-field changes in the near field, where the signal is generated and a broad frequency range of the signal. Despite low efficiency, the conversion cells created were found to be useful as broadband fast UV-IR detectors, which was a subject of a patent application.

Benefits:
The primary benefits are a patent application for a broadband fast UV-IR detector arising from tests with femtosecond laser, developed and constructed measurement scheme to measure fast alpha particle induced electromagnetic effects, and established scientific cooperation between the International Laser Center and the Faculty.

Next steps:
Based on the test results, follow-up of the project is not expected unless substantial improvement in conversion cell efficiency is achieved.

Novel magnesium composites for ultralight structural components - MagUltra

Institute of Materials and Machine Mechanics, Slovak Academy of Sciences (IMSAS), Slovakia			
Contract: 4000117031/16/NL/Nde Proposal: SK1-17			YoC: 2016
TRL	Initial: 2	Achieved: 3	Target TRL: 4 Date: Q4 2020

Background and justification: The weight of load-bearing components is limiting factor in almost all space structures. Therefore the aim of the activity was to develop novel structural material with increased property to density ratio. The primary choice is magnesium based composite reinforced with high modulus carbon fibers that has a chance to form one of the lightest structural materials in the world. As previous attempts suffered from poor fiber to matrix interface, the activity was focused to solve this problem. The basic idea was to add suitable elements which form stable carbides at the interface.

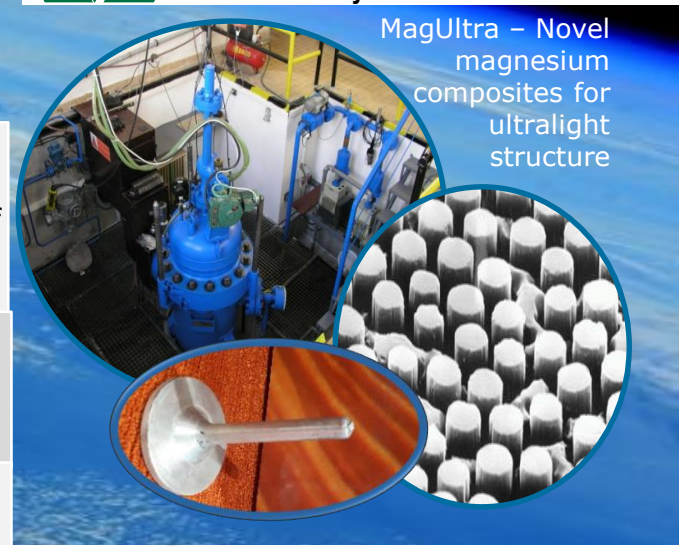
Objective(s): To develop new class of Mg matrix composite with improved interface quality, possessing following targeted properties (density ~ 1,8 g/cm3; strength at RT > 400 MPa; Young's modulus > 100GPa; Fracture toughness (above 20 MPa m1/2); Thermal conductivity> 300W/mK; CTE < 18 ppm/K, controllable via fibre orientation; good damping – loss factor > 0.001; Satisfactory corrosion resistance, incl. resistance to stress corrosion; Excellent machinability)

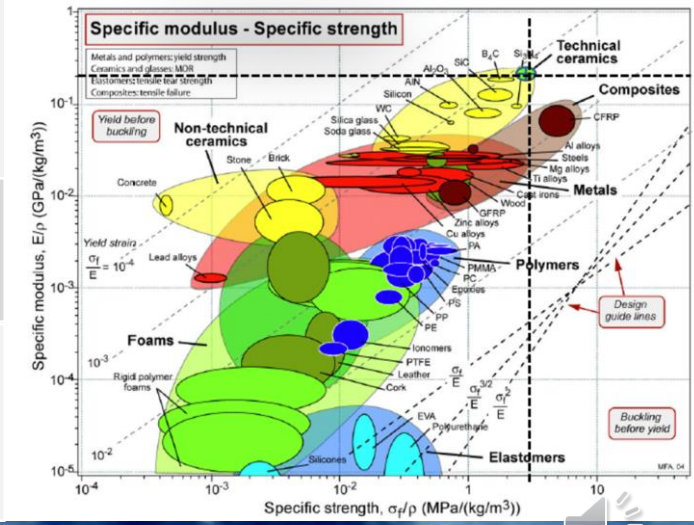
Achievements and status: The elements forming stable carbides (Zr, Cr, Ti, Y) were used for alloying of Mg matrix. The composites were prepared by gas pressure infiltration (GPI) of molten matrix into the array of carbon fibers. The technology was develop to improve quality of fiber/matrix interface, whereas alloying elements were entirely spent for carbide forming reaction without any impact on Mg matrix properties. The prepared composites underwent detailed microstructural investigations and systematic testing of most important properties including corrosion test. The most promising composites achieved bending strength over 600 MPa and Young's modulus over 300 GPa at the density of 1,8 g/cm3. The complex shape component (strut joint) has been manufactured to demonstrate attained TRL.

Benefits: The combination of Mg and C fibres form one of the lightest structural materials in the world, with excellent strength and stiffness to weight ratio, good machinability, damping, heat conductivity and dimensional stability. Stable carbides at the fibre matrix interface do not impair corrosion resistance and support the long-term durability of material. The GPI technology makes possible manufacturing of complex shape components for many structural applications.

Next steps: Such ultralight structural material will surely find a variety of space related applications, i.e. trusses, masts frameworks for launchers, platforms and planetary habitats, solar arrays, attachment systems, kinematics mounts, fasteners, components for robots, rovers, etc. The follow up projects within national funding schemes or PECS are envisaged to develop structural space related complex shape components from obtained composites and test them in space relevant environments.

institute of materials & machine mechanics
slovak academy of sciences





European Space Agency

Development of a Multi-turn Absolute Rotary Encoder for Space Application

Contractor: CTRL s.r.o., Omska 14, Kosice 04001, SLOVAKIA			
Contract No.: 4000117030/16/NL/NDe /		**PECS ref.: SK1_19**	**Year of Contract: 2016**
TRL	**Initial: 3**	**Achieved: 4**	**Target TRL: 4 Date: 19/9/2017**

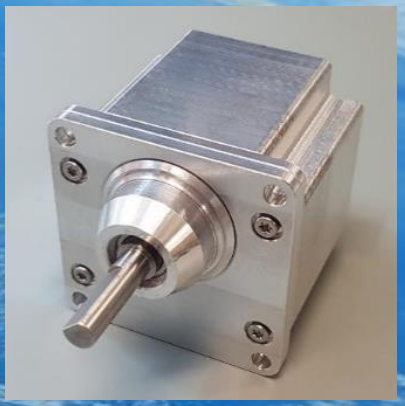
Background and justification:
The scope of CAPMARE project is to design and manufacture an EQM model of an innovative CAPacitive Multiturn Absolute Rotary Encoder that can be qualified for space application. The existing industrial prototype developed by CTRL Ltd. has been adapted in order to fulfill the requirements for space applications.

Objective(s): To develop an EQM of rotary capacitive encoder and bring it close to TRL level 5. This includes creating a design that is compatible with space environment, performing functional testing of it, and writing an environmental qualification plan with all tests required to qualify the encoder for use in space. To promote our working standards and processes to the high expectations of the European Space Agency for this and future collaborations with ESA.

Achievements and status:
The objectives of this project have been achieved by development of mechanical, hardware and firmware design of the EQM. The EQM design has been reviewed to be compatible with space environment and an environmental qualification plan has been outlined to allow future qualification of the encoder for its use in space. TRL 4 was fulfilled.

Benefits:
The project allowed CTRL to get acquainted with ESA standards and processes that were introduced into internal work processes. Another contribution of this project is that we started new work relation and collaboration with local and foreign companies involved in space area. A better understanding of requirements, processes, and level of complexity of space projects was gained during the course of the project.

Next steps:
Redesign and adjustment of CAPMARE in collaboration with Synopta GmbH, Switzerland. *(a new PECS proposal)*
Requirements are derived from Beam Pointing and Stabilization System used for laser communication in space and in Optical Ground Station. (ESA Artes SkyLight programme).



Advanced Techniques for Biomass Mapping in Abandoned Agriculture Land using Novel Combination of Optical and Radar Remote Sensing Sensors

Contractor: National Forest Centre Zvolen			
Contract No.: 4000123812/18/NL/SC / Proposal: SK2-04			Year of Contract: 2018
TRL	Initial: 1	Achieved: 2	Target TRL: 3 Date: 29. 04. 2020

Background and justification: Abandonment of agricultural landscape is an all-European problem. The project ATBIOMAP is aimed at mapping and quantification of aboveground biomass on Abandoned Agricultural Land (AAL). Methodological framework is based on analyses and cross-validation of optical (Sentinel 2) and radar satellite data (Sentinel 1 and ALOS PALSAR-2), supported by field research and airborne laser scanning (ALS) data. Users and potential customers of the project outputs are decision making sphere, land owners, managers and producers of energy from biomass.

Objective(s): The project aims to provide methodology and models for mapping – identification of succession stages and biomass estimation on AAL using novel combination of optical and radar remote sensing sensors. The main technical objectives are:
TO1) Mapping of succession stages (herbaceous, scrub and tree formations) on AAL.
TO2) Quantification of wood stock and increments on AAL and proposal of a system of permanent inventorying of wood biomass within these areas.

Achievements and status: Finalized: State of art and List of requirements of stakeholders for mapping an AAL (TN1); Theoretical base of mapping an AAL (TN2); Database of spatial reference data – description of structure and metadata (TN3); A mid-term progress report (TN4)
Open: Map outputs with information on AAL (TN5);Theoretical base of proposed algorithm for estimation of biomass stock on AAL (TN6); Models for estimation of biomass stock on AAL (TN7);
Planned: Innovative methodology of permanent tree biomass inventory on AAL based on optical and SAR satellite data (TN8); Technical data package containing detailed description of all technical works within the project implementation (TDP); Reports and documents (TN4, FR, ESR, CCD);

Benefits: The primary benefit is the development of methodology for identification of succession stages of AAL and quantification of biomass on AAL. It can be utilized in reporting of carbon sequestration and agricultural subsidiary mechanisms. Results will contribute to tracking the dynamics of AAL and its assessment in terms of biomass increment by application of satellite data in a pan-European context.

Next steps: The following phase will be: TO1) Application of computer aided photointerpretation and object-based classification of AAL classes based on a segmentation process using multi-resolution segmentation with the support of the automated Estimation of Scale Parameter; TO2) finalization of the biomass estimation models (extension of Sentinel-1 database with the winter period: with and without snow cover; fusion of Sentinel-2, Sentinel-1 and ALOS data; derivation of additional products from radar data: average images from leaf-on and leaf-off period; estimation of the classification accuracy using derived reference databases.

ADDITIVE MANUFACTURING OF CERAMIC COMPONENTS BY FDM TECHNOLOGY.

Contractor: Slovak University of Technology, Institute of Inorganic Chemistry, Technology and Materials, Faculty of Chemical and Food Technology			
Contract No.: 4000124760 / Proposal: SK2_05			Year of Contract: 2018
TRL	Initial: 2	Achieved: TBD	Target TRL: 3 Date: 2020

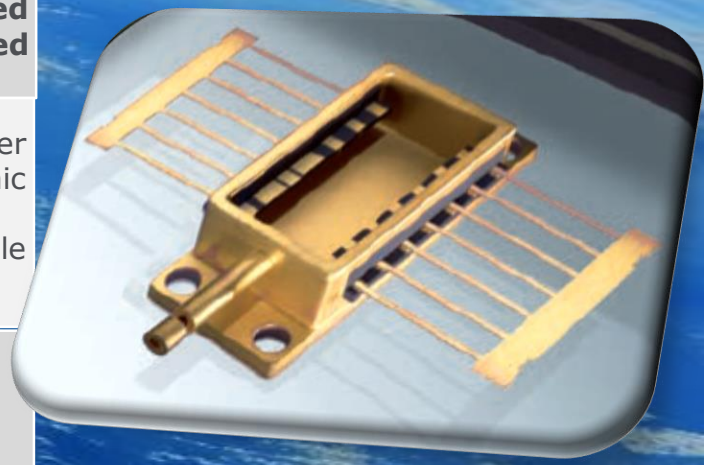
Background and justification: This activity is an important step towards freeform fabrication of ceramic components for various applications (e.g. ceramic packages to house optical and electronic components) by simple, low price fused deposition of ceramics technology using biodegradable binder systems for preparation of highly filled Al_2O_3 based filaments.

Objective(s): The project aims to provide an innovative research on the **biodegradable and/or water soluble thermoplastic polymers** (such as PVA, PLA or PEG), which shall be used to design a binder system for **alumina based composite filament. This filament will be used for manufacturing of ceramic electronic components** by **fused deposition of ceramics** (FDC) technology.

Achivements: In the first phase of the project a detailed review of the industrial, patent and scientific literature in order to find whole possible concepts for application of FDM™ technology into the development and commercialization of ceramic products was performed.
Status: Five proposed binder systems were prepared and characterized. These water soluble and/or biodegradable thermoplastic binders are under development in order to prepare highly filled ceramic-polymer composites filaments.

Benefits:
- the simple operability of the FDMTM machines, small dimensions, low weight and the simplicity of their construction
- low price and and wide availability in the market
- the multimaterial deposition is possible
- environmetally fiendly biodegradable binders for preparation of composite fillaments are proposed
- handling and storing of feedstock in the form of spools
- two phase de-binding process to eliminate part of the binder without collapse of the 3D structure

Next steps:
The key feature of Phase 2 will to develop and test five proposed binder systems containing just biodegradable thermoplastic polymers in order to obtain suitable base for manufacturing of composite filaments. These filaments will be then used for 3D printing, two steps debinding process (can reduce organic residuals by solvent - preferentially water based pre-treatment) and sintering to final ceramic body.



Electronic Packaging
SCHOTT AG, Germany

NATURAsat: Software tool for monitoring NATURA 2000 habitats by satellite images

Contractor: Algoritmy:SK

Contract No.: 4000122575/17/Proposal: SK2-06			Year of Contract: 2017
TRL	Initial: 1	Achieved: 2	Target TRL: 2 Date: Dec 2019

Background and justification:
The NaturaSat mission is an important step towards effective identification, monitoring and conservation of Natura 2000 habitats

Objective(s): The project aims to provide software tool for monitoring of Natura 2000 habitats by satellite images.

Achievements and status: Semi-automatic and automatic image segmentation methods based on evolving curves were developed, tested and validated by comparison with GPS tracks in the field. Computed image characteristics in segmented regions are used for Natura 2000 habitat classification by statistical analysis and deep learning forward-backward nonlinear diffusion networks.

Benefits:
Usefull tool for ecologists, bonatists and nature conservation

Next steps:
Further development, testing and validation of classification methods and development of tool for dynamic monitoring of habitat status.

GOCE-based high-resolution gravity field modelling in a space domain

Contractor: Slovak University of Technology in Bratislava, Faculty of Civil Engineering, Department of Mathematics and Descriptive Geometry			
Contract No.: 4000122230/17/NL/SC / Proposal: SK2-08			Year of Contract: 2017
TRL	Initial: 2	Achieved: TBD	Target TRL: 3 Date: 2019

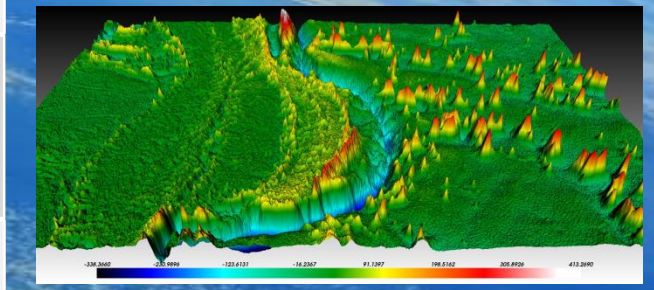
Background and justification:
The GOCE-numerics project is dealing with high-resolution gravity field modelling in a space domain based on the GOCE observations. This involves nonlinear diffusion filtering of the input GOCE gravity gradients and their processing using efficient numerical methods like the method of fundamental solutions, singular boundary method or finite volume method.

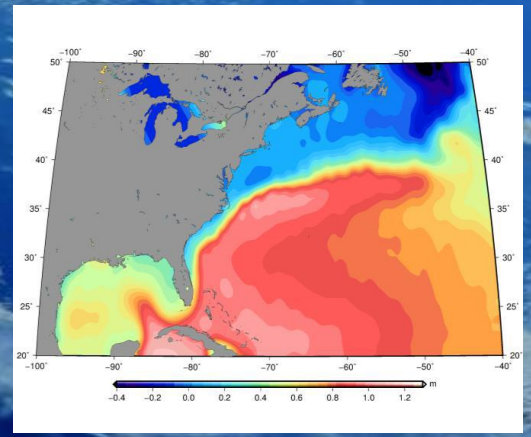
Objective(s):
The project aims to provide a static global gravity filed model by processing the filtered GOCE gravity gradients in a spatial domain that will be used (i) for precise modelling of the mean dynamic topography (MDT) and deriving velocities of surface geostrophic currents, (ii) for high-resolution modelling (1x1 arc min) of altimetry-derived gravity data on the mean sea surface, and (iii) for precise local quasigeoid modelling over Slovakia.

Achievements and status:
- The design of numerical methods for nonlinear diffusion filtering of the GOCE gravity gradients → delivered (Deliverables D2.1)
- The filtered GOCE gravity gradients in the GRF system for all period 10/2010 – 10/2013 → delivered (Deliverables D2.2)
- The design of numerical methods for global gravity filed modelling by processing the filtered GOCE gravity gradients in the spatial domain using the method of fundamental solutions and singular boundary method → delivered (Deliverables D3.1)
- The obtained static global gravity filed model → delivered (Deliverables D3.2)
- The precise MDT modelling and deriving velocities of surface geostrophic currents → delivered (Deliverables D4.1a)
- The design of numerical methods for (i) high-resolution modelling of altimetry-derived gravity data on the mean sea surface, and for (ii) precise local quasigeoid modelling over Slovakia → delivered (Deliverables D4.1b and 5.1)

Benefits:
The primary benefits are the filtered GOCE gravity gradients, static global gravity filed model processed in a spatial domain, mean dynamic topography, high-resolution altimetry-derived gravity data (1x1 arc min) and the local quasigeoid model in Slovakia.

Next steps:
The last phase of the project will be focused on high-resolution modelling (1x1 arc min) of altimetry-derived gravity data on the mean sea surface and on precise local quasigeoid modelling over Slovakia





Follow-up of feasibility study to observe ionospheric disturbances by airglow monitoring network (AMON-net)

Contractor: Institute of Experimental Physics, Slovak Academy of Sciences

Contract No.: 4000125330 / Proposal: SK2_09			YoC: 2018
TRL	**Initial: 3**	**Achieved: 3**	**Target TRL: 4 Date: 2020**

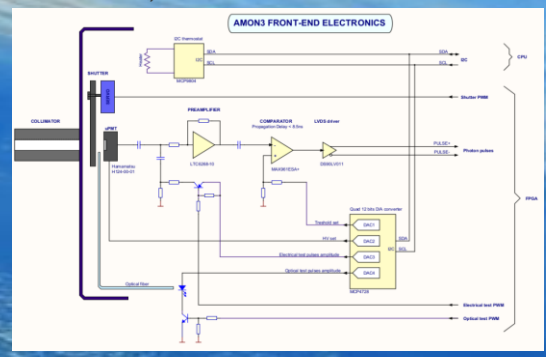
Background and justification:
The thermosphere-ionosphere system is strongly connected, therefore there is a correlation between monitoring of ionosphere by GNSS receivers and monitoring of airglow light, that is produced in thermosphere, by photosensitive detectors. This is a link up to the AMON-net that might be a part of a future multi-messenger detection network of thermosphere-ionosphere system. The development of AMON-net system is a follow-up of the project "Feasibility study to observe ionospheric disturbances by one pixel UV detector" (SK1-05).

Objective(s):
The main objective of the project is to investigate the feasibility if the network of relatively cheap and easily operated one-pixel detectors, AMON-net, could detect the variations of the airglow intensities and so to contribute to the monitoring systems of the ionospheric disturbances.

Achievements and status:
The SK2-09 activity was started on 1st October 2018. The 1st Milestone (MS1 - Preliminary Requirements Review) was successfully completed in January 2019. All following tasks are performed according Manufacturing, Assembly, Integration and Test Plan for the AMON-ES to fulfill Technical Note of System Requirement Specifications. The theoretical study was prepared to extend the results from SK1-05 activity. The results of these activities (i.e. description of construction of AMON-ES and ist first data were reported in the documentation for the 2nd milestone in July 2019. Now the work continue according to the schedule with the next planned milestone in January 2020.

Benefits:
The primary benefit of our activity is to provide investigation of the feasibility if the network of relatively cheap and easily operated one-pixel detectors (AMON-net) could detect the variations of airglow intensity and so to contribute to the monitoring systems of the ionospheric disturbances.

Next steps:
Continue in the observations by AMON-ES (Airglow MONitor - Extended Station). The AMON instrument is in process of upgrade based on AMON-ES observations and then it will be tested in the laboratory conditions.



Stratospheric Autonomous Landing System Application (SALSA)

Contractor: GOSPACE Tech. s.r.o.

Contract No.: 4000123130/18/NL/SC	**Proposal: SK2-11**	**Year of Contract: 2019**
TRL **Initial: 2**	**Achieved: In progress**	**Target TRL: 5 Date: 01/2020**

Background and justification:

Stratospheric ballooning has become a very common and popular way to conduct various experiments in the extreme environment conditions of upper layers of Earth's atmosphere. The stratosphere, ranging from 10 - 50 km above sea level, and often nicknamed as "near space", is considered to be a very valuable environment to test and verify scientific or technological concepts, many of them designed to operate later in true space environment (above 100 km of altitude).

Objective(s):

The project aims to define, develop and test an **Autonomous Landing System** of our stratospheric probe, making use of on-board GPS receivers (and other motion sensors such as gyroscopes and accelerometers), a gliding parachute driven by servomotors and an on-board computer with proper controlling software.

Achievements and status:

MS1 & MS2 completed

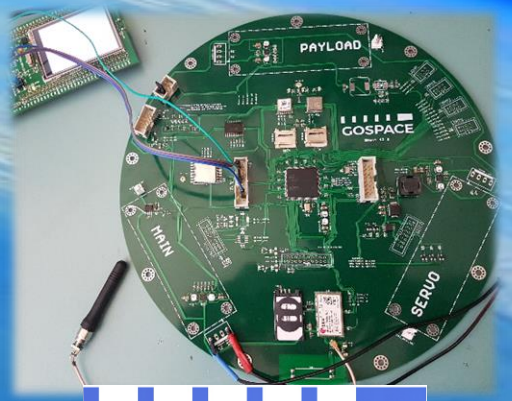
WP1 Flight theory research 100%
WP2 Computer simulation.....100%
WP3 Onboard computer HW & SW development.....100%
WP4 Design and development of Flight Equipment Chamber.....100%

Benefits:

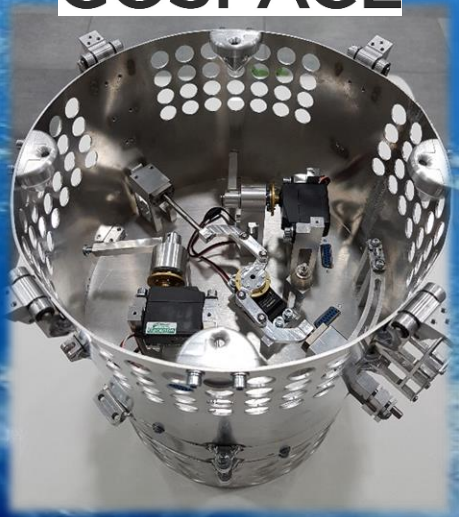
The primary benefits of MS1 - familiarization and implementation of ECSS standards in companies' practice; theoretical knowledge related to the stratospheric probes;
The primary benefits of MS2 – design, development and manufacturing of stratospheric probe SALSA; preparing of flight test procedure

Next steps:

The following phase will be functional and performance testing of designed and manufactured SALSA probe.



GOSPACE



Retrieval of Motions and Potential Deformation Threats using Sentinel-1 (remotIO)

Contractor: insar.sk s.r.o.			
Contract No.: 4000123625/18/NL/SC	**Proposal: SK2_12**		**Year of Contract: 2018**
TRL	**Initial: 2**	**Achieved: N/A**	**Target TRL: 4, Date: April 2020**

Background and justification:
The remotIO project focuses on the operational exploitation of Sentinel-1 mission for detection of potential deformation threats from Multi-Temporal InSAR (MTI) deformation maps. Our vision is to provide easy-to-interpret outputs intended for non-expert users by improving and automating some of the routine procedures involved in professional InSAR expertise, what we see as the key step towards widespread usage of InSAR data.

Objective(s):
The visual inspection of millions of scatters with wide area coverage capabilities of Sentinel-1 is not more sufficient in providing useful insights into the actual nature of undergoing processes. Our ambition is to examine data mining tools in order to improve the clarity of InSAR products, highlighting the full potential of Sentinel-1 mission.

Achievements and status:
The first prototype of a complete remotIO framework and web-based platform was successfully established and made accessible to pilot end-users at: **https://remotio.space**

All selected pilot monitoring scenarios are now processed automatically with near real-time capabilities of a remotIO system. Every pilot test site is processed utilizing PSInSAR (Persistent Scatterer InSAR) methodology and Sentinel-1 measurements.

Benefits:
Aiming at improving the understanding of kinematical behaviour of our changing environment, we are challenged to make the interpretation of InSAR results easier for key target audiences: industrial service providers, decision and policy makers, scientific and technical communities.

Next steps:
The projects aims to design a portfolio of higher level data products tailored according to demands of a wide variety of expert and non-expert InSAR users.

remotio
RETRIEVAL OF MOTIONS AND POTENTIAL DEFORMATION THREATS USING SENTINEL-1

insar.sk

Distributed European network of ground stations (DENGS)

Contractor: Orbisys s.r.o.			
Contract No.: 400121830/17/NL/SC /	**Proposal: SK2-18**		**Year of Contract: 2017**
TRL	**Initial: 2**	**Achieved: 3**	**Target TRL: 4 Date: 2019**

Background and justification:
Building high performance no-maintenance ground station with ability to track multiple satellites in LEO is a necessary task to fulfill the demand of satellite operators and operators of satellite constellations. The growth of launched satellites is larger than growth of ground stations. Inevitably, downlink will become limited if more efficient ground stations are not developed.

Objective(s):
The project aims to provide building block for the distributed network of phased-array ground stations.

Achievements and status:
Most of the PCB designs finalized & manufactured & tested in 2 units. Antenna currently tested. After 1st functioning setup is verified, the rest of the parts will be manufactured to complete the array.

Benefits:
The primary benefit is an ability to track multiple satellites in LEO with 1 ground station with zero maintenance (no moving parts).

Next steps:
Finish Phase 1 of the project and continue to Phase2: The next phase after the prototype is built and deployed will be to complete backend part of the Application SW. It will enable the whole loop - from satellite downlink to having telemetry available for customers within minutes of the satellite pass.

SPACE::LAB – Educational initiatives

Contractor: Institute of Experimental Physics of the Slovak Academy of Sciences			
Contract No.: 4000125987 / Proposal: SK3-02		Year of Contract: 2018	
TRL	Initial: NA	Achieved: NA	Target TRL: NA End Date: 2020

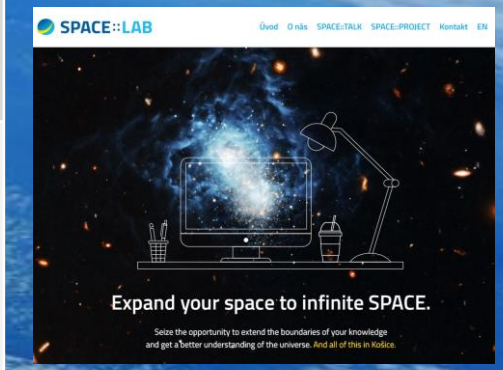
Background and justification: The Department of Space Physics (DSP) of Institute of Experimental Physics (IEP, SAS) has one of the longest tradition in the space science and engineering in Slovakia. The direct participation on the space missions began in 1970s. We would like to continue and enlarge this rich tradition, but this will be not possible without involving of the young and enthusiastic generation. The successful implementation of the activity would lead to the increasing of the Slovak young generation participation in the space science and engineering projects and could initiate new space related ideas for the future.

Objective(s): The main objectives of the "SPACE::LAB" activity are to ATTRACT young generation (high school and university students and young workers below 30 years old) by the communication channels that they are using. Then, to create a platform where the skilled space scientists and engineers could EDUCATE the attracted community directly in their lab. Finally, to select the best students and INVOLVE them to the actual space science and engineering projects of the DSP.

Achievements and status: In the first phase of the project, we have concentrated on the ATTRACT activities to present space science and engineering to the young generation. According to the communication plan we have created a web page www.space-lab.sk that is a main communication channel of SPACE::LAB project and its activities. The accounts on the social networks - Facebook, Instagram, Youtube, Meetup - were also created to communicate with the young generation by the tools that they are using. Within EDUCATE activities, four meetups SPACE::TALK were held since April for 40 - 50 participants and the capacity of the meeting room was filled. The SPACE::LAB summer school with the topic 'Machine learning and Space data' was held in August. The first round of SPACE::PROJECT competition was performed and 4 winners were selected. They took their internships in our lab in the summer 2019.

Benefits: The primary benefits are raise of awareness about space science and engineering via attractive communication channels and SPACE::TALK events. This should increase young people's motivation to choose space related education and it will offer direct participation of students on real space projects at DSP through the SPACE::PROJECT competition.

Next steps: The ATTRACT activities will continue according the communication plan. We will continue in the EDUCATE activities i.e. SPACE::TALK meetups in the following months (always each 1st Thursday in the month). We will also continue to prepare INVOLVE activities for the next year.



Laser Post-ionization Mass Spectrometer Platform for High Performance Meteorite Analysis, LaPoMaSSA

Contractor: International Laser Centre, ILC

Contract No.: 40001126501/19/NL/SC / Proposal: SK3_04			Year of Contract: 2019
TRL	Initial: 2	Achieved: TBD	Target TRL: 3 Date: 2021

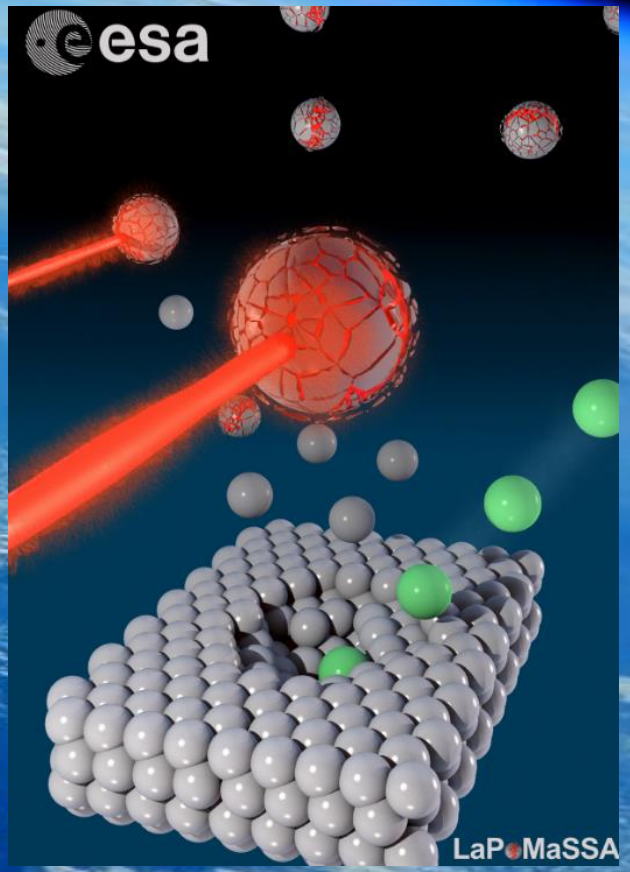
Background and justification:
Chemical composition, surface chemical imaging, and chemical depth profile of space samples are of interest, spanning from meteorites characterization, through space equipment contamination analysis, to astrobiology.

Objective(s):
Main technical objective is to develop a unique laboratory platform for chemical analysis of solid state space samples. The platform, integrating a secondary ion mass spectrometer and an ultrafast amplified laser system, is proposed to enhance sensitivity of the chemical identification of (micro-) meteorites and surface contamination layers supplied by ESA.

Achievements and status:
The elemental and molecular species are sputtered from the sample surface by the primary ions of mass spectrometer. Since the secondary ions, which are only analysed, represent only few percent of the sputtered species, the post-ionization can enhance the ion yield. The ultrafast amplified laser post-ionization is proposed with unique infrared pulses which ionize the sputtered neutral surface sample species. The platform of laser post-ionization mass spectrometer can enhance the signal up to two orders of magnitude and will be optimized on proposed samples. The optimization can also utilize an adaptive control with focus on molecular analysis. The post-ionized spectra are proposed to be automatically analysed by means of machine learning, as main programmatic objective.

Benefits:
Effectively achieved object activities will result in a goal of the fully functional laboratory platform.

Next steps:
This unique integrated platform with improved parameters will be available for return mission samples and therefore the ESA existing infrastructure would benefit from the access.



Sentinel 2 based support of forest disturbance mapping and monitoring (Sen2ForMaM)

Contractor: YMS, a.s. (ESA Entity code 1000028117)			
Contract No.: 4000126273 Proposal: SK3-05			**Year of Contract: 2018**
TRL	**Initial: 5**	**Achieved: TBD**	**Target TRL: 7 Date: 30.5.2019**

Background and justification:

The **Sen2ForMaM** mission is an important step towards to extend of viewing on existing forest geospatial information decision support system for customer State forestry Slovak republic with functionality for monitoring of forest status and disturbances with use of timely Sentinel2 satellite images and derived products. The products and services will be implemented, thoroughly tested and verified in Orava forest administration district according to requirements of already identified customer (at regional scale (ca 1500 km2 forested landscape)).

Objective(s): Improvement of forest status and disturbance with use of timely Sentinel2 satellite images and derived products

1. Development of analytical tools for assessment of forest status and disturbance using Sentinel2 products
2. Development data collection and visualization services for web and mobile platforms of forestry GIS system
3. Operationalization of Sentinel2 based forest disturbance mapping for regional forestry sector

Achievements and status:

1st meeting with external customer FORESTS Slovakia regarding user requirements and receiving the real data for winter season.
Ongoing activity:

1. Algorithms development for regional specificities – testing of example data on Sentinel Application Platform (SNAP)
2. Classification algorithm development (T1.2) – testing of example data on SNAP´
3. Change detection algorithm development – detailed analysis and first testing of example data on SNAP
4. Development of data processor for S2 L2A products (T2.1)
5. Finalization of user requirements document with ILE SAS (Andrej Halabuk)

Benefits:

1. Early identification of changes in forest health and forest disturbances
2. Prevention of larger forest disturbance and damages by timely forest management measures
3. Minimizing of the management costs and optimization of field work for monitoring

Next steps:

1. Analysis of 3 ATB documents and creation of detail development task for starting WP2
2. Check control with responsible from ILE SAS and company FOREST SK regarding implementation of ATB's documents
3. The following phase will be finalization of task Algorithms development for regional specificities
   - Development of data processor for S2 L2A products (T2.1)
   - Preparation of detailed level tasks for customer based on user requirements

Think in space.

Preparation for Athena mission – Establishing a Slovak research team oriented to existing X-ray Missions and AGN Study

Contractor: Slovak University of Technology in Bratislava			
Contract No.: 4000126330 / Proposal: SK3_06		Year of Contract: 2018	
TRL	Initial: 1	Achieved: 3	Target TRL: 4 Date: Feb-2021

Background and justification:
The research of active galactic nucley (AGNs) is a "hot" topic in modern astrophysics. These exotic objects are very luminous in X-rays, therefore they are one of the primary goals of a future X-ray mission Athena. There are several operational X-ray telescopes so far which observe AGNs. The ability to work with them is a necessary step before the use of the new Athena telescope.

Objective(s): We will establish and train new team dedicated to satellite data handling and analysis, especially oriented to X-ray missions XMM-Newton (ESA), Chandra (NASA), Swift (NASA) and NuSTAR (NASA) having accreting systems like AGNs as targets. The objective is to become independent in work with raw data, and to prepare recently non-existing Slovak platform for future X-ray mission Athena (ESA).

Achievements and status:
The scientific leader is already active in observations of cataclysmic variables with XMM-Newton, and the team has already first contact with AGN study using data from Kepler and Swift satellites. We published so far two papers in scientific journal (MNRAS), and very probably, these are first published works about AGNs by authors working at Slovak institute. Concerning the presented project, we learned so far how to handle raw data from XMM-Newton and Swift. For this purpose we invited Jan-Uwe Ness from ESAC and Achille Nucita from University of Salento as leaders of the two first workshops.

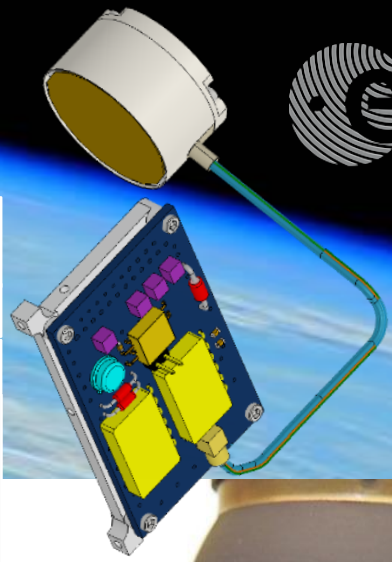
Benefits:
We are now fully independent in work with XMM-Newton and Swift which simplifies our research process. Our team members educated in software engineering can start to work as a support for other astronomers from Slovak community.

Next steps:
As a next step, we will be trained by other foreign experts how to work with data from Chandra and NuSTAR (November 2019). During the second year (starting 1.3.2020) we will increase our knowledge in AGN phenomenology and physics.

STU MTF
SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA
FACULTY OF MATERIALS SCIENCE AND TECHNOLOGY IN TRNAVA

ATRI
Advanced Technologies Research Institute

Slovak contribution to ESA-JUICE mission: Development of Anti-Coincidence Module ACM for Particle Environment Package PEP



Contractor: Institute of Experimental Physics, Slovak Academy of Sciences

Contract No.: 4000125788 / Proposal: SK3-03			Year of Contract: 2018
TRL	Initial: 5	Achieved: 6	Target TRL: 8 Date: 10/2020

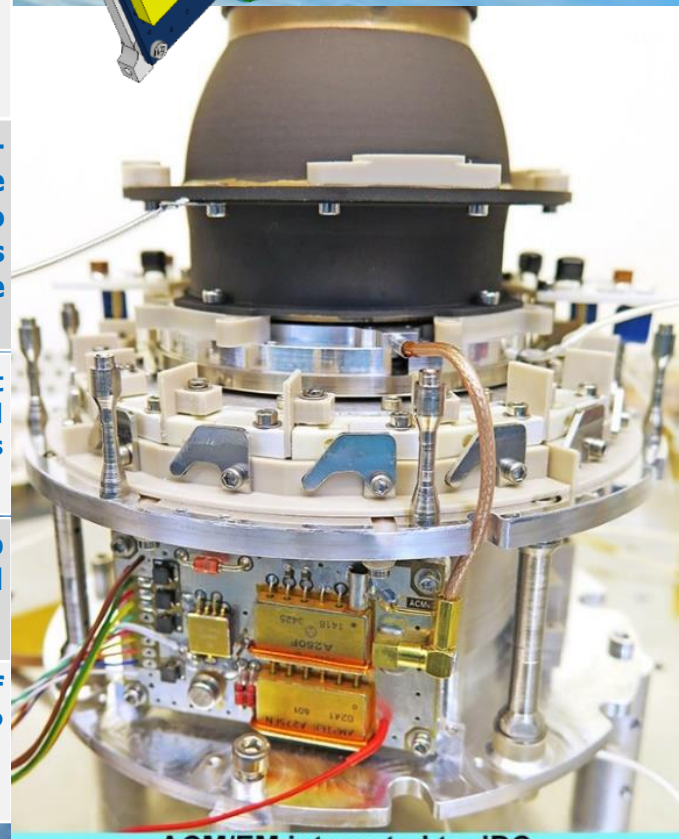
Background and justification: JUICE - JUpiter ICy moons Explorer - is the first large-class mission in ESA's Cosmic Vision 2015-2025 programme. Planned for launch in 2022 and arrival at Jupiter in 2029, it will spend at least three years making detailed observations of the giant gaseous planet Jupiter and three of its largest moons, Ganymede, Callisto and Europa. The PEP (Particle Environment Package) is science paylod of the mission to detect charged and neutral particles in the energy range 0.001 eV to > 1 MeV.

Objectives: The project aims to provide the Anti-Coincidence Module (ACM) for PEP-JDC science suite of ESA-JUICE spacecraft. The PEP (Particle Environment Package) payload is under development within wide international consortium led by Swedish Institute for Space Physics (IRF). IRF has invited IEP SAS to contribute to PEP, taking to account a long-term IEP experience with space application of solid state detectors (SSD) and previous join missions. The ACM subsystem will provide significant improvement of the particle detection efficiency on the strong electron radiation background from the Jupiter radiation belts.

Achievements and status: The engineering model ACM/EM has been succesfully designed, constructed and tested at IEP SAS facilities – and finally delivered to IRF Kiruna, Sweden in December 2018 where it was successfully integrated into PEP/JDC unit in February 2019. The flight model ACM/FM is re-designed with small modifications and improvements against the EM.

Benefits: In-time development, construction and delivery of ACM/EM to IRF was a necessary condition to keep delivery schedule for engineering model of overall PEP payload. The manufacture, testing, calibration and delivery of the ACM/FM is in compliance with present IRF schedule for PEP/FM delivery to ESA.

Next steps: The population of the ACM/FM board will start at the IRF ESA-certified facilities at beginning of October. The environmental tests (thermal vacuum, vibrations, burn-in) and calibration will take place at IEP SAS facilities in Kosice in November. The activities are in compliance with IRF schedule for PEP/FM delivery.



ACM/EM integrated to JDC

Improvement of European capabilities for LEO objects tracking with optical passive sensors

Contractor: Comenius University in Bratislava Faculty of Mathematics, Physics and Informatics

Contract No.: 4000126272/ Proposal: SK3-08	**Year of Contract: 2018**

TRL	**Initial: 2**	**Achieved: TBD**	**Target TRL: 3 Date: 2020**

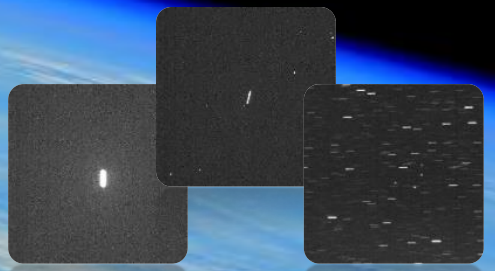
Background and justification:
Active monitoring of space debris population is essential for the safety of satellite infrastructure and its operations. Active tracking helps to improve the conjunction analysis to avoid possible on-orbit collisions, while active debris removal leads to the long-term stabilization of the space environment. Optical passive sensors can deliver observation data in the form of angular measurements which are used to improve the orbits or the pointing direction, e.g., trough the improved TLEs. The improved pointing can be delivered to Satellite Laser Ranging (SLR) sensors which can then determine the position of the object up to dozen of cm in accuracy.

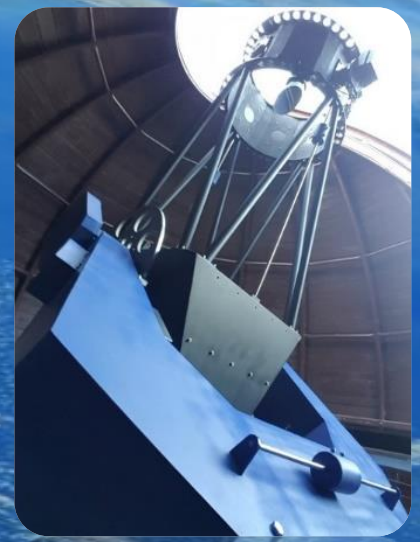
Objective(s): The project aims to provide improvement of LEO tracking by passive optical systems (telescopes) and active optical means (SLR) for both, cooperative and non-cooperative objects, development of TLE improvements from angular measurements, demonstration of technical support of other European sensors (example: AIUB in CH). It also aims to create a know-how in Slovakia for space debris tracking with optical passive sensors covering variety of subjects including telescope tasking, image processing, hardware development, observations planning/scheduling, interface development, etc.

Achievements and status:
The possible designs for the 70-cm telescope (AGO70) control unit are under preparation. H/W needs to fulfill challenging criteria for the tracking velocities up to 0.5 deg/s to be able to track LEO. Extensive testing and improvement of the so-called Image Processing Elements (IPEs), responsible for the extraction of the object's position and brightness and which were developed in the previous ESA PECS activity "HamrOptSen", is ongoing. Tests are executed on thousands of debris and NEA images acquired with the 70-cm telescope within last few years. The goal is to connect all the elements into one continuous processing pipeline with minimum interaction with a user.

Benefits:
This activity addresses a growing concern, linked to operations, and prepares Slovakia for participation in ESA's SSA, Clean Space, & Debris Research. Hence, the activity significantly benefits the institution, the Slovak Space Sector and ESA needs. Specifically, this activity offers to evolve the AGO70 system, making it a very capable European asset, and open room for Slovakian partners to step into the emerging field of laser ranging of non-cooperative objects. This is in line with the SSA programme objectives expected to meet the needs of future space safety applications, and could support operational needs in 2020 and beyond.

Next steps:
The following phase will cover improvement of the telescope control unit and the scheduling software to reach required LEO object tracking capability. Software development will be focused on processing of images with streak like objects and for the TLE improvement. The quality of the extracted products, tracklets, will be investigated. The interfaces with real-time data exchange between project's partners such as AIUB (CH), IWF (AT) and the Expert Coordination Center (ESA SST) in order to prepare for the observation campaign will be developed.





SUN SENSOR OROL PROJECT

Contractor: NEEDRONIX s.r.o. Slovakia		
Contract No.: 4000126146 / Proposal: SK3_09		**Year of Contract: 2018**
Initial TRL: 3	**Achieved: in progress**	**Target TRL: 4, Date: 2020**

Background and justification: Attitude determination systems are a vital part of almost any satellite. These systems are necessary for the proper stabilization of a spacecraft. Sun sensors are primarily used as a backup sensors, thus high reliability and durability is necessary. The activities of this project could help increase the competitiveness of Slovak companies with space industry processes, following ESA standards in the field of

Objective(s): The main goals of this project are to create a reliable and robust analogue sun sensor solution that is radiation and vibration tolerant with sufficient accuracy. The sensor will also be capable of self analysis - identification of the state of the sensor and energy saving, and it will be able to function up to 15 years in geostationary orbit.

Achievements and status: The project started in January 2019. To date, the first work package has been completed and the first deliverables have been submitted. The activity is progressing well and on schedule so far.

Benefits: The project also aims to increase the quality level and competitiveness of NEEDRONIX s.r.o. in the field of space technologies. For instance, the company will focus on maintaining high quality control and the usage of ESA standards and guidelines in manufacturing processes.

Next steps: The preparation for a Systems Requirements Review is underway. Upon the completion of the project, the sun sensor will be developed into a flight ready version to be tested in space. NEEDRONIX s.r.o. is also planning on developing other optical sensors and products in radio communication with focus primarily on S-band, X-band and optical communication links.