



VEREINIGUNG ZUR FÖRDERUNG  
DER ÖSTERREICHISCHEN WELTRAUMINDUSTRIE

AUSTRIAN SPACE INDUSTRY ASSOCIATION


# Annual Report 2023



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Anyone  
who is not active  
in space today  
will lose their lead  
on earth.

— Matthias Wachter (BDI)  
im Rahmen des 2. Weltraumkongress,  
Berlin Oktober 2023

The current AUSTROSPACE Annual Report comprises an up-to-date list of members, including their contact information, along with contributions from industrial members and research organizations detailing their space activities throughout the year 2023.

Holzhausen , September 2024



**Dieter Grebner**  
President



**Hans-Martin Steiner**  
Vice President and  
Managing Director

# Executive Committee

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## Industrial members

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Leading supplier of advanced on-board digital signal processing solutions, including navigation receivers for precise orbit determination. Well-recognized partner for deployment/pointing subsystems (mechanisms and electronics) and high-performance mechanical ground support equipment (MGSE). European market leader for design, production and integration of space thermal insulation products.

beyondgravity

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With more than 200 propulsion systems in space, more than 300 propulsion systems delivered, and over 400 years of accumulated on-orbit operation, ENPULSION is a global reference for electric propulsion systems for nano- and microsatellites. The company supports more than 40 customers on four continents from its headquarters in Austria and offices in the US and France. In 2024 ENPULSION has tripled the size of its company facilities to 4,000 sqm (43,000 sqft) to further improve its short and dependable lead times.

  
ENPULSION  
SPACECRAFT TECHNOLOGY

### EODC EARTH OBSERVATION DATA CENTRE FOR WATER RESOURCES MONITORING GMBH

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EODC provides access to high performance computing and a dedicated cloud infrastructure to access and process Earth Observation data to its customers, supporting them in building cloud native EO applications. Furthermore, EODC has a proofed track record in the operational service implementation of scientific algorithms.

eodc



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Develops and operates advanced information platforms and services for access and combined analysis of data provided by satellite Earth Observation and other geospatial sources with information of socio-economic origins. EOX is technology partner of choice in major environment monitoring and space programs (e.g. Copernicus) and in applications domains like agricultural monitoring and digital cartography.



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Eviden is your trusted digital partner for your journey to next generation space solutions. Eviden provides products, solutions and services, for ground based satellite monitoring and space situational awareness systems, for the commercial, military and governmental satellite market, for satellite operators and national space agencies.



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Founded in 2022, GATE Space develops green, chemical in-space propulsion solutions for the NewSpace economy. The company's main product is the GATE Jet-pack, a plug-and-play mobility solution for satellites, powered by the innovative GATE Thruster – the world's first spacecraft thruster capable of highly responsive deep throttling, enabling differential thrust stabilization. With these scalable, cost-effective technologies, GATE Space equips satellites with mission-lasting mobility.





## GEOVILLE INFORMATION SYSTEMS AND DATA PROCESSING GMBH

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Internationally renowned for its innovative Earth observation services, Austrian lead organisation and among the top-three in the European Commission Copernicus Land Monitoring Service Programme. GeoVille offers targeted, value-added geo-information products and related solutions for a broad international client base.



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With more than 20 years of experience as a supplier of cryogenic fluid transfer and storage solutions, Magna Aerospace has established a strong reputation as a reliable and experienced partner for the Aerospace industry. Our competences encompass design, process development, and manufacture according to the highest industry standards.



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OHB Austria GmbH is specialized in developing and combining navigation, telecommunications, and information technologies. The company is considered the leading provider of products and services for various applications in the context of satellite-based navigation systems. OHB Austria GmbH has more than two decades of research and development experience in the field of GNSS quality assurance and GNSS signal simulation.





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The company was founded in 2007 and is headquartered in Holzhausen, Upper Austria. By now Peak Technology GmbH is one of the major providers for cryogenic storage systems and high-pressure vessels as lightweight hybrid composite structures, which are installed in commercial launcher and satellite applications. By combining the whole value chain from product design to manufacturing in one place, integrated solutions for complete repulsion tank systems can be provided to our customers.



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European market leader of state-of-the-art satellite testing products and solutions. Our cutting-edge technological expertise allows for the provision of end-to-end Electrical Ground Support Equipment (EGSE) infrastructures such as Satellite Platform, Instrument and Payload test benches. We are a well-recognized long-term development partner and supplier of Ground Segment solutions for Mission Control and Earth Observation.



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The TTech Group stands for reliability, robustness and safety. Its deterministic TTEthernet solutions are increasingly used in space applications with the NASA Orion MPCV being the most prominent use case.





## Research members

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Founded in 2010 as a spin-off from the Austrian Institute of Technology (AIT), AAC is a private company (SME) that provides research, development and engineering capabilities in materials technology and testing for industrial applications with a focus in aeronautics and space. AAC started in 1998 with the ESA-certified Space Materials Testhouse under ESTEC frame contract and is coordinator of European and national research cooperation projects in aeronautics and space.



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The Space Research Institute (Institut für Weltraumforschung, IWF) in Graz focuses on the physics of our solar system and the diversity of exoplanets. With about 100 staff members from 20 nations it is not only one of the largest institutes of the Austrian Academy of Sciences (Österreichische Akademie der Wissenschaften, ÖAW), but also the only institute in Austria that develops and builds space-qualified instruments on a large scale. The data returned by them are scientifically analyzed and physically interpreted at the institute. Currently, the IWF is involved in 24 international space missions, led by ESA, NASA or national space agencies in Japan, Russia, China, or South Korea. The missions cover fleets of satellites in near-Earth space, the observation of the Sun, and the exploration of planets such as Mercury, Jupiter, and extrasolar planets.



## FACHHOCHSCHULE WIENER NEUSTADT AND FOTEC FORSCHUNGS- UND TECHNOLOGIETRANSFER GMBH

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The University of Applied Science Wiener Neustadt provides a modern education in the field of Aerospace Engineering. Combining traditional education methods with the most cutting edge R&D in Space Propulsion Technology, Space Engineering and Additive Layer Manufacturing Methods, prepares their students for the most challenging jobs in the Aerospace Engineering industry.



## TECHNISCHE UNIVERSITÄT GRAZ, INSTITUT FÜR GEODÄSIE GRAZ UNIVERSITY OF TECHNOLOGY, INSTITUTE OF GEODESY

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Internationally renowned partner in the areas of nanosatellite technology, satellite communications and navigation, satellite geodesy, remote sensing as well as development and test of Space-qualified hardware and software. Responsible for the first Austrian satellite TUGSAT-1/BRITE-Austria and follow-up missions OPS-SAT and PRETTY.





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JOANNEUM RESEARCH develops solutions and technologies for business and industry across a broad range of sectors, and conducts world-class research with over 500 employees at six locations. In cooperation with the provinces of Styria, Carinthia and Burgenland it has built up a strong, highly innovative research hub extending across southern Austria. DIGITAL – the Institute for Digital Technologies develops innovative solutions that can be used in practice under harsh conditions. The research activities focus on intelligent sensor systems that help to optimise processes and conserve resources, ensure safety and master societal challenges.



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Austria's leading laboratory for radiation hardness assurance testing of EEE components, electromagnetic compatibility and laser technology. Accredited for dosimetry services for aircrew exposure to cosmic radiation (AVIDOS). Pioneering facility for real-time prediction of space weather radiation effects. Experts in Monte Carlo modeling of radiation environments in aviation and space and shielding optimization. Trusted partner of esteemed entities such as ESA, NASA, as well as various international space organizations and industries. Involved in several space projects, providing specialized insight into both ionizing and non-ionizing radiation environments.



## Institutional members

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### FACHVERBAND DER ELEKTRO- UND ELEKTRONIKINDUSTRIE (FEEI) ELECTRICAL AND ELECTRONICS INDUSTRY

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The association for Austria's electrical and electronics industry makes an essential contribution to securing Austria's position as an attractive business location and positively influences and shapes the economic and legal framework – in ways that benefit the electrical and electronics industry. Together with 30 network partners, the FEEI plays a central role in strengthening the competitive position of the represented industry segments in the global marketplace.



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The products made by the approximately 145 members of this Association include all kinds of vehicles: from bicycles and motorbikes to on- and off-road cars, utility vehicles, trailers, surface mountings and small airplanes, as well as components such as motors, gear boxes and parts for the space industry. The products of the Austrian vehicle industry enjoy a very high reputation all over the world, which explains the high quota of international direct exports of presently 90%.



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Austria's strongest branch includes over 1,200 companies from mechanical engineering, plant construction, steel construction, metalware and foundry industries form the backbone of domestic industry. The export-oriented sector is medium-sized, consists of more than 85% of family businesses and accounts for a quarter of all Austrian exports. Many companies are world market leaders and "hidden champions".





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The Austrian Research Promotion Agency (FFG) is the national funding agency for industrial research and development in Austria. All FFG activities aim to strengthen Austria as a research and innovation location on the global market. The FFG Aeronautics and Space Agency (ALR) is the central hub for Austria's industry and science to the international aerospace sector. It implements the Austrian space policy and represents Austria in international space organisations like ESA, EU, EUMET-SAT and UN-COPUOS.



## WIRTSCHAFTSKAMMER ÖSTERREICH, SPARTE INDUSTRIE AUSTRIAN FEDERAL ECONOMIC CHAMBER, DIVISION INDUSTRY

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The Division Industry of the Austrian Economic Chamber represents the interests of more than 5,000 members in Austria. The Austrian industry generates a production value of 200 billion euros and contributes 50 billion euros to Austria's gross value added. Austria's industrial companies employ more than 450,000 people and have a strong international network with an export ratio of 69%.



# Overview of Competencies

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	AAC	Beyond Gravity	ENPULSION	EODC	EOX	Eviden	FH Wiener Neustadt	GATE Space	GeoVille	Joanneum Research	MAGNA STEYR	OHB Austria	ÖAW – IWF	Peak Technology	Selbersdorf Labor	TU Graz	Terna	TTTech
<b>Space Transportation, Manned Flights and Infrastructures</b>																		
Guidance Navigation and Control (GNC)												×						
On-Board Data Systems		×								×								×
Power																	×	
On-Board Software										×		×						×
Telemetry Tracking & Command (TT&C)										×							×	
Thermal Control		×																
Mechanisms		×																
Structural Elements														×				
Liquid Oxygen (LOx) / Liquid Hydrogen (LH2) Propulsion											×			×				
Storable Propulsion								×						×				
Liquid Oxygen (LOx) / Hydrocarbon Propulsion								×			×			×				
Solid Propulsion								×						×				
In-Situ Resource Utilisation (ISRU)							×											
Crew Habitation, Safe Haven and Extra Vehicular Activity (EVA) suits																		
Human Spaceflight and Microgravity Experiments										×					×			
<b>Satellite</b>																		
Space System Control		×					×					×						
On-Board Data Systems		×								×		×			×			×
Power		×															×	
On-Board Software		×								×		×	×		×			
Telemetry Tracking & Command (TT&C)							×			×							×	
Thermal Control		×					×											
Mechanisms		×									×							



	AAC	Beyond Gravity	ENPULSION	EODC	EOX	Eviden	FH Wiener Neustadt	GATE Space	GeoVill	Joanneum Research	MAGNA STEYR	OHB Austria	ÖAW - IWF	Peak Technology	Seibersdorf Labor	TU Graz	Terma	TTTech
<b>Satellite</b>																		
Structural Elements							×							×				
Propulsion		×	×				×	×			×			×				
Passive Instruments		×																
Telecommunication and Navigation Payloads		×								×		×					×	
Planetary Lander		×						×						×				
Planetary Lander Payloads										×			×					
<b>Ground Segment</b>																		
Ground Segment of Operating Spacecrafts							×			×							×	
Development and Construction of Space Segment		×										×		×				
Development and Construction of Ground Segment						×	×	×		×				×			×	
Operations support				×					×	×		×						
Data dissemination and access solutions				×					×	×		×						
<b>Services</b>																		
Management Support		×	×	×					×	×		×	×		×			×
Test and Certification	×	×	×				×	×				×			×		×	×
Research and Development	×		×	×			×	×	×	×	×	×	×	×	×	×	×	×
Monitoring and Analytics	×			×					×	×		×	×		×	×		
Satellite Data and Geoproducts				×	×				×	×			×		×	×		
Data Access and Streaming				×	×				×	×						×		
GI Systems and Platform Interfaces				×	×				×	×			×					
Advisory and Capacity Building									×	×			×					
Other				×	×				×			×	×		×	×		

*In this image of the Serpens Nebula from the Near-InfraRed Camera (NIRCam) on the NASA/ESA/CSA James Webb Space Telescope, astronomers found a grouping of aligned protostellar outflows within one small region (the top left corner).*

© NASA, ESA, CSA, STScI, K. Pontoppidan (NASA's Jet Propulsion Laboratory), J. Green (Space Telescope Science Institute)





# Member Reports





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*Closer Euclid view of NGC 6744's centre*

© ESA/Euclid/Euclid Consortium/NASA,  
image processing by J.-C. Cuillandre (CEA  
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# Aerospace & Advanced Composites GmbH

(AAC)

The Aerospace & Advanced Composites GmbH (AAC) was founded in 2010 as a spin-off from the Austrian Institute of Technology (AIT). AAC is a private company (SME) that provides research, development and engineering capabilities in materials technology and testing for industrial applications with a focus in aeronautics and space. AAC's aerospace research started in 1998 with the ESA-certified Space Materials Testhouse under ESTEC frame contract. AAC acts as coordinator of European and national research cooperation projects in aeronautics and space. With its interdisciplinary background in physics, chemistry, materials science, polymer engineering and mechanical and electrical engineering, More than one hundred research projects have been successfully concluded in the past 30 years.



AAC facilities at TFZ in Wiener Neustadt

In 2012 AAC moved to its new premises in Wiener Neustadt, which is based on strategic decision: in this area several new research entities and one University of Applied Sciences are located which provide for AAC a more prosperous growth. The infrastructure covers one building with labs and offices and a hall for heavy test equipment and polymer composite prototyping manufacturing. The increasing number of TVAC-services offered to space industry, made it reasonable to extend the liquid nitrogen supply with a nicely visible tank.

## Upgrade of XVC Thermal Vacuum Test Facility for MLI Bake-Out

On customer request, AAC has developed a special jig for thermal vacuum bake-out of larger MLI blankets, e.g. for METOP. The set-up had been successfully used for several activities. Apart from the METOP MLI Bakeout runs, AAC has performed a number of thermal vacuum cycling and bakeout activities for various ESA missions, like PLATO (manipulator rings), HERA (several components), JUICE (harness), CIRR (LDRS Hinge Breadboard, structural CFRP/Titanium struts), OPTISAT (TSTA MLI).

## Services to space industry from Material to Components

Furthermore, thermal vacuum qualification projects of various components on breadboard and EM level had been successfully performed for several European customers as well as bakeout of MLI and Components. Besides that, testing of materials and components was performed as services to space industry. More than 70% of the revenues from space segment were earned by testing services. However, due to confidentiality reason they cannot be shown in here.



Examples for testing services to industry

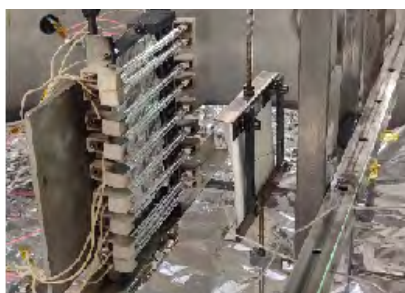
## D4D – Design for Demise

Rising space debris populations have been recognized as a significant issue for the space community. A breadth of mitigation methods have been assessed such as moving satellites to safe long-term orbits at the end of their active life or disposing of them via re-entry either actively or within reasonable timeframes after life. The second is preferred for spacecraft in Low Earth Orbits (LEO) as they do not require additional systems or significant propellant allocations. The downside is that they pose a risk to the human population when they re-enter. Within an ESA activity led by OHB [D4D Breadboarding Executive Summary, Document D4DBB-OHB-ES-001], development of feasible design concepts to achieve structure break-up or opening at an altitude above the natural break-up altitude was carried out.

This study and testing had focused on obtaining results to inform the future selection and implementation of passive technologies, active technologies, and demisable joining technologies.

At AAC, a simple and extremely cost-efficient testbed for simulating the early stages of atmospheric re-entry, targeting at altitudes of 120 to 80 km, had been developed. These tests allow the assessment of component disintegration at high altitude, identify failure mechanisms of components, thus minimizing potential damage and preserving mission integrity.

### Demisability Test of MLI Insulated Honeycomb Sample



Radiant Heater Configuration



Sample before Test



Sample after Test



AAC's radiant heater test configuration – in combination with application of mechanical loads – acts as a vital pre-screening tool, aiding in the selection of materials and components for the much more costly plasma-wind-tunnel experiments. By identifying suitable materials or components by a simple screening, we enhance the overall safety and effectiveness of re-entry processes. Our commitment to rigorous testing helps advance aerospace technology and ensures the success of future missions.

## CME – upgrade

A high degree of dimensional stability is often required for aircraft and spacecraft components. In order to evaluate polymeric composite materials for aerospace applications the coefficient of moisture expansion (CME – The ratio of length to mass variation) has to be determined. AAC measures length change and mass loss of samples in situ in vacuum.



**CME: updated Laser-Interferometer for increased accuracy**

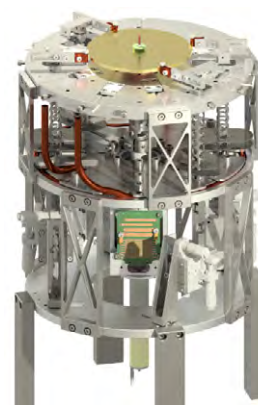
The length variation is determined by two laser interferometers, one focused to the front and one to the rear end of the sample, which is thermally stabilized with a thermostat. Those two laser interferometers have now been upgraded to gain higher accuracy and have lower thermal impact onto the setup which increases long term thermal stability on the other hand.

The main advantage of AAC CME test method is a highly accurate measurement within some days of a process, which takes typically weeks or months. AAC measures the mass loss in vacuum with an accuracy of 1 µg and the length change with an accuracy of 10nm. Both measurements are done in vacuum and are therefore close to real space conditions.

## Slipring Testing in thermal vacuum

Sliprings are a common building block of satellites and are used to transfer electrical signals and electric power onto a rotating axis. A lot of R&D in this field was ongoing in the last years and it was found, that actual tribometers are reaching their limits when it comes to testing of sliprings.

Not only the harsh environment of thermal vacuum, but also very low forces and currents ensure challenging measurements. Self-heating effects, electrical micro-interruptions, preload loss of brushes and many more effects were discovered and analysed at AAC. With the new slipring tribometer, an extended temperature range can now be covered for further analysis. The tribometer is actually under verification testing and is already foreseen to be used in two upcoming activities.

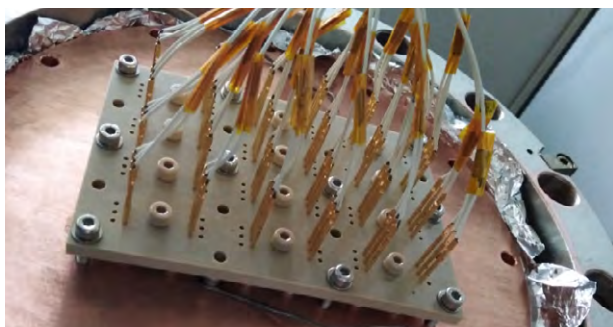


**Slipring-Tribometer**

## RF-switch – Validation of Sputter targets by RHP-Technology GmbH

This ESA-project "COMPACT KU- AND KA-BAND RF SWITCH NETWORK" led by Thales Alenia Space, has the objective to develop RF-switching components based on Ge-Te-technique: Ge-Te-Coatings allow to be switched between being electrically conductive and isolating by simple "heating pulses". Such coatings are produced by vacuum coating processed (PVD), for which RHP-Technology GmbH (AT) aims to develop sputter targets for the coating process for such Ge-Te-based Rf-switches.

One main issue is to define the proper composition of these targets. AAC assists with metallographic experience to RHP, if the Ge-Te-coatings produced from these new targets offer the proper composition. Secondly,



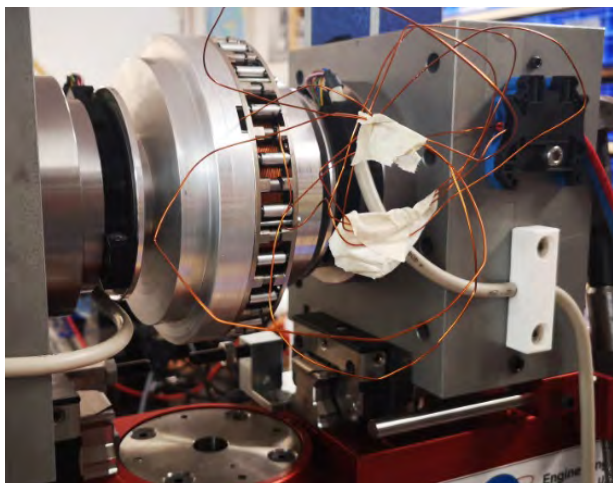
**TVAC-Testing of new Ge-Te-coating candidates: determination of switching temperature**

thermal vacuum tests were performed to assess, at which temperature these coating switch to conductive state.

Secondly it was investigated by long term TVAC-testing, if unwanted switches may occur within the operating temperatures in orbit. Finally, microscopic investigation after those tests were done to assess the coatings to be still in good condition. Based on those investigations, the best performing target was selected for production of breadboards by Thales Alenia Space (still ongoing).

## Magnetic Brake one step ahead in commercial production

Started with the ESA-project "Magnetic Brake" in 2020, an Austrian consortium (IIES, AAC, LCM) under the lead of AAC designed, built, and tested a magnetic braking system, which is based on a fundamentally new magnetic principle. The magnetic brake increases the motor's holding torque, and combines minimal power consumption, high braking torque and very smooth rotational behaviour. Therefore, and due to the convincing work and impressive results of the Austrian consortium, it was chosen by a European space company for their highly sensitive optical instrument. To meet the requirements of the new application, a new design for the magnetic brake was chosen. The engineering model (EM) was designed, manufactured, and tested. The brakes were delivered to the company end of January 2024 for initial integration steps to build their optical instrument, where final acceptance tests are expected. The flight models will be ready for shipping in July 2024. These brakes will be part of the complex satellite instrument and will be launched to space end of 2024 / beginning of 2025.



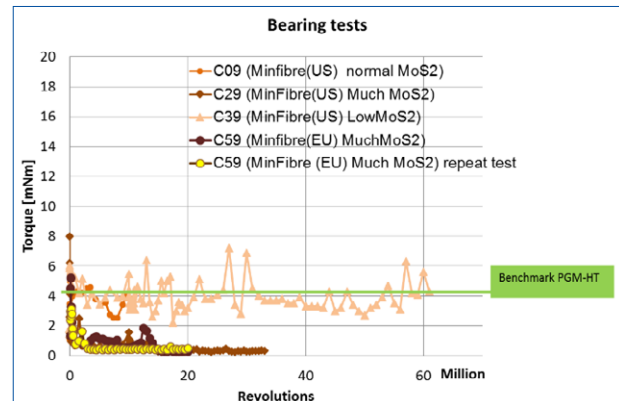
**Magnetic Brake: EM during release functional tests at IIES (left) and EM ready for shipping (right)**

## New EU-Solid lubricating material for Bearings by ENSINGER (TS8591)

To get non-dependent from non-EU-suppliers, a new material based on PTFE was developed by ENSINGER SINTIMID (AT) under assistance of AAC (Project "SLPMC2", ARTES). It's targeted use as cages in ball bearings offers the lubricant to be transferred by the balls from the cage onto the races. Bearings can be equipped only with a cage made of the new PTFE-based material. The GSTP-project "SLPMC2" could be finalised successfully in 2020.

Long term ball bearing tests show promisingly low torque of less than 1mNm, which is even lower than for competitive materials.

These promising results were derived on a lab-scale process. Within the De-Risk activity "A3Lub-Phase2" the manufacturing process was transferred to the commercial production by ENSINGER at the site of Seewalchen in Austria. Following an extensive testing campaign at AAC, the successful validation of the material was confirmed by ESA in 2023. The material can now be purchased as "TS 8519" from ENSINGER.



## Materials testhouse @ AAC

AACs frame contract to ESTEC on Metallic Material Characterisation ("ESA testhouse") aims to validate new materials and processes for use in space. The contract shall provide data necessary for space engineers to apply those new materials in their missions (which often do neither have time nor budget for extended validation of new materials).

Recent studies continued validating the SCC-resistance of new materials made by AM (Additive Manufacturing, 3D-Printing). As those alloys are intended for use in structural applications being subjected to tensile stresses, they need to offer at least medium, but preferable high resistances against Stress-Corrosion-Cracking (SCC, according to the ECSS-Q-ST-70-36). With upcoming of his new manufacturing method concerns were raised that due to "composing" those materials from powders high risk of failure due to SCC might follow. Recent studies were focusing on new Al- and Ti-based alloys. Results are published via ESA.

AAC as test service provider offers to initiate further such validation campaigns under this ESA-funding. Industry and space players are welcome to contact AAC.

## Aerospace & Advanced Composites GmbH (AAC)

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### FACTS

Sales: 1,6 M€  
 ESA Share: 0,2 M€





ESA's JUICE spacecraft  
launched from Kourou, French  
Guiana, on 14 April 2023

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# Austrian Academy of Sciences

## Space Research Institute

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The Space Research Institute (IWF) in Graz focuses on the physics of our solar system and the diversity of exoplanets. With about 100 staff members from 20 nations, it is one of the largest institutes of the Austrian Academy of Sciences (Österreichische Akademie der Wissenschaften, OeAW). The IWF is the only institute in Austria that develops and builds space-qualified instruments on a large scale. The data returned by them are scientifically analyzed and physically interpreted at the institute. IWF's core engineering expertise is in building magnetometers and on-board computers, as well as in satellite laser ranging, which is performed at a station operated by the IWF at the Lustbühl Observatory. In terms of science, the institute concentrates on the physics of solar and extrasolar planets, planet-forming disks, and space plasmas.

The IWF cooperates closely with international space agencies and with numerous other national and international research institutions. Tight cooperation exists with the European Space Agency (ESA). In 2023, the IWF was involved in 24 active and future international space missions; among these: The Cluster mission continues to provide unique data to better understand plasma processes in near-Earth space. The four Magnetospheric Multi Scale (MMS) spacecraft perform multi-point measurements to study the dynamics of the Earth's magnetosphere. The first China Seismo-Electromagnetic Satellite (CSES-1) is studying the Earth's ionosphere. CSES-2 will follow in 2024. On its way to Mercury, BepiColombo had its third planetary flyby in June.

CHEOPS (CHAracterizing ExOPlanets Satellite) continues nominal science operations, characterizing exoplanets around bright stars. ESA's Solar Orbiter observed many interesting aspects of the Sun's activity. The NASA CubeSat CUTE (Colorado Ultraviolet Transit Experiment) delivered new details about exoplanet WASP-189 b as its first science target. ESA's Jupiter ICy moons Explorer (JUICE) was launched on 14 April 2023 to investigate Jupiter and its icy moons: Ganymede, Callisto, and Europa. SMILE (launch: 2025) will study the interaction between the solar wind and Earth's magnetosphere.

The FORESAIL-2 (launch: 2025) CubeSat will characterize the variability of ultra-low frequency waves in the inner magnetosphere. PLATO (launch: 2026) is a space-based observatory to search for planets orbiting alien stars. The multi-satellite mission HelioSwarm (launch: 2028) will help to better understand the interaction between the solar wind and geospace. Comet Interceptor (launch: 2029) will characterize in detail, for the first time, a dynamically-new comet or interstellar object.

## Scientific Highlights in 2023

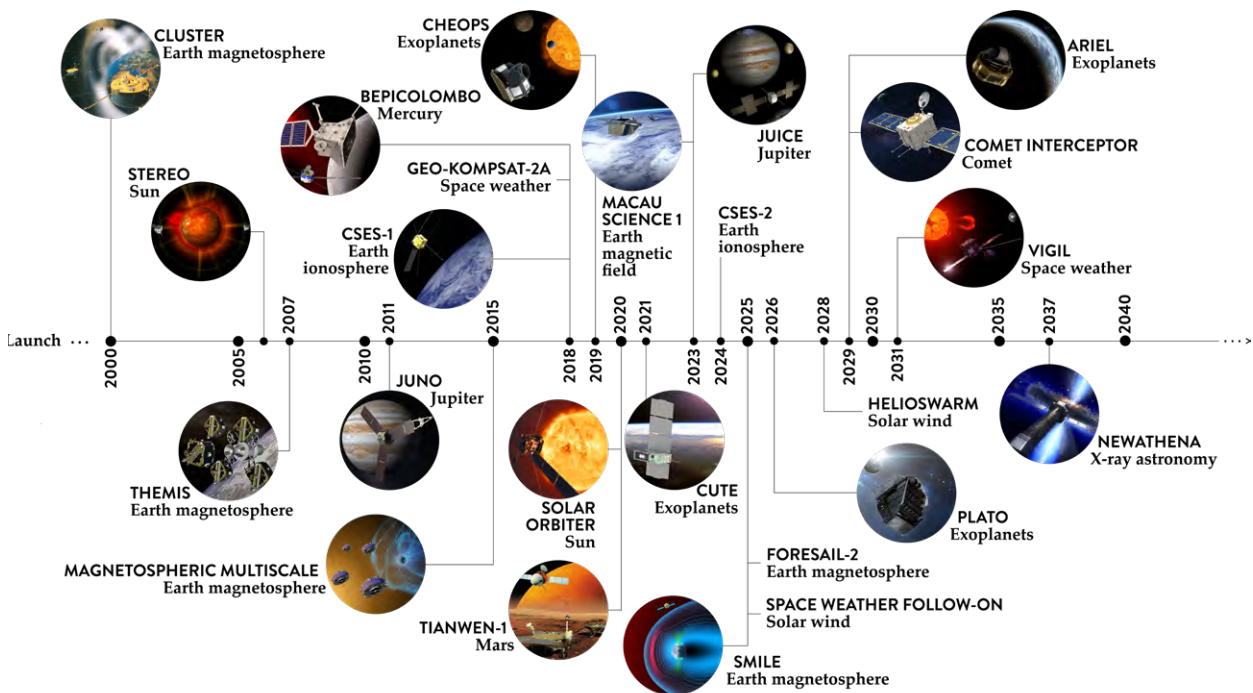
- In "Nature Geoscience" P. Barth et al. investigated experimentally the contribution of lightning to the production of biologically useful nitrogen in the early Earth atmosphere, providing new insights into the role of lightning as a source of nutrients for early life forms on Earth and exoplanets.
- T. Käufer et al. used neural networks to predict spectral energy distributions of protoplanetary disks to determine their physical structure and the dust properties. This new and faster innovative approach was presented in "Astronomy & Astrophysics".
- In "Astrophysical Journal Letters" A.G. Sreejith et al. presented the first results of observations carried out with the CUTE CubeSat mission. The near-ultraviolet spectra obtained by CUTE during the transit of the hot Jupiter WASP-189 b in front of the host star led to detection of Mg and Fe in the planetary upper atmosphere and put constraints on the atmospheric temperature profile. These results demonstrate that also small satellites are capable of providing scientific relevant results in the exoplanetary research field.
- D. Teubenbacher et al. used MMS's Active Spacecraft Potential Control data to estimate the electron density and investigate compressive turbulence in the Earth's magnetosheath. Results were published in the "Journal of Geophysical Research: Space Physics".

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## The Year 2023 in Numbers

Members of the institute published 172 papers in refereed international journals, of which 38 were first author publications. During the same period, articles with authors from the institute were cited 8134 times in the international literature. In addition, 70 talks (16 invited) and 29 posters were presented by IWF members at international conferences. Institute members were involved in the organization of 13 international meetings, e.g. EGU General Assembly, ISSI Team Meetings, EPSC, and a PLATO Workshop.

In the following, some mission highlights are summarized for each research field. For details and scientific papers published in 2023 please refer to [www.oew.ac.at/en/iwf/publications/annual-reports](http://www.oew.ac.at/en/iwf/publications/annual-reports).



**Timeline of IWF's active and future space missions** © Cluster, BepiColombo, CHEOPS, Solar Orbiter, JUICE, SMILE, Comet Interceptor, Vigil, NEWATHENA: ESA; STEREO: NASA/Jay Friedlander, THEMIS, MMS: NASA; JUNO: NASA/JPL; CSES-1: NSSC/CAS; Tianwen-1: W. X. Wan, C. Wang, C. L. Li & Y. Wei / CNSA; CUTE: LASP/UCB; Macau Science Satellite 1: MUST; PLATO: OHB System AG; ARIEL: Airbus

## Solar Wind and Geospace

A study using the BepiColombo data during its cruise phase towards Mercury revealed the presence of magnetic holes in the solar wind. The occurrence rate of these structures remained constant between Earth and Mercury, showing that these holes are created all along the solar wind.

The magnetometer sensors of CSES-1 have completed the fifth year of successful operation in low Earth orbit in February 2023. For the newly developed scalar magnetometer, this is an important proof of its reliability in space operations.

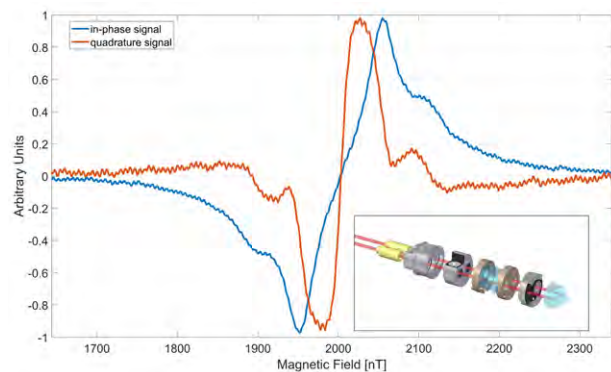
The Macau Science Satellite 1 was launched on 21 May 2023 followed by the successful commissioning of the scalar magnetometer, which supported the start of science phase of the mission end of November.

IWF's main activities for the Space Weather Follow-On (SWFO) mission included the finalization of the flight model pre-calibration, the shipment of the flight model to University of New Hampshire (UNH) and remote support of the magnetometer assembly and test at UNH as well as other test sites in the United States.

For the Solar wind Magnetosphere Ionosphere Link Explorer (SMILE) the ProtoFlight Model of the DPUs and the EBox for the Soft X-ray Imager (SXI) were produced and tested. The EBox underwent extensive functional and environmental testings, namely: thermal vacuum cycling at the IWF, vibration testing at Beyond Gravity in Vienna, electromagnetic compatibility (EMC) testing at ESTEC in The Netherlands and bakeout at the IWF. After the delivery of the EBox to the University of Leicester in December, it will be integrated to the rest of the SXI instrument, namely the X-ray telescope, sensors and front-end electronics.

## Solar System

The JUperiter ICy moons Explorer (JUICE) was launched on 14 April 2023 from Kourou, French Guiana. Its powerful instrument package will make in-situ and remote sensing measurements of Jupiter and the Galilean moons during a three-year science operation phase starting in July 2031. The IWF participates on Co-Investigator basis in the atomic scalar sensor MAGSCA for the Jupiter MAGnetometer (J-MAG), the Particle Environment Package (PEP), and the Radio and Plasma Wave Investigation (RPWI). During a three months long commissioning phase, following JUICE's launch, all antennas and deployment mechanisms were brought into flight configuration and the scientific instruments were checked out in space for the first time. MAGSCA, which was developed in close collaboration with TU Graz, verified its perfect performance, including the very first detection of a quantum interference signal used to measure magnetic fields at a distance of five million kilometers from Earth.



**The chart shows the first quantum interference signal of the Graz MAGSCA sensor, confirming the perfect functioning of the instrument after launch.**

On 19 June 2023 BepiColombo successfully performed its third Mercury flyby. The closest approach took place at 19:34 UTC at just 235 km above the planet's surface. Similar to the first two Mercury flybys in 2021 and 2022, the spacecraft approached the planet from the nightside. During the flyby most of the science instrument were activated, including the three payloads with an IWF hardware contribution on both the European Mercury Planetary Orbiter (MPO) and the Japanese Mercury Magnetospheric Orbiter (Mio): PICAM (Planetary Ion CAMera, part of the SERENA sensor suite), and the magnetometers MPO-MAG (under IWF technical management) and Mio-MGF (under IWF PI-ship). PICAM was switched on 44 hours prior to the closest approach and continued its operation until 44 hours afterwards. During this interval, PICAM monitored the solar wind, which proved to be very dynamic

and dense. The long interval in the solar wind also provided a great opportunity for PICAM to collect data of high scientific importance. The magnetosphere of Mercury was very responsive and PICAM observed ions of planetary source, for the first time since the launch of the mission. The high-time resolution data by PICAM is now being analyzed, providing more details on bow shock and magnetopause crossings, as well as inner-magnetosphere ion dynamics. Also the two magnetometers were operational during the flyby and provided valuable scientific measurements of Mercury's internal magnetic field and its interaction with the solar wind. During BepiColombo's cruise phase configuration, however, the magnetometers are severely affected by magnetic disturbance from the Mercury Transfer Module (MTM), which carries the two orbiters to Mercury. An intentional data cleaning process, utilizing measurements from MAG and MGF, has been initiated to deliver high-quality data. This effort aims to ensure the availability of reliable scientific data for the analysis of Mercury's highly dynamic magnetosphere.

Comet Interceptor, ESA's first F(ast)-class mission, is well underway in instrument development and building. The IWF contributes the Data Processing Unit (DPU) for the Mass Analyzer for Neutrals and ions at Comets (MANiaC) on spacecraft A. On spacecraft B the electronics for the Flux Gate magnetometer (BFG) as part of the Dust Field and Particles suite (DFP) is being developed and built by the IWF. In 2023, the BFG electronics of the first Engineering Model (EM1) and the structural models of the sensor and boards were delivered to the lead institute at the Polish Academy of Sciences. Further development and testing of the Electrical Functional Model (EFM, equivalent to a Qualification Model) were successfully performed. The actual EFM sensors and boards were successfully tested with in thermal-vacuum, vibration as well as calibrated in Braunschweig (Germany), which paved the way for the upcoming Comet Interceptor Flight Model. EM1 and EM2 of the MANiaC DPU were manufactured at the IWF and the functional tests for EM1 started in November.

## Exoplanets & Disks

The main exoplanet missions in which the IWF is involved with hardware and/or science are CHEOPS, CUTE, PLATO, ARIEL, and NEWATHENA.

The IWF contributed the Back-End-Electronics that is one of the two onboard computers and is responsible for controlling the data flow and the thermal stability of the CHEOPS telescope structure. The institute also developed and maintains the mission's signal-to-noise calculator. Within the Guaranteed Time Observations of the CHEOPS consortium, the IWF chairs the task force coordinating the effort towards obtaining ground-based radial velocity observations for planetary mass measurements, coordinates the re-analysis of archival observations from other facilities to better constrain planetary transit ephemerides prior to CHEOPS observations and the efforts towards modeling eclipse and phase curves observations. The institute hosts two members of the CHEOPS board, as well as two CHEOPS science team members. In 2023, about 20 refereed publications dealt with CHEOPS observations. Among those, the team published the first CHEOPS Nature paper, which carries significant IWF contribution and has been listed among the top six Nature papers of all times in terms of media coverage.

The IWF is the only technological contributor to NASA's CUTE mission outside of the University of Colorado (Boulder). In 2023, the IWF finalized the development of the data analysis pipeline and of the signal-to-noise calculator, which is extensively used for target selection and scheduling of CUTE observations, and published first scientific results.

The IWF co-leads the PLATO work package aiming at studying planetary habitability and leads the work packages studying cloud and gas chemistry, as well as multi-dimensional properties of planetary atmospheres. The institute takes part in two further work packages (on stellar characterization and on planetary evolution) aiming at gaining the knowledge and preparing the tools necessary to best exploit the data. The IWF contributes to the development of the Instrument Control Unit (ICU) by delivering the Router and Data Compression Unit (RDCU). In 2023, the RDCU Engineering Qualification Model (EQM) was completed and delivered to the National Institute for Astrophysics INAF in Italy. It was integrated with the ICU and performed nominally. The team also completed the manufacturing of the three Flight Model boards (FM1 as nominal, FM2 as redundant and FM3 as spare). The boards were inspected by an ESA soldering qualification expert in November 2023, and the minor re-works required were implemented.



ESA's ARIEL mission passed Preliminary Design Review. The IWF co-leads the upper atmosphere working group, is part of the laboratory data working group and is involved in testing the mission's performances, advancing the atmospheric retrieval tools and improving the inference of fundamental parameters (e.g. mass, age) of the host stars. ATHENA was ESA's second L(arge)-class mission in the Cosmic Vision 2015–2025 plan. It was reformulated in 2023 due to cost overrun. The now approved mission is called NEWATHENA. The institute is part of the consortium for the Wide Field Imager (WFI) and will provide the Data Processing Unit (DPU) as part of the Instrument Control Unit (ICU). In 2023, design work for the DPU prototype has started, the finalization and manufacturing is expected to be completed next year.

## Satellite Laser Ranging

The IWF operates a Satellite Laser Ranging (SLR) station at the Lustbühel Observatory, which – as one of the world-leading SLR stations – has been measuring continuously since 1982. In addition to routinely tracking more than 150 targets, which are equipped with laser retro-reflectors, the Graz SLR station is working on various international projects. Two new expansion telescope designs were developed for new SLR stations; one based on an aspheric exit lens, the second using the full aperture of a 0.8-meter telescope. Continuous upgrades to the SLR station are deployed such as the new modular observation software Sky Vision. A method for improving the precision of range measurements to Galileo satellites was developed in 2023.

## New Developments

The development of new instrument technologies is essential for competitive and excellent space research. The IWF and the Institute of Electrical Measurement and Sensor Systems of TU Graz are collaborating on the next generation of the space proven Magnetometer Front-end ASIC (MFA). It includes the readout electronics for magnetic field sensors, which is optimized in terms of size and power consumption. The next generation Application Specific Integrated Circuit (ASIC) shall feature an improved dynamic range and increased radiation hardness. It will be space qualified in the frame of the FORESAIL mission. In 2023, the MFA-4.4 prototype was tested, the design of its successor microchip was elaborated and the test hardware for radiation tests of the MFA-4.4, planned for early 2024, was developed.

As fluxgate magnetometers – the most commonly used instruments to measure static and low frequency magnetic fields in space – suffer temperature and long-term drifts, they are in specific mission cases accompanied by optical magnetometers, which use atomic resonances to provide a reference point for calibration. A recent example is the Coupled Dark State Magnetometer (CDSM), which measures the strength of the magnetic field with the help of a quantum-interference effect called Coherent Population Trapping (CPT). Thereby, the interference between quantum states of rubidium atoms excited by coherent light fields is read out optically. End of 2022, a PhD project was initiated in the frame of IWF's Young Researcher Program and in cooperation with the Institute of Experimental Physics of TU Graz to study the physical background of utilizing CPT in the so-called Hanle configuration to measure all vector components of the magnetic field. A key aspect of this study is the feasibility of a 3D-Hanle magnetometer to serve as a potential space instrument which can be combined with the existing CDSM. A combination of both instruments would yield a sensor that is fully capable of in-flight self-calibration. The focus in 2023 was on the measurements with a 1D-setup to explore the parameter space of the resonances that arise from the Hanle effect, the investigation of cross-field effects on the Hanle resonances and the definition of first concepts for the realization of a vector magnetometer based on the Hanle effect.

Machine learning (ML) techniques have shown to be valuable for accelerating data analysis and modeling efforts and may therefore become important in space research and technology. The IWF has started to identify potential application of ML, ranging from laser-ranging data analysis and integrating ML-based data compression with new hardware systems for space missions to modeling planetary disks and characterizing exoplanets. The ML initiative, led by Christiane Helling, identified and worked on ten potential research projects with ML and submitted seven research proposals to the funding agency.

## Public Outreach

The highlight of the year 2023 was the launch of ESA's JUICE mission. Together with the Austrian Research Promotion Agency (FFG), Graz University of Technology, Beyond Gravity, Terma and Geosphere Austria, the IWF organized a launch event on 13 April, which was attended by numerous guests, including OeAW President Heinz Faßmann, Rector Harald Kainz and Vice Rector Horst Bischof of TU Graz as well as City Councilor Manfred Eber representing Mayor Elke Kahr. Although the launch itself had to be postponed by one day, the audience listened to several talks, learned all about Austria's contributions to the mission and toasted the team's successes to date.

The scientific questions and results of IWF's exoplanet researchers inspired artists to video and sound installations shown in the mobile pavilion as part of the exhibition SHOWING STYRIA under the title "Atmospheres. Art, Climate and Space Research". In March, the pavilion was opened in Vienna, in April, it moved to Herberstein and in December a mini-version traveled to New York.

In the IWF colloquium and seminar series, international guest speakers (colloquium) and local speakers (seminar) inform about current research topics and scientific results. In 2023, 12 colloquia and 8 seminars were given, most of them are available on IWF's YouTube channel. The topics ranged from modeling the near-Earth plasma environment to magnetic fields shaping protoplanetary disks.

Her first visit to Austria took ESA's Director of Science, Carole Mundell, to Graz on 5 September 2023, where she presented the activities and plans of ESA's science program to the Austrian space community.

During the European Researchers' Night (ERN) held at the University of Applied Arts in Vienna on 29 September 2023, the IWF presented its contributions to JUICE to a large number of visitors of all ages.

In autumn and winter 2023, the astronomy lectures at Urania Graz focused on the James Webb Space Telescope and research at the IWF. Under the scientific lead of Christiane Helling, 8 talks were given by IWF members.



The IWF team and one of its youngest visitors at ERN in Vienna  
© bee produced

More information and pictures of the events are found at [oeaw.ac.at/en/iwf/latest/events](https://oeaw.ac.at/en/iwf/latest/events).

## Young Researcher Program

The Young Researcher Program in interdisciplinary space science and planetary research (YRP@Graz) is a close collaboration between the IWF and the two local universities, Graz University of Technology (TU Graz) and the University of Graz, which helps future researchers to gain first experiences in science. In the second year of YRP@Graz two PhD positions were funded by TU Graz and the University of Graz.

During summer time, two students from TU Wien and University of Graz performed a two-months internship, funded by the City of Graz. Additionally, three high-school students conducted an internship at the IWF, funded by FFG, and two more students completed their practical work experience days at the IWF.

Following the OeAW young science initiative "Akademie im Klassenzimmer" IWF members visited (primary) schools in Styria, Carinthia, and Vienna.

## Recognition

IWF Director Christiane Helling was nominated for Austria 23 in the category "research" by the daily newspaper "Die Presse". Daria Kubyshkina was awarded a Schrödinger Fellowship, which will take her to the University of Bern in 2024. Yasuhito Narita was appointed Professor of Theoretical Physics at TU Braunschweig and Owen Wyn Roberts was appointed Lecturer in Physics at Aberystwyth University.

## Meetings

The IWF chairs the Program Committee of the Summer School Alpbach, which took place from 11 to 20 July and was dedicated to "Exoplanets: Understanding alien worlds in diverse environments". Every year, 60 students and about 25 lecturers and tutors from ESA's member states are invited to this meeting.

At the CHAMELEON School III, the Early Stage Researchers presented their scientific results to date.

The Graz-Vienna Exoplanet Scientist Meeting (GVESM) is a series of meetings, focused on strengthening connections between researchers working in Austria in the field of exoplanet science. The meetings take place twice a year, alternating between Graz and Vienna. GVSEM II was held on 5 May at the IWF.

Graz in Space is a biennial public lecture series in which scientists and engineers present their different research areas. The first event was organized in 2002 in cooperation with the University of Graz. After a forced break of five years due to the pandemic, the 10th edition took place at the IWF. On 7 and 8 September, 16 scientists presented an overview of various space topics. Guided tours at the IWF and the Lustbühel Observatory provided additional insights into space research in Graz.

## Lecturing & Theses

In summer 2023 and in winter term 2023/2024 IWF members gave (online) lectures at the University of Graz, Graz University of Technology, FH Wiener Neustadt, TU Braunschweig, and University of Jena. Besides lecturing, IWF members are supervising Bachelor, Diploma, Master and Doctoral Theses. In 2023, 10 theses, including 2 PhD theses, have been completed.

## Austrian Academy of Sciences

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### MORE INFO

More information about IWF's research activities and publications during the year 2023 is found in the IWF Annual Report: [www.oeaw.ac.at/en/iwf/publications/annual-reports](http://www.oeaw.ac.at/en/iwf/publications/annual-reports)  
 X: @IWF\_oeaw





NASA's TEMPO instrument integrated  
on Intelsat satellite.

© Intelsat

# Beyond Gravity Austria GmbH

Since 2008 Beyond Gravity Austria GmbH has been part of Beyond Gravity with its headquarters in Switzerland. The rebranding from RUAG Space to Beyond Gravity happened in 2022. Beyond Gravity is Europe's largest independent space product supplier. In 2023 it employed around 1600 people in Switzerland, Sweden, Austria, Finland, Germany and the USA. Beyond Gravity Austria with around 240 employees is the largest space company in Austria and started its operations in 1983. The product portfolio comprises on-board electronics, mechanisms and thermal hardware as well as mechanical ground support equipment.



Highlights in 2023 include the start of the expansion of the mechanisms cleanroom in Vienna. In October the PRETTY cubesat was launched. In April Beyond Gravity Austria was awarded the state prize patent in the special category space. In November the company handed over Austria's first space product (viewport adapter for Spacelab-1) to the Technical Museum in Vienna.

## TEMPO mission: First geostationary navigation receiver in space

In April the NASA climate mission TEMPO (Tropospheric Emissions Monitoring of Pollution) launched into space. Beyond Gravity delivered a geostationary navigation receiver, called GEORIX, and an antenna to Maxar in 2021. The receiver precisely determines a satellite's position in orbit. Maxar installed GEORIX on Intelsat-40e, a geostationary communications satellite. Intelsat-40e is hosting NASA's climate payload called (TEMPO). GEORIX will help TEMPO determine where it is in orbit as it measures atmospheric gases – including ozone, nitrogen dioxide and formaldehyde, and aerosols – over North America. Data collected by TEMPO will help improve air quality forecasting. This is the first time that a Beyond Gravity navigation receiver flies in geostationary orbit, around 36'000 kilometers away from Earth. The more precisely the position that NASA's TEMPO can be determined by GEORIX, the more precise the climate data TEMPO can provide. The GEORIX receiver can process both US GPS and European Galileo navigation signals.



## 100 steering mechanisms sold

Steering mechanisms from Beyond Gravity for electrical satellite thrusters are in high demand. In 2023, a major order and other individual orders totaling over 24 million euros brought the total number of space mechanisms ordered by customers to date to almost 100. Beyond Gravity is therefore expanding its production in Vienna.

## Thermal insulation for Juice probe

The European Juice spacecraft (Jupiter Icy moons Explorer) will study the largest planet in our Solar System, Jupiter. Juice launched in April 2023 aboard an Ariane 5 rocket from Europe's spaceport in Kourou. A new type of thermal insulation keeps the internal temperature of the Juice spacecraft stable. The thermal insulation protects Juice from temperatures ranging from plus 250 degrees Celsius during Venus flyby and minus 230 degrees Celsius at Jupiter. The spacecraft weighs about six tons (including fuel). The total mass of the thermal insulation alone is 100 kilograms. In total, more than 500 individual parts of the thermal insulation were installed on the spacecraft, ranging from simple aluminized polyester film inside the satellite to external multilayer insulation consisting of more than 20 layers of coated high temperature capable polyimide film.



Thermal insulation from Beyond Gravity for Juice mission. © ESA

## Euclid telescope protected by insulation from Austria



Thermal insulation from Austria protects the Euclid telescope. © ESA

In July the Euclid telescope was launched into space. The European Space Agency (ESA) mission is designed to explore the composition and evolution of the dark Universe. Thermal insulation protects the space telescope and the platform it sits on from the extreme heat and cold in space. The thermal insulation consists of several layers of ultra-thin special plastic films. They are separated by sophisticated nettings that achieve a highly efficient insulation in the vacuum of space comparable to a brick wall of several meters thickness on Earth. The thermal insulation protects the Euclid telescope from temperatures ranging from plus 350 degrees Celsius and

minus 190 degrees Celsius. Euclid's mass in orbit is two tons. The total mass of the thermal insulation alone is 38 kilograms. In total, more than 500 individual parts of the thermal insulation were installed for the Euclid mission.

## Spacecraft container protected NASA asteroid satellite

In October 2023 NASA's asteroid satellite Psyche, was brought into space. Psyche will fly to a metal-bearing asteroid of the same name. On its way from the production facility in Pasadena, California, in the west of the USA to the spaceport in Florida on the east coast, the multi-million euro satellite was transported in a high-tech container from Beyond Gravity. The satellite container functions as a mobile clean room with high-quality damping and air-conditioning technology and a high level of cleanliness.



## Space spin-off: 30 years of cryogenic insulation for terrestrial applications

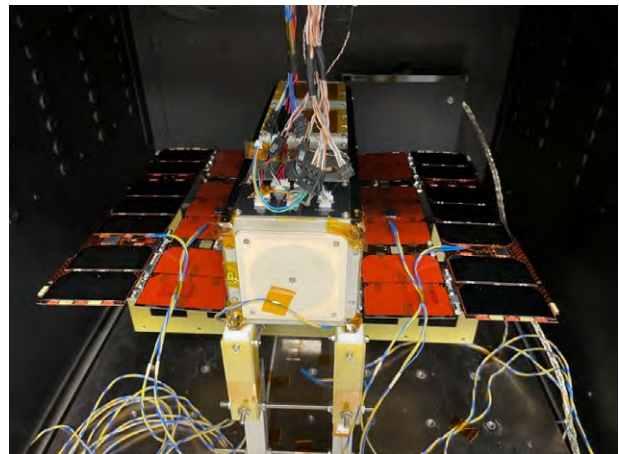
Sales in the area of cryogenic insulation for terrestrial applications – a spin-off of the company's space business – have remained a strong and commercially successful element in our thermal hardware offerings throughout 2023. 30 years ago, in 1993, Beyond Gravity started to create insulation solutions for superconductors cooled with liquid helium. These superconductors are integral to technologies like magnetic resonance imaging (MRI), superconducting accelerators and helium liquefiers. The company also extended to insulating infrastructure for liquid gas tanks, such as those used for hydrogen or liquefied natural gas, using nonflammable materials like aluminum and glass-fiber spacers.

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In recent years, Beyond Gravity Austria has intensified its efforts to develop insulation for liquid hydrogen, with a particular focus on long-haul transport vehicles, ships and aircraft powered by liquid hydrogen propulsion systems. Additionally, the company has ventured into partnerships aimed at advancing high temperature superconducting cables and superconducting generators, underlining its commitment to innovation and technological progress.

### PRETTY climate cubesat: Beyond Gravity as prime contractor

In October 2023 the Austrian mini climate satellite PRETTY was successfully launched into space on board a European Vega rocket. Austria's fifth satellite will measure the height of the glacier ice in Greenland, the wave height of the oceans and analyze the influence of space weather on the lifespan of satellites. The PRETTY climate satellite was developed and built entirely in Austria. For the first time, Beyond Gravity Austria has the overall responsibility for a satellite mission. The PRETTY (Passive REflectomeTry and dosimeTry) mission is a joint project of Beyond Gravity, TU Graz and Seibersdorf Laboratories.



Austrian climate cubesat PRETTY during tests at a thermal vacuum chamber at Beyond Gravity in Vienna.

## Beyond Gravity Austria GmbH

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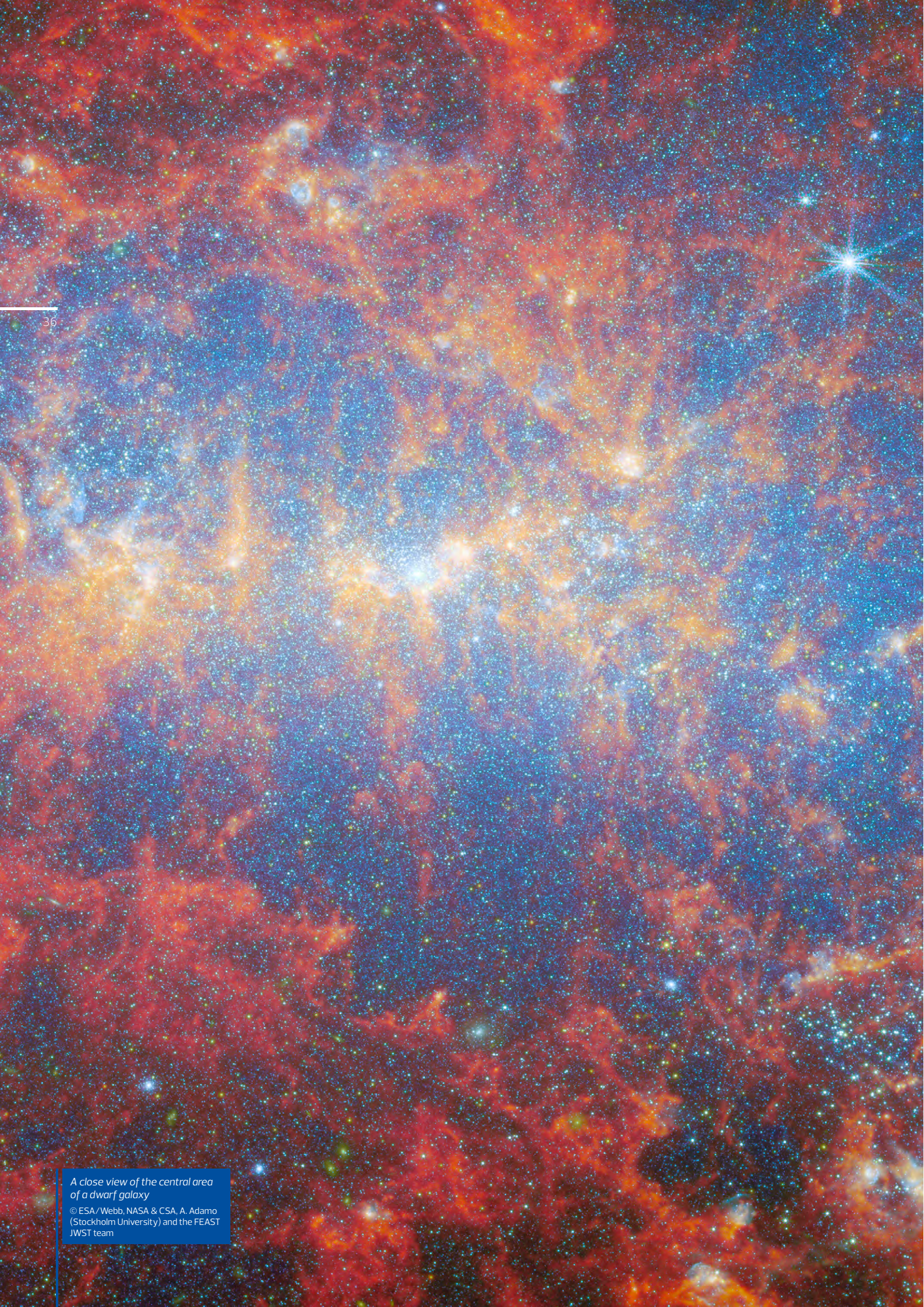
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### FACTS

Sales: 48 M€  
ESA Share: 12,2 M€







# ENPULSION GmbH

With close to 200 thrusters in space, more than 300 thrusters delivered to customers worldwide and more than 400 years of accumulated on-orbit operation, ENPULSION has rapidly become a global reference in electric propulsion systems for nano- and microsatellites.

Founded in 2016, the company has fast grown to be a leading provider of highest quality propulsion solutions for small to mid-sized and even large satellites of up to 2.000kg launch mass. In 2023 the company took the next step on its path of growth and signed the contract for its new 3,000 sqm facilities at the Vienna International Airport office park, triple the size of its current HQ in Wiener Neustadt with the planned opening of the new facilities in early 2024.

## Successes 2023

In 2023 fast-growing ENPULSION has reached several notable milestones. More than 80 employees in 3 different locations in Europe and the USA are working with more than 40 international customers, including well-known companies like Blue Canyon Technologies, OHB Italia and OHB Sweden as well as scientific institutions and space agencies, including ESA and NASA.



ENPULSION Crown Emitters

## Space Inventor and ENPULSION successfully positioned the world's first nanosatellite in GEO

On May 1st, 2023 GS-1 by Gravity Space, the world's first nanosatellite destined for geostationary orbit, was launched on board a SpaceX Falcon Heavy rocket. Mid July it reached another important milestone: commissioning of the spacecraft was successfully completed, and the satellite was sent on its way to its final orbit in GEO, which it successfully reached in August 2023 by utilizing three of ENPULSION's NANO AR<sup>3</sup> propulsion systems.



## A historical effort

GS-1, a 16U satellite manufactured by Space Inventor, is the smallest satellite ever to go to geostationary orbit. It is utilizing the ENPULSION NANO AR<sup>3</sup> thruster – which is the first ENPULSION thruster with vectoring capabilities to be used in GEO. This first of its kind mission demonstrates that nanosatellites and FEEP propulsion technology are a competitive and viable option for GEO missions – historically a domain of large and very heavy satellites and traditional chemical propulsion systems.

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## ENPULSION signed the Statement for a Responsible Space Sector

Paris, France, September 11, 2023 – In Paris last week, in the margins of the World Satellite Business Week and together with Josef Aschbacher, Luise Clemens, Andrea Vena from ESA, Chief Science Officer David Krejci signed the Statement for a Responsible Space Sector on behalf of ENPULSION together with other leading European space companies – AstroAgency, Exolaunch, GlobeEye, Open Cosmos, NorthStar Earth & Space. This important declaration initiated by European Space Agency – ESA aims at pushing consensus on Space Sustainability efforts and responsible governance among the key stakeholders of

the space  
sector  
and promoting a  
shared vision on the future of our industry.

“Planet Earth is  
unique. It is ours.  
And it is a gift,  
vibrant and full of  
life that we must  
cherish.”

– from “Statement for a  
Responsible Space Sector”



Signing of the Statement with ESA and 22 European space actors.

The fast acceleration of hardware deployment in orbit poses serious security threats to the space infrastructure that only collaborative efforts can tackle. For this reason, upping the game on sustainability standards remains one of the biggest challenges looking ahead. In this sense, the signing of this document reiterates ENPULSION's commitment to providing adequate technical solutions to preserve the space environment's carrying capacity and supporting international space diplomacy initiatives to protect orbital resources.

## Development of the ENPULSION NEO propulsion system.

As the next step in the development of FEEP systems, ENPULSION has reached another important milestone. In December 2022 the ENPULSION NEO thruster successfully passed the Preliminary Design Review (PDR) with ESA.

The ENPULSION NEO propulsion system is designed to provide more than 500 kN.s of total impulse and 20mN of thrust in a low volume package. It is especially suited for commissioning ESPA and ESPA Grande class spacecraft and is dimensioned to meet operator requirements for orbit raising, station-keeping, and de-orbiting mission phases.

The ENPULSION NEO propulsion system is designed for easy satellite integration. With their non-toxic, non-pressurized indium propellant, all of ENPULSION's propulsion systems are shipped to customers through normal parcel carriers. They include the propulsion subsystem as well as propellant. They do not necessitate any special proce-

ture for integration on the spacecraft and are virtually plug and play solutions.

The ENPULSION NEO propulsion system development and qualification is supported by the European Space Agency as part of the ESA ARTES programme.

## The Future of Space Sustainability

ENPULSION is investigating how far the FEEP technology can be a good base to enter the business of automated de-orbiting at the end of spacecraft lifetime. Adjacent and complementary technologies are evaluated for expanding the capabilities beyond propulsion system level.

This may lead to the development of an innovative In-Space Mobility Suite comprising several subsystems to enable automated de-orbiting in accordance with the five-year timeframe set by the new deorbiting requirements of the FCC. In this way, sustainability is not just a buzzword, but is built in by design.

## About ENPULSION

ENPULSION was founded in 2016 in Wiener Neustadt, Austria, to produce and commercialize electric propulsion systems for small to midsize satellites using Field-Emission Electric Propulsion (FEEP) technology for the global market. This technology is based on more than 30 years of research and development work by FOTEC and in cooperation with the European Space Agency (ESA).



ENPULSION NEO propulsion system

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# EODC

Earth Observation Data Centre for Water Resources Monitoring GmbH

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EODC provides access to high performance computing and a dedicated cloud infrastructure to access and process Earth Observation data to its customers, supporting them in building cloud native EO applications. Furthermore, EODC has a proofed track record in the operational service implementation of scientific algorithms.

## What we do

The EODC ([www.eodc.eu](http://www.eodc.eu)) was established in May 2014 to tackle the upcoming challenges of the increased data volumes of the operational Copernicus Sentinel missions. Next to the support of the current and future Austrian actors in the earth observation domain. EODC was setup as an international player with a focus on European activities within Copernicus, ESA, EUMETSAT and ECMWF.

To tackle the challenge of the increased data volumes EODC's initial focus was the setup of a long-term storage solution (disk and tape storage) to set-up a long-term archive of Sentinel data. As one initial requirement the storage system was connected to the supercomputing facility of the Vienna Scientific cluster (initially VSC-3, now VSC-4 and VSC-5, <https://vsc.ac.at>). Moreover, EODC has established his own cloud computing infrastructure based on OpenStack that allowed to access the EODC data repository and colocated private folders.

EODC has a proofed track record in the operational service implementation of scientific algorithms, started with the ESA Climate Change Initiative (CCI) Soil Moisture, followed by the Copernicus Climate Change Service for Land Hydrology and Cryosphere, the Copernicus Global Land Monitoring Service and



EODC booth at BIDS 2023

finally in the successful implementation of the Global Flood Monitoring Service within the Copernicus Emergency Service. The EODC team has a broad range of expertise, ranging from state-of-the-art HPC, data centre and cloud infrastructure technologies, network operations, high performant storage systems, up to the needed software stack to automatically provision and configure those infrastructure layers. A core competency of EODC is the understanding of user needs and transforming those into valuable services for big data processing in the cloud, by providing tailored platform and software as a service solution.

The EODC has the following broad spheres of service provision:

- Cloud Computing
- High Performance Computing
- Sentinel Data Provision and other earth observation products
- Long-term data repository
- Automated processing workflow solutions

## Project highlights in 2023

### The Austrian Space Applications Programme

#### AI4SAR

The usability of Synthetic Aperture Radar (SAR) satellite data depends on the correct interpretation of the underlying scatter mechanism, where current modelling approaches perform poorly or fail. Within the proposed project AI4SAR, different state-of-the-art artificial intelligence (AI) algorithms based on unsupervised, active and knowledge-based learning are further developed to find a data-driven solution for this impressive challenge. The AI-based separation of different scattering mechanisms then allows optimised SAR despeckle filtering, interferometric phase preservation, SAR-to-optical matching, and in general advanced SAR processing. The AI4SAR developments will be demonstrated with the help of different use cases in the fields of forest monitoring, deformation monitoring and ground control point transfer.

#### ***GHG-KIT – Prototyping a tool-kit system for GHG verification in Austria***

The project goal is the finalisation of a reliable and scientifically proven concept for the development of an EO-supported GHG reporting system. This system will support the stakeholder with the overall GHG reporting process, including data collection, integration, processing, modelling, and visualisation.

In addition to the overall system, we propose to develop and demonstrate two specific prototypes, enabling

- an improvement in the LULUCF reporting (GHG-KIT LULUCF Inventory Reporter, bottom-up approach)
- the verification of the currently reported emissions (GHG-KIT Verification Element, top-down approach)

both to showcase the value of EO information for the improvement and verification of GHG reporting in Austria as well as to demonstrate the sustainability of the KIT approach.

#### ***INTERFACE – INformation accEss seRvice For Austrian CopErnicus & contributing missions data***

The "INformation accEss seRvice For Austrian CopErnicus and contribution missions data" (INTERFACE) aims to simplify the data access for the public sector. The focus will be on user-centric interfaces and data standards with special attention to integrating different data sets and setting up a prototype system that allows the systematic generation of higher level information products. During a consultation phase while preparing for INTERFACE, we have identified the following initial specific products:

1. Indicating and monitoring sealed surfaces based on Sentinel-2 and on-demand VHR Pleiades access for verification

2. Wetland monitoring service using Sentinel-1
3. Snow characteristics service using Copernicus Sentinel data and information
4. Semantic content based image retrieval system for automated provision of cloud-free Sentinel-2 data before and after an event based on a user-defined date
5. Ground motion and mass movement detection service based on Sentinel 1 InSAR data
6. Service for deriving on-demand high resolution 3D products (DSM and DTM) from Pleiades (Tri) – stereo data

We aim to set up a flexible system that allows us to expand the INTERFACE service prototype with additional information and data layers, e.g. from other existing or future ASAP or Horizon projects. This would provide the public sector one interface at their disposal towards several EO-based developments within Austria. These developments will significantly contribute to lowering the entrance barrier to accessing data and products from Copernicus and contributing missions as well as ASAP results in general.

### **ROSSIHNI – Remote Sensing and Social Interest for Humanitarian Insights**

ROSSIHNI is the first research-driven attempt to link a new drought monitoring data product based on radar backscatter observations from Sentinel-1 and ASCAT to a suite of algorithms that measure social interest and awareness at a global scale. The resulting prototype dashboard will use the radar-based drought product as visual evidence for emergency impacts and related humanitarian financing requirements. Our study region is Eastern Africa, a humanitarian hot spot region frequently hit by droughts and other natural extremes. The radar-based drought product will be developed by merging a new full-resolution ASCAT soil moisture data set with Sentinel-1 data, and by calculating anomaly percentages suited to compare drought conditions across different climatic regions.

### **ScaleFloodS – Preparing for Scaling Up Flood Monitoring Capabilities with ROSE-L and Sentinel-1 NG**

The aim of the project is to prepare for ROSE-L and Sentinel-1 NG by developing scientific algorithms capable of ingesting near-instantaneous L- and C-band SAR data and by investigating the benefits of the improved spatio-temporal coverage for capturing more and smaller flood events. This will be done by analysing the available worldwide Sentinel-1 flood archive as provided by Global Flood Monitoring and using the L-band SAR data from ALOS and the NISAR mission to be launched by NASA in 2024. The insights from this analysis will be shared with ESA that is currently fine-tuning the specifications of both ROSE-L and Sentinel-1 NG to best meet the requirements of diverse applications.

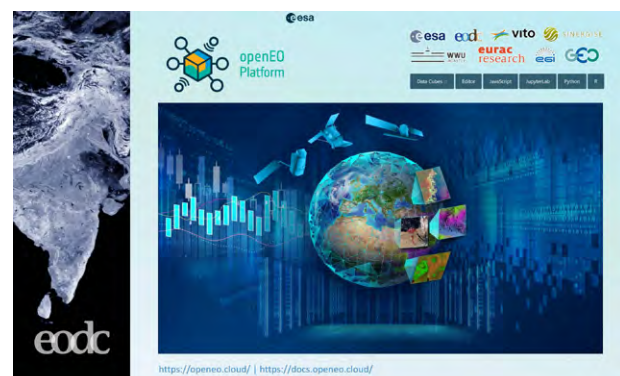
## **ESA**

CCI+ – Climate Change Initiative Extension (CCI+) Phase 2 New R&D on CCI ECVs: Soil Moisture

The objective of the CCI+ Phase 2 soil moisture project is to continue the successful achievements of CCI on the research, development and qualification of pre-operational soil moisture ECV products and processing systems, with the goal of transferring developments made into operational production outside (currently C3S). The production system hosted at EODC allows for the merging of the different sensor-specific Level 2 soil moisture datasets (retrieved surface soil moisture) into combined products.

### **openEO Platform**

The openEO Platform is a project built on top of the H2020 project openEO. It brings openEO to production and offers data access and data processing services to the EO community, see <https://openeo.cloud/>.



openEO Platform Service



## DHR Framework Austria

The Collaborative Data Hub Relay Framework – Austria Service (DHR Framework AT) is supporting the ground segment operations on national level, with the intention of new data integration access services.

## EU – Copernicus

### C3S2 – Copernicus Climate Change Service (C3S): Land Hydrology and Cryosphere

The service focuses on Terrestrial ECV's in the land hydrology and cryosphere domain and will operationally produce and deliver, or broker access to a suite of Climate Data Records (CDRs) and Intermediate Climate Data Records (ICDR) for the ECV variables of Soil Moisture, Glaciers, Lakes, and Ice Sheets.

### GFM – Sentinel-1 based global flood monitoring system of Copernicus Emergency Management Service

Using EO data from the Sentinel-1 suite of satellites, linked with the state-of-the-art flood detection models, the GFM service will produce near real time flood monitoring products within 8 hours of the satellite observation. The products will be integrated within the current Copernicus EMS European Flood Awareness System (EFAS) and the EC and ECMWF's Global Flood Awareness System (GloFAS).

## EU

### C-SCALE – Copernicus – eoSC AnaLytics Engine

The C-SCALE project aims to federate European EO infrastructure services, such as the Copernicus DIAS and others. The federation shall capitalise on the European Open Science Cloud's (EOSC) capacity and capabilities to support Copernicus research and operations with large and easily accessible European computing environments.

The image displays three promotional materials for the C-SCALE project. The leftmost material is a poster titled "C-SCALE" featuring the "eosc" logo and the text "Enabling Copernicus Big Data Analytics through EOSC". The central material is a large banner with the "C-SCALE" logo, the text "Federated Data and Compute within EOSC", and "ENABLING COPERNICUS BIG DATA ANALYTICS THROUGH EOSC". The rightmost material is a vertical infographic titled "C-SCALE" with the "eosc" logo and the text "enables", "Seamless access", "Easy Processing & Analysis", "Cross-disciplinary research", and "Knowledge for sound decision making".

Copernicus – eoSC AnaLytics Engine (C-SCALE), European Union's Horizon 2020 project (grant agreement No 101017529), see: <https://c-scale.eu/>

That would allow the rapid scaling and sharing of EO data among a large community of users by increasing the service offering of the EOSC Portal. By making such a scalable Big Copernicus Data Analytics federated services available through EOSC and its Portal and linking the problems and results with experience from other research disciplines, C-SCALE will help to support the EO sector in its development and furthermore will enable the integration of EO data into other existing and future domains within EOSC. <https://c-scale.eu/>

#### ***interTwin – Co-designing and prototyping an interdisciplinary Digital Twin Engine***

interTwin is an EU-funded project with the goal to co-design and implement the prototype of an interdisciplinary Digital Twin Engine – an open source platform based on open standards that offers the capability to integrate with application-specific Digital Twins. Its functional specifications and implementation are based on a co-designed interoperability framework and conceptual model of a DT for research – the DTE blueprint architecture. <https://www.intertwin.eu/>

#### ***GREAT – GREEN DEAL DATA SPACE***

The GREAT project, funded by the Digital Europe program, aims to establish the Green Deal Data Space Foundation and its Community of Practice which builds on both the European Green Deal and the EU's Strategy for Data. The project will deliver a roadmap for implementing and deploying the Green Deal Data Space, an infrastructure that will allow data providers and initiatives to openly share their data to tackle climate change in a multidisciplinary manner. <https://www.greatproject.eu/>

## EODC Earth Observation Data Centre for Water Resources Monitoring GmbH

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[www.eodc.eu](http://www.eodc.eu)

### **CONTACT**

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### **FACTS**

Sales: 4,2 M€  
ESA Share: 474 K€



Image from Sentinel-2 cloudless – <https://s2maps.eu>

© EOX IT Services GmbH  
(Contains modified Copernicus Sentinel data 2022)



# EOX IT Services GmbH

View the world through our eyes

EOX IT Services GmbH (EOX) is a geospatial engineering and service company based in Austria, a non-start-up, founder-managed business. It creates software and tools to allow people to consume geospatial data in the cloud and on the Web. The company focuses on getting the most value out of the vast amount of the data acquired by Earth observation satellites. EOX furnishes software and cloud infrastructure services to selected customers in geoscience and European government organisations.

EOX is among the main ESA contractors in Austria and has successfully carried out more than 70 engineering and operations projects for ESA. In recent years, the client base has been expanding to customers stemming from private industry sectors, non-space public organisations, and research institutes interested in engineering, consultancy, data products as well as online workspace services provided by EOX.

EOX also offers attractive satellite mapping products to world-wide consumer markets. EOX further provides managed online workspaces in the cloud to process and analyse satellite data for example for the Common Agriculture Policy (CAP) applications or researchers. EOX recently added a focus to support research teams conducting FAIR and open science projects.



The EOX Team

EOX has a fifteen-years long record of space software projects building components of Earth Observation satellite payload ground segments most of them including (sophisticated) geospatial Web GUI implementations together with adequate server infrastructure functions including data cubes, as can be checked on the company's home page <https://eox.at>. EOX is also a provider of high-throughput processing lines for production of exploitation-ready satellite data which are used in downstream applications for viewing and analysis. EOX has gained special expertise related to the deployment of processing lines and data access software functionality on cloud-based ICT infrastructures like on Copernicus Data Space Ecosystem OTC and CreoDIAS, AWS, and GCP.

EOX is strongly committed towards utilising and contributing to Open Source Software for example via the EOX GitHub organisation. In this respect, EOX is an active member of FOSSGIS and OSGEO, the most important associations promoting free and open source software in the geospatial sector. EOX is further committed to comply with and improve Open Standards particularly those of the Open Geospatial Consortium (OGC). EOX is an active promoter of such standards and offers related consultancy and implementation services.

EOX is certified according to the IT security standard ISO27001-2022.

At present, EOX employs around 25 permanent staff and, in addition, temporary co-workers including master students and stagiaires. Administrative processes are to a good deal outsourced to external professionals.

## Highlights

EOX has again been well recognized in ESA activities in the year 2023. Several new activities were positively evaluated and started as well as ongoing ones extended beyond their original planned duration because of their successful execution. This was made possible through relationships and trust building over the past years with well established and renowned partners in the Earth Observation world as well as through the flexibility to integrate EOX technology solutions as required by the projects and its partners. Please read about EOX technology solutions further down.

EOX was well represented in 2023 presenting and demonstrating successful projects and activities at industry leading events and workshops like:

- User Consultation for the Green Transition Information Factory (GTIF) – Austrian demonstrator
  - 40+ Austrian stakeholder organisation; 125 attendees
- FOSS4G 2023, Prizren, Kosovo – Dedicated workshops on Dashboards and EOX technology (ViewServer) and multiple talks
- IGARSS 2023, Pasadena, USA – Supporting a workshop by NASA, ESA, and JAXA on the EO Dashboard as well as dashboard presentations
- Big Data from Space 2023 (BiDS – Vienna) – EOX booth alongside Austrospace; dedicated presentations of multiple EOX leading projects by ESA including OSGEO Community Sprint



At the BiDS in Vienna

As enthusiastic members of the Open Source community EOX has also supported the FOSS4G 2023 in Kosovo as well as the OSGEO Community Sprint in Vienna with sponsorships.

In summary, 2023 marked a year of substantial progress and expansion for EOX. With a steadfast commitment to

innovation and customer satisfaction, the company strives to position itself as a prominent player in the Austrian earth observation IT market. As it looks towards the future, EOX remains poised to sustain its momentum, driving positive change and continuing to deliver exceptional value to its clients and communities.

## Technology

EOX is a full-stack technology provider for the handling of big data from Earth observation (EO) satellite missions. The following figure shows the 4 main technology pillars of EOX.

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The technologies built within these pillars are modular and re-combinable. This allows re-use and synergistic developments where implementations done for one project benefit all other projects using the same modules. The following figure shows what aspects of a complete system architecture can be covered by software modules developed and delivered by EOX. The entire chain from the satellite data resources to the end-consumer system is offered. Due to the modularity of the solutions and the support of industry-standard interfaces, subsets of the functionality can be used as "plug and play" components for integration into custom system architectures.

EOX excels in know-how about EO-relevant Free and Open Source Software (FOSS) and its integrability. Four core examples of the many software elements integrated in EOX-provided solutions are shown in the next figure providing further insights in their technology context:

- **View Server** – truly cloud native EO data management and servicing technology
- **eodash** – state of the art web widgets and service integrations into one customizable web interface
- **Mapchete Hub** – distributed processing and managing service for massive EO data tasks
- **EOxHub** – full cloud solution for operating and monitoring large scale environments

## Complete solutions & services

As described, the technology pillars are composed of interchangeable modules which can be combined and configured based on needs of specific projects.



Screenshot of Area Monitoring Services Application



EOX masters different cultures and tasks of software development and operations under one roof to the satisfaction of its customers: software engineering; IT infrastructure & cloud management; deployment; operations; customer/user support. E.g. EOX' principal customer ESA requires both ECSS and Agile approaches to be applied in the same project and in a unique blend. Below are some of the highlights of complete solutions that EOX provided within a project or as standalone service during 2023.

### Area Monitoring Services – The satellite solution for managing area-based direct payments

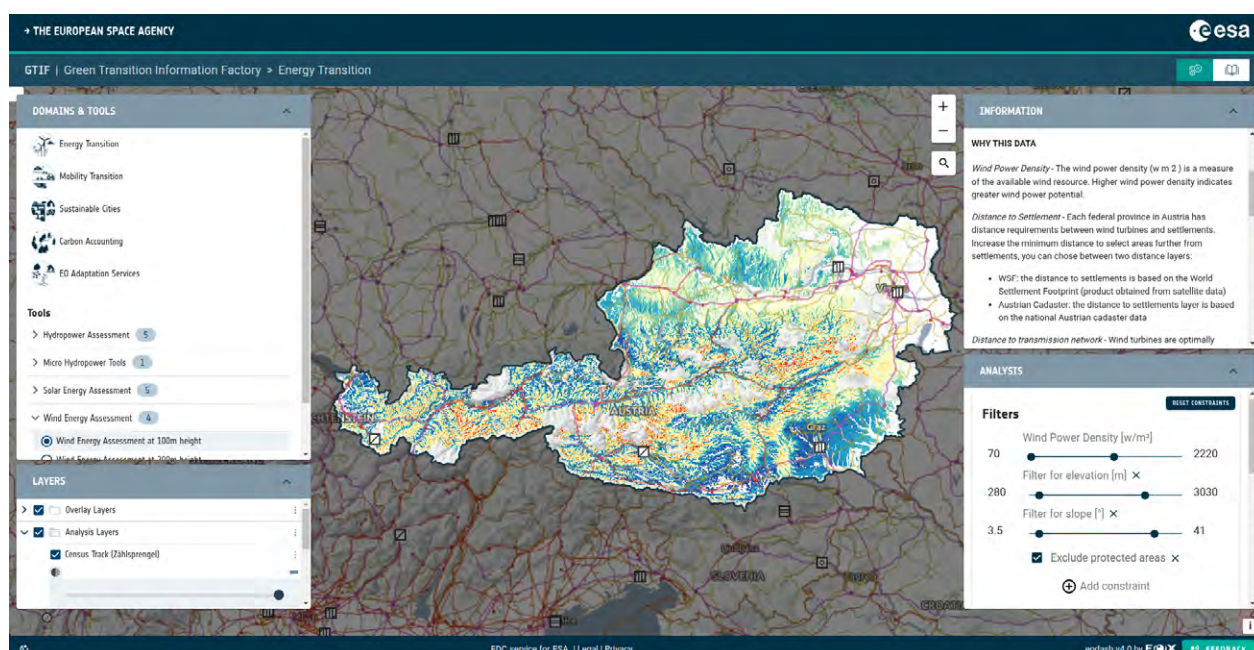
EOX offers Agricultural Area Monitoring solutions based on satellite EO data to support expert judgement and decision making compliant with the EU Common Agricultural Policy (CAP). The following figure shows the "Parcel Explorer" user interface for crop type validation which is an example from a number of tools which EOX provides to Paying Agencies in EU Member States for assessment of farmer applications for subsidies.

In 2023 EOX provided operational CAP Area Monitoring Services to the Paying Agencies of Austria and Ireland. EOX' footprint in this market is expected to grow in the years to come thus establishing an increasingly important business sector for EOX.

### Green Transition Information Factory (GTIF)

Due to the success of other web dashboard projects, such as the "Rapid Action for Citizens with EO" and the "Earth Observing Dashboard" EOX has been tasked with the development of a technology demonstrator for Austria. The goal of the GTIF project is to provide actionable information from Earth Observation to accelerate the Green Transition of society and economy. The cloud-based integrated GTIF environment enables decision-makers to assess and monitor the effectiveness of policies, and evaluate political objectives and outcomes using GTIF-provided data, indicators and interactive exploration tools.

The developments started in spring 2022 and in May 2023 the public release of the platform was achieved. Creation and integration of a wide range of datasets was made possible through excellent collaboration of multiple institutions and companies. The success of the project has sparked follow-on activities as well as potential extension activities with governmental agencies within Austria.

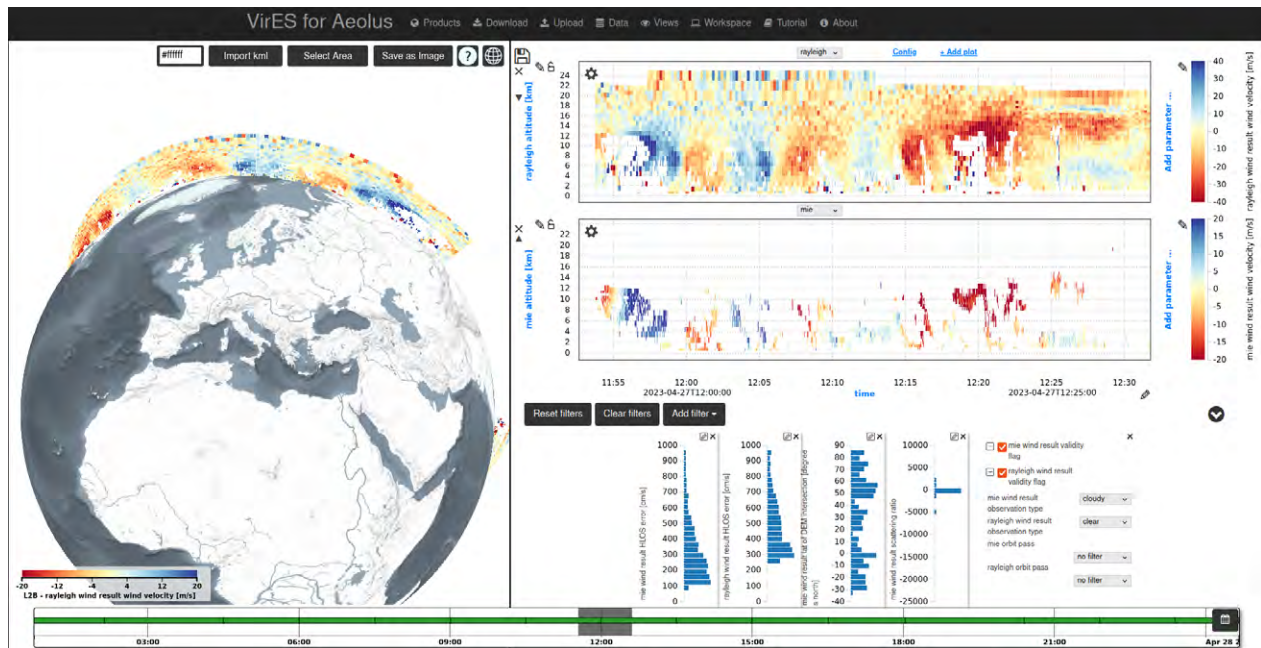


Screenshot of Green Transition Information Factory Application (<https://gtif.esa.int>)

## Virtual Research Environments

The VirES family of services has its 10 year anniversary! Since then it has been operated by EOx for ESA providing operational user services for the Earth Explorer missions Swarm and Aeolus. EOx is continuously synchronising the entire Swarm and Aeolus mission data archives and provides data access to them via VirES Server. Besides the direct access via the dedicated Web GUI for data exploration, a workflow which supports flexible scientific data analysis and collaboration by code sharing using Jupyter Notebooks has been implemented using EOxHub. In order to welcome users (of various degrees of expertise) into the environment an extensive documentation has been created with support of experts in the field and made available.

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Screenshot of VirES for Aeolus interactive workspace (<https://aeolus.services>)

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### FACTS

Sales: 3,2 M€  
ESA Share: 1,9 M€





*Eviden ensures high quality satellite communication with its next generation satellite monitoring system SkyMonNG.*

© Eviden



# Eviden Austria GmbH

former Atos IT Solutions & Services GmbH

Eviden (former Atos IT Solutions & Services GmbH) is a next-gen technology leader in data-driven, trusted and sustainable digital transformation. With a strong portfolio of patented technologies and worldwide leading positions in advanced computing, security, AI, cloud and digital platforms, it provides deep expertise for all industries in more than 47 countries.

Bringing together 53,000 world-class talents, Eviden expands the possibilities of data and technology across the digital continuum, now and for generations to come. Eviden is an Atos Group company with an annual revenue of over € 5 billion.

In Austria, Eviden Austria GmbH acts as a competent partner for public administration and the private sector with around 1,000 local employees and local decision-making authority. In addition, Eviden in Austria has global responsibility for solutions in the areas of critical communication systems and satellite monitoring systems.



In 2023, Eviden Austria GmbH has moved his headquarter and offices to the IZD Tower in 1220 Vienna.

The Space related business is part of the Business Unit Aerospace Defense and Electronics (ADE), a unit established in 2018. This business unit addresses both, the commercial as well as the defense market, which broadens our S&A addressable market and creates new opportunities in the satellite defense market.

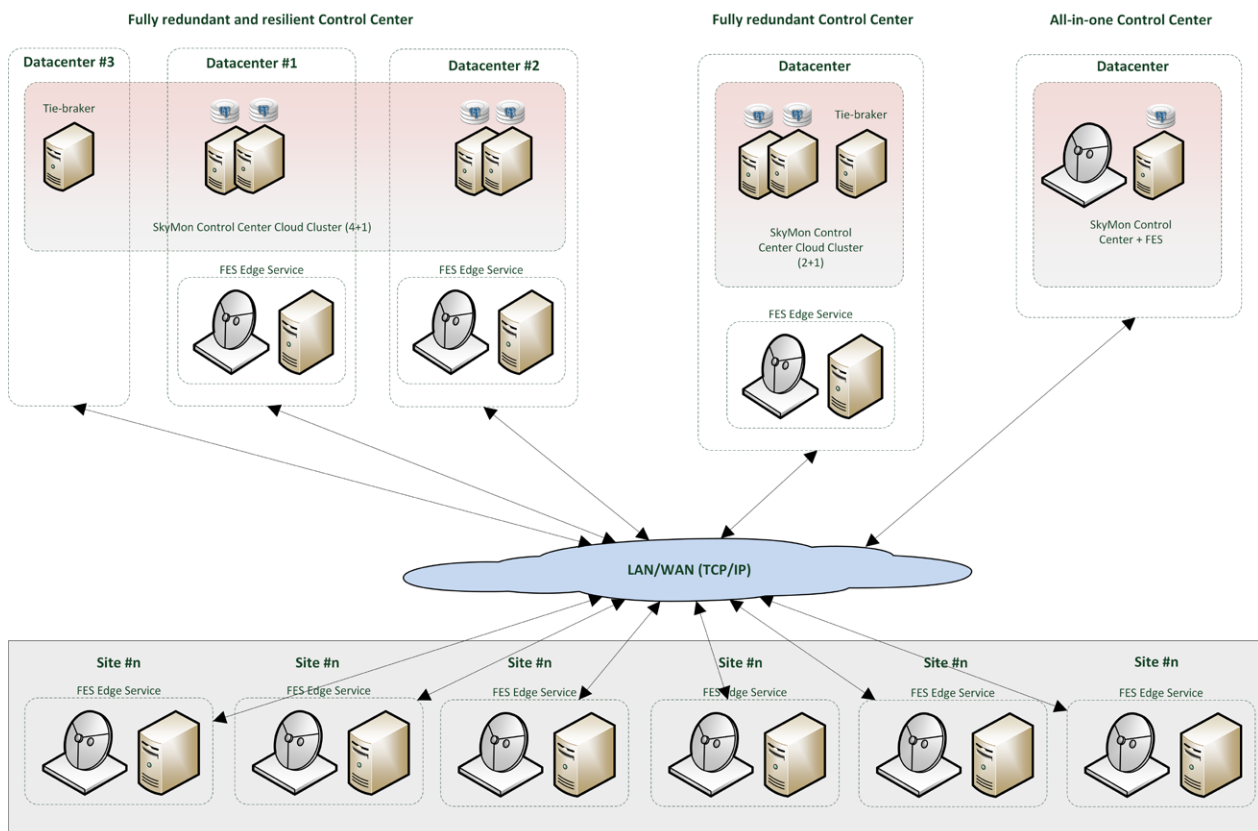
The activities in 2023 have been focused on two major developments:

- The evolution of our satellite monitoring system SkyMon towards a next generation payload monitoring system to meet the growing challenges of a new space era which include new satellite communications technologies, the need to integrate 5G and the potential increase of signal interferences caused by the growing number of satellite mega constellations.
- The development of a satellite monitoring portfolio (SATELLITE COMMUNICATION SITUATIONAL AWARENESS (SCSA) to meet the requirements from the defense / governmental market.

## SkyMon Next generation payload monitoring system (SkyMonNG)

SkyMonNG is based on the **Eviden Scalable Backend Architecture**, which is a generic architectural concept, already used in a wide range of projects and is

- **Designed for the future**
  - While simpler straight forward solutions, as available on the market, may be sufficient on the short term, we are already looking at the future where millions of devices may connect.
  - State of the Art Microservice Architecture on top of a high-performance generic core is reusable also for future use cases.
  - Agile migration path from existing system allows flexible adaptation on changing requirements with minimal risk.
- **Proven Technology**
  - Full scalable and capable for handling millions of devices sending real-time status update data within fractions of seconds each.
  - Technology as used internally by Google, Twitter, Facebook, Netflix and others to deal with huge data volume.
  - Successfully applied in several major Eviden IOT projects.
- **Fully redundant cloud based failsafe solution**
  - The customers are more and more asking for cloud based solution to reduce CAPEX but also to have a more flexible and scalable solution. SkyMonNG offers a modern cloud based active – active solution, where all services and data are replicated over several hosts spread over different datacenters. In case of a failure or unavailability of a node or even datacenter the other remaining will take over the work transparently. All nodes are active at the same time and can be used by the clients.

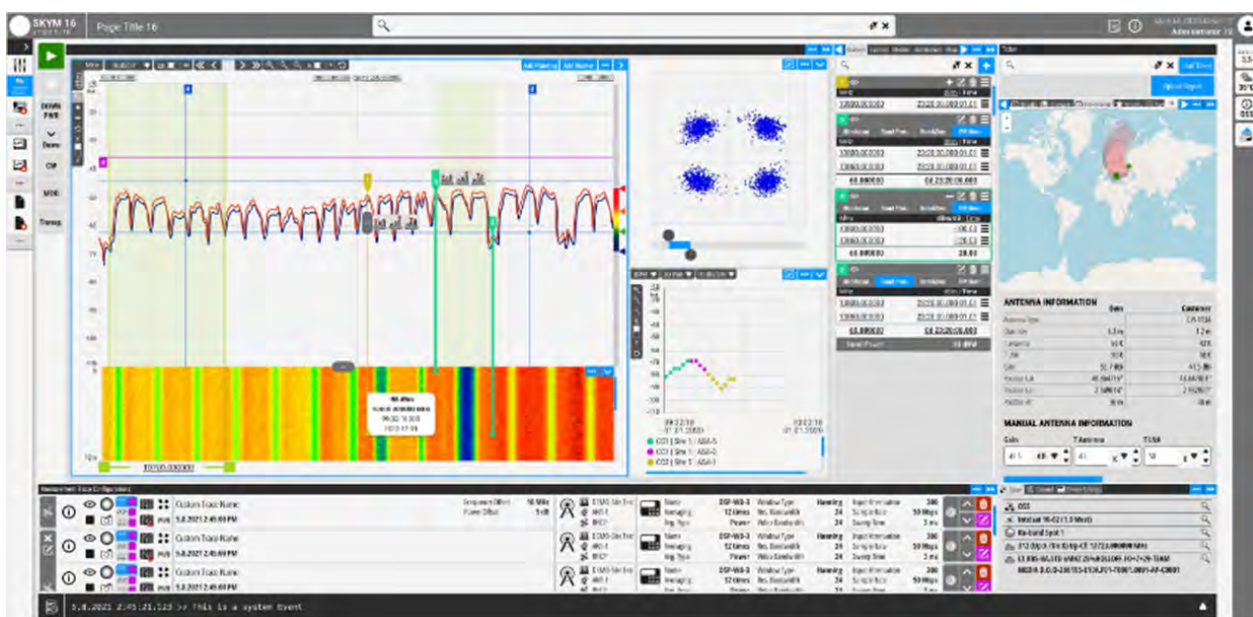


An example architecture is shown where the SkyMonNG control center is realized in a cloud cluster



- **Provides a modern web page design**

- For the frontend, SkyMonNG will provide a modern web based graphical user interface. Angular is used as underlying framework for implementation. It facilitates reactive and modern web applications that enhance the overall usability and user experience. Angular is well supported on a broad variety of browsers. The platform is provided by Google and the support and maintenance is ongoing with good long-term-support versions. An essential requirement for modern web applications is responsiveness. A responsive web page adapts itself to the screen size given. This ensures that the page is independent from the used device (mobile, tablet, pc). The design will adapt and show the content in an adequate way.



Example screenshot of the new web based frontend, showing the manual measurement mode

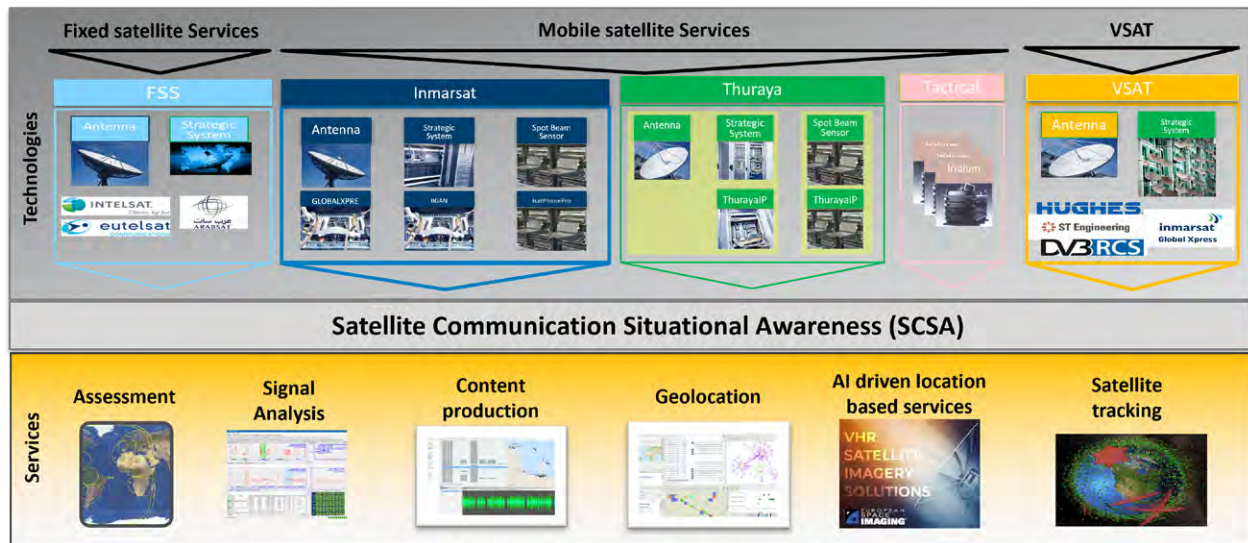
## Satellite Communication Situational Awareness (SCSA)

In an evolving landscape where national security hinges significantly on the space domain for communication and surveillance, Eviden stands at the forefront of empowering defense strategies through cutting-edge space-based intelligence capabilities. Modern armed forces heavily rely on Satellite Communication (SATCOM), necessitating continual observation of satellite communication signals for comprehensive situational awareness. Eviden excels in mastering this critical signal intelligence environment.

In Eviden we share the vision that Space will define the future of national security as any military operations rely more and more on the space domain for communication and observation.

SCSA is an end-to-end capability for detection, identification, classification, interception, localization and monitoring of satellite signals. It is a modular and scalable solution that benefits from over 30 years of expertise. Implemented with virtualization and artificial intelligence (AI), SCSA supports all major FSS\* and MSS\* satellite services as well as various proprietary standards for VSAT networks.

Following an overview about the SCSA portfolio:



Overview about the SCSA portfolio

## Satellite Tracking System (STS)

A new component of the SCSA portfolio, which we started to develop in 2023 is the Satellite Tracking System. The main objective of STS is

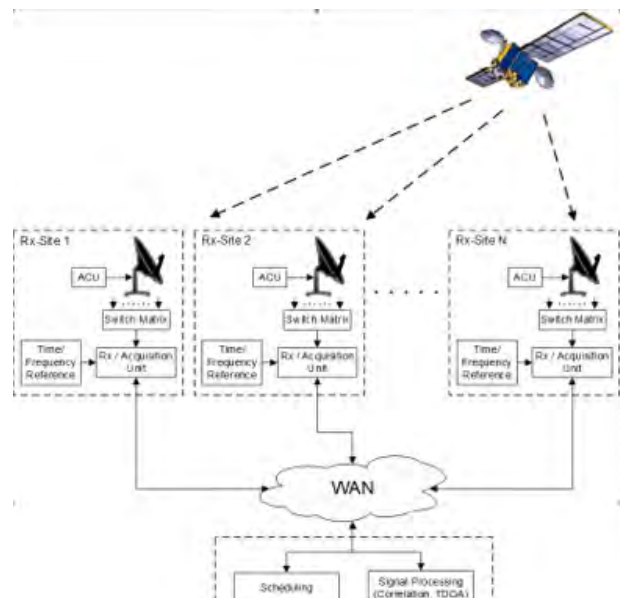
- to provide a product to satisfy the market's demand for accurate position and velocity state data for satellites, so called ephemeris data
- to continuously determine satellite ephemeris data for the purpose of providing a tracking system for GEO, MEO and LEO satellites.
- to provide very accurate satellite ephemeris data as input for geolocation systems for the purpose of improving their accuracy
- to predict the trajectory of a satellite based on historical ephemeris data

In addition, this data can be used for

- Traditional satellite ranging activity (supporting flight dynamics operators to prepare satellite manoeuvres and calculate the state vector before/after the manoeuvre)
- Collision and interference avoidance (e.g., co-ordination of co-located satellites)
- Space situational awareness activity
- Remote sensing applications.

The idea is to develop a passive RF ranging system which does not transmit signals towards the satellites but only receives available satellite signals. This approach has the benefit of

- Avoiding any risk of interfering with operational services. This would require careful co-ordination with satellite operators (as it is the case for traditional tone ranging systems)
- Reducing costs because of not needing expensive transmitting hardware and accurate antenna tracking equipment

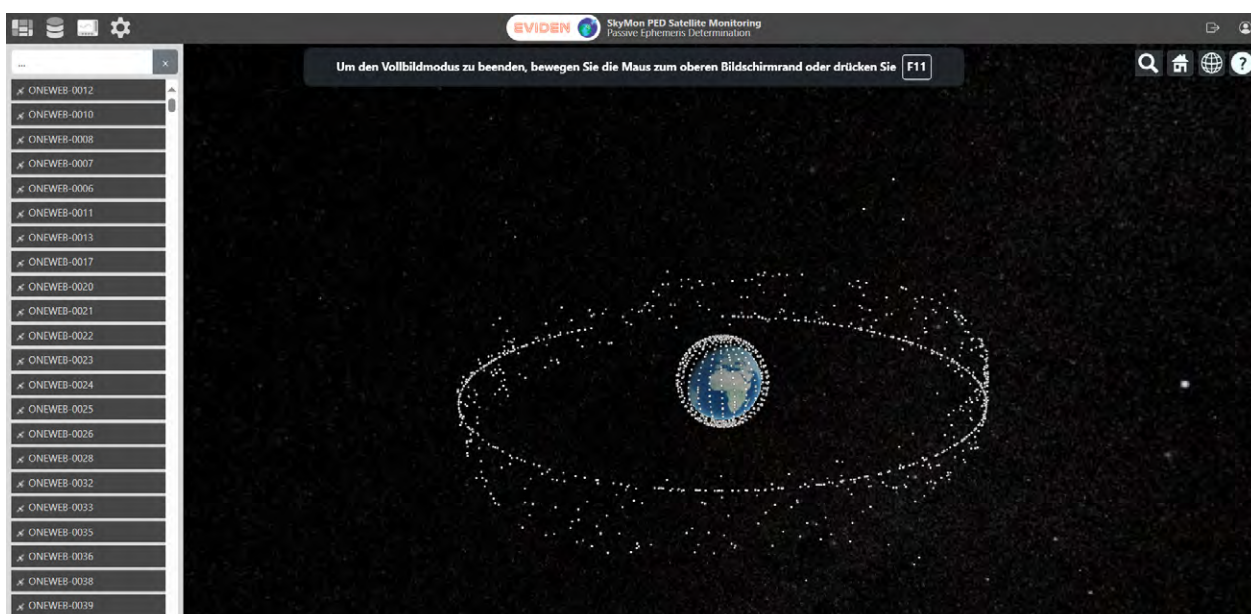


General architecture of STS

Therefore, the system will provide ephemeris data of active satellites in terms of simultaneously receiving a signal of a satellite at different places on earth (Rx-Stations) and measuring the Time Difference Of Arrival (TDOA) between each station pair (passive ranging).

Each Rx station is planned to be equipped with antennas and RF downconverters translating the received signal to lower frequency before being digitized. A switching unit will enable connecting signals with different polarization and frequency range (e.g., C, Ku, X). For synchronization purpose (simultaneous measurements) a 1PPS signal from a time and frequency reference unit (GNSS receiver) will be used as trigger for the digitizers and an ACU unit together with mechanical steering equipment will allow pointing the antenna to different satellites. All equipment will be operated remotely and fully automatic.

The result will show the calculated orbit of the satellite in a map. A first version of STS will be released mid of 2024.



Example of the orbit visualization

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### FACTS

Sales: 10,3 M€  
 ESA Share: 0,07 M€





The customized thermal shroud as being installed in FOTEC's large vacuum chamber.  
© FH Wiener Neustadt



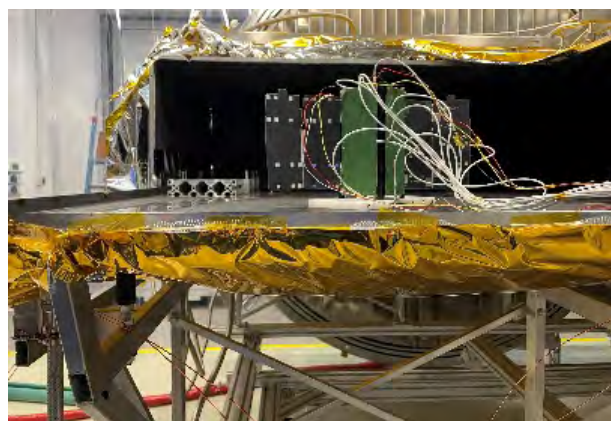
# Fachhochschule Wiener Neustadt GmbH

with its Forschungsgesellschaft FOTEC

## Nanosatellite Development and Testing

In 2021, FOTEC and the FHWN started the FFG-funded project DEEP with the goal to increase FOTEC's testing and analysis capability specifically for small satellite systems and CubeSats. For thermal vacuum tests of small satellites and space hardware in general, the thermal vacuum facility at FOTEC was significantly improved in 2023. The shroud allows DUTs of up to 2 x 2 x 0.5 m in size which is suitable for a variety of test items – such as the grabber mechanism of Clearspace which was successfully TVAC tested at FOTEC in 2023. The shroud is subdivided into four zones that can individually be cooled with liquid nitrogen down to  $-150^{\circ}\text{C}$  or electrically heated up to  $+150^{\circ}\text{C}$ . This ensures a very uniform temperature distribution within the thermal shroud. FOTEC's TVAC facility also provides thermal interfaces or ALM-manufactured heat exchangers that are temperature controlled by laboratory chillers in the temperature range from  $-60$  to  $+90^{\circ}\text{C}$ .

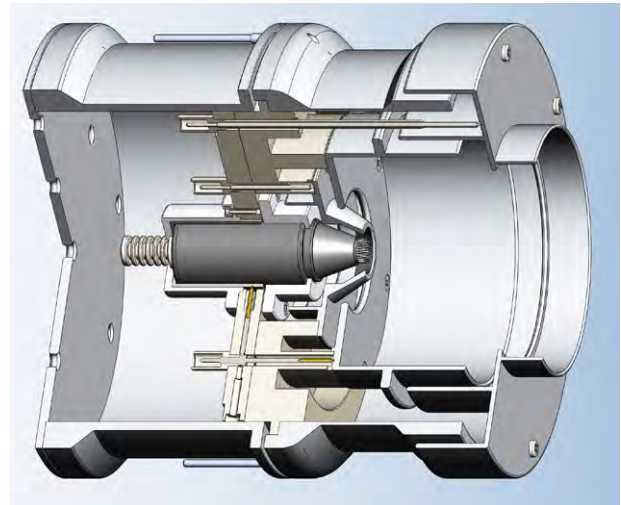
The facility was tested and its performance was verified in cooperation with R-Space GmbH. R-Space provided a thermal model of a 2U CubeSat, equipped with all relevant subsystems to have a realistic representation of the internal thermal loads.



Handover of the thermal CubeSat model of R-Space (left) and its integration into FOTEC's thermal vacuum chamber

## Field Emission Electric Propulsion Technology

The core-piece of FOTEC's mN-FEEP technology is a crown of 28 sharp porous tungsten needles, infiltrated with liquid indium. This crown is raised to high electric potential, which then leads to electrostatic field emission on the tips. In 2023, the endurance test campaign was successfully concluded after a period of more than 48,000 h accumulated operation time. In total, a propellant mass of 763.67 g was consumed. Since this exceeded the capacity of the reservoir by far, the thruster operation was periodically interrupted to refill the propellant reservoir. The following picture shows the test module that was used for the endurance tests.

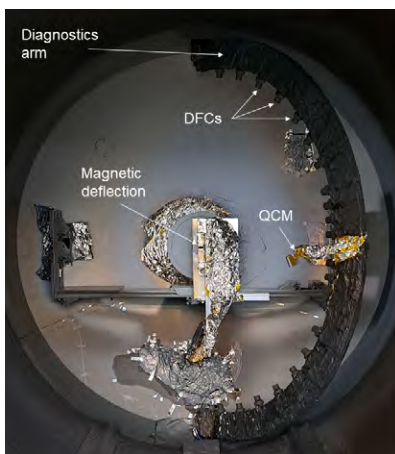


The IFM 350 module which was used for the endurance test of more than 48,000 hours.

The endurance test has shown that FOTEC's proprietary FEEP technology based on porous tungsten multi-emitters is a suitable candidate for EP systems to be used for highly demanding scientific, Earth observation or deep space missions – such as NGGM. For this mission, a highly precise and reliable EP system in the range of up to 500  $\mu\text{N}$  is required. This system needs to be fully operational for more than 6 years. FOTEC's proprietary FEEP technology would be an ideal candidate to fulfil these and other highly demanding requirements.

## Diagnostic Capabilities

FOTEC has been developing electric thrusters for spacecraft based on the advanced Field Emission Electric Propulsion (FEEP) technology for several decades. To generate ions, a strong electric field is created by applying high voltage between the emitter and the surrounding extractor electrode. The ions are then accelerated in the very same electric field thus generating thrust. In addition to the expelled ions, the emission process produces what are known as "micro-droplets". These "micro-droplets" are quasi-neutral and have a diameter in the range of a few nanometres. These quasi-neutral micro-droplets do not contribute to the overall thrust and thus, can reduce the propellant mass efficiency of the ion source. Therefore, the investigation of the droplet emission is of great importance for further investigating the Liquid Metal Ion Source (LMIS).



Test setup for characterization of the QCM and validation of the electromagnetic ion shield (left), QCM (middle), electromagnet with collimator (right).

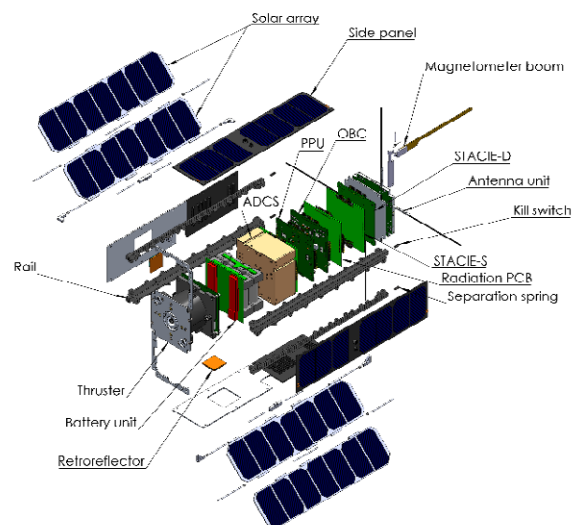


Therefore, FOTEC started to develop, manufacture, test and verify a proof-of-concept of a Quartz Crystal Microbalance (QCM) in combination with an ion deflection mechanism to allow analysis of the droplet distribution. The technological innovation was to integrate the electronics directly into the sensor head. A Quartz Crystal Microbalance (QCM) is commonly used to quantify the area density of deposited mass within a given time. It consists of an oscillating quartz crystal and the corresponding read-out electronics. By tracking changes in the crystal's eigen-frequency, it is possible to determine very small mass changes caused by particle deposits on its surface. In contrast to conventional QCMs, FOTEC developed the electronics PCB which is located directly in the sensor head. This innovation results in an almost interference-free measurement signal and allows to move the detector inside the vacuum chamber. The following pictures show the test setup as being used for the successful verification of the functionality of the QCM.

In an effort to further extend the testing capabilities of CubeSats and propulsion systems, a new thermal vacuum test (TVT) facility was developed by the Aerospace engineering department of the FHWN. This facility was established as part of the COIN project DEEP (Diagnostic Equipment for Electric Propulsion). This unique TVT facility allows thermal vacuum testing of a running electric propulsion systems integrated in a CubeSat. Standard TVT facilities do not permit a running propulsion system due to detrimental interaction of the ion beam with the thermal shroud or the vacuum chamber. This facility allows the combination of a propulsion test with a thermal vacuum test, providing therefore a much more realistic picture of the thermal impact of the propulsion system on a CubeSat than other facilities can.

## CubeSat CLIMB

CLIMB is the second CubeSat mission by the FHWN and FOTEC. While its purpose is mainly the education of students, its mission objectives include the assessment of radiation impact on COTS electronic elements and the measurement of Earth's magnetic field. While the design process enters its final phase prior to the CDR, the preparation for registration with the Austrian government and the search for a suitable launch opportunity in 2025 has only been recently started. The satellite will carry a propulsion system from ENPULSION and a space radiation monitor developed by the Seibersdorf Laboratories. For the magnetic field measurements, a magnetometer developed by the FHWN will measure Earth's magnetic field in an accuracy in the range of 1-10 nT. This magnetometer was developed by the FHWN in cooperation with Space Research Institute (IWF) in Graz.



An explosion view of CLIMB showing the major elements of the satellite

## Small Satellite Research Network (SSRN)

The University of Applied Sciences has been involved in the development of small satellites, aka CubeSats, since 2013. Those small satellites are a cost-efficient way to get access to space and to be able to test new technologies without waiting for many years for a flight opportunity. Although a significant number of Lower Austrian companies and R&D institutions have relevant know-how and expertise in the field of space travel and nanosatellites a common strategy or objectives does not exist. In order not to miss out on current developments and to become a force to be reckoned with in the field of small satellites, the Wiener Neustadt University of Applied Sciences has set itself the goal of bundling these selective interests and expertise, identifying weak points and strengthening

existing capabilities in the "Small Satellites Research Network" (SSRN) project.

Under the leadership of the University of Applied Sciences Wiener Neustadt, a core team consisting of FOTEC, Seibersdorf Laboratories and R-Space has dedicated itself to this task and will build up networks over the next three years and prepare the relevant industrial companies and research institutions for the challenges and opportunities in the field of nanosatellites.

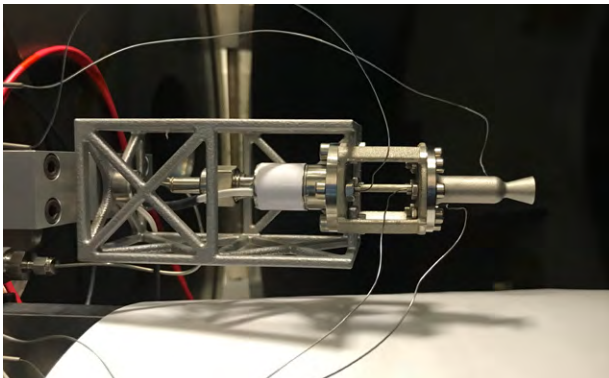


**SSRN**  
SMALL SATELLITE RESEARCH NETWORK

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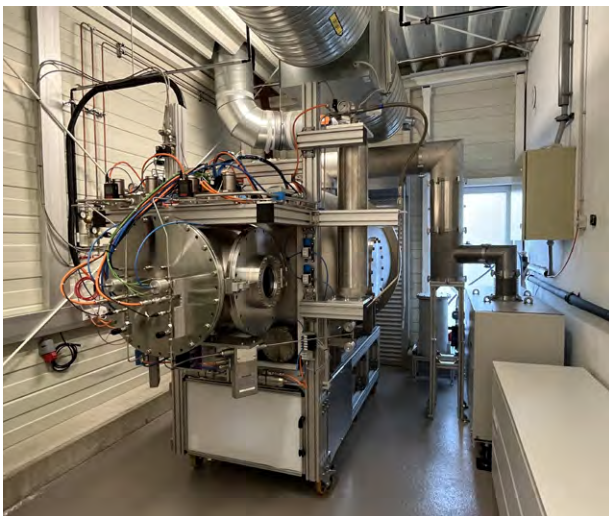
## Chemical propulsion thrusters (CP)

FOTEC has been involved in the development of chemical propulsion systems based on green propellant technology with Hydrogen peroxide and Nitrous oxide to replace the traditional toxic propellants such as Hydrazine. It is generally expected that Hydrazine will be banned from use within the EU in the near future and the space industry will possibly be forced to use alternative propellants. Although Hydrogen peroxide mono propulsion system performance is less compared to Hydrazine, it is a safer and environmentally friendly alternative and the performance to price ratio is significantly higher. Similarly switching to Nitrous oxide-based propulsion systems can achieve similar environmental benefits and it is expected to have similar or better performance than Hydrazine. Therefore, R&D of Hydrogen peroxide and Nitrous oxide-based propulsion systems will in general reduce costs and offer a better & greener future.



A 1N hydrogen peroxide thruster during hot fire testing

The main goals of FOTEC is to design, manufacture and operate a cost-effective 1-20N class Hydrogen peroxide and Nitrous oxide based mono and bipropellant thruster that can sustain the harsh conditions and can outperform the traditional thrusters. These propulsion systems are expected to be used in CubeSats and small satellites that weigh up to 500 kg. These types of satellites share a major percentage of the new space market recently. The propulsion systems will be used for orbit maintenance, orbit raising, attitude control and deorbit of the satellite after its mission and FOTEC is expecting to reduce the costs of systems by 30-50%.



FOTEC chemical propulsion testing laboratory.

To achieve the goals, FOTEC has successfully demonstrated for the first time the feasibility of using additive layer manufacturing technology to 3D print high strength and robust catalysts for decomposition of 98 HTP (98% high test peroxide). The catalysts are also capable of operation with other types of propellants such as ADN and HAN based propellants. 1N level thruster prototypes for HTP monopropellant and Nitrous oxide bipropellant with special injector are currently being developed at FOTEC. A 5, 10, 20 N thrusters are in the pipeline for the development soon. The mono propellant thrusters are manufactured using ALM technology from Ni-Cr alloys. The bipropellant thrusters due to their higher operating temperatures need high temperature material technology. FOTEC is currently developing Iridium, Rhenium and Tungsten thruster chambers that



can sustain up to 2200°C. This technology will be implemented in the bipropellant thrusters.

A state-of-the-art test facility was also designed and commissioned to test the thrusters from 1–20 N range. The test facility is capable of 10 kHz data acquisition rates and steady state and minimum impulse bit testing down to 10 milliseconds at vacuum level of 5 mbar. The vacuum pumps have an effective pumping speed of 10000 m<sup>3</sup>/h. State of the art flow meters can measure flow rates at rate of 4 kHz and pressure regulators with ultra-fast response time are installed in the testing facility for testing at wide range of pressures and flow rates.

## Additive Manufacturing (AM)

FOTEC has long-term expertise in R&D along the complete process chain of additive manufacturing and had shown in the past that existing manufacturing routines for space hardware such as RF antenna components, flexible metal bellows or motor brackets can be optimized or completely exchanged by additive manufacturing. The main drivers for this approach are mass saving potentials, integration of additional functionality and reduction of spare parts (towards a monolithic design). Depending on the application additive manufacturing can offer a customized solution. In 2023 the AM team of FOTEC focused on electric propulsion applications with two new projects, continued the work on shape-memory alloys for deployment mechanisms and in-situ resource utilization by processing Martian regolith simulant in relevant environmental conditions.

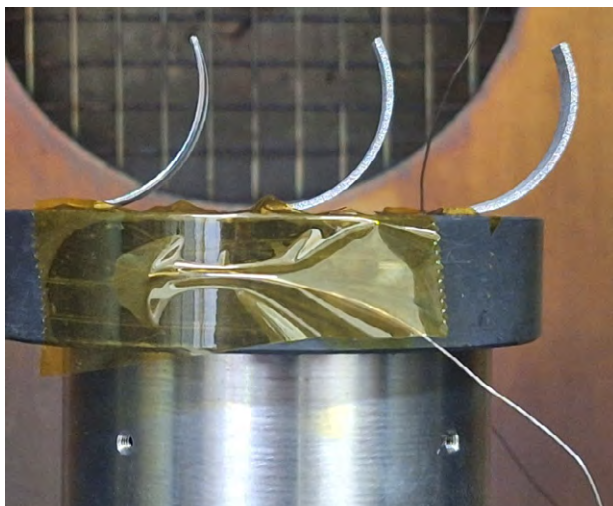


**Monolithic bracket for solar panel motor (left), flexible metal bellow for isolation valve applications (right).**

Within the additive manufacturing process and material developments, FOTEC started the FFG project STEPS (Stereolithographic printing of Tantalum for Electric Propulsion Systems) in May 2023. The main objective of this project is to investigate the use of Tantalum in combination with additive manufacturing to produce porous emitter structures required for FEEP (Field Emission Electric Propulsion) thrusters. Beside increased resource efficiency compared to the conventional powder injection moulding (PIM) process, which is currently used, the design freedom and flexibility offered by additive manufacturing shall help to investigate new porous emitter structure designs and further optimize the performance. In 2023 the Tantalum feedstock development has started and first samples were 3D-printed in the frame of a parameter study. Furthermore, etching trials with conventional Tantalum wire were performed to investigate the etching behavior incl. identification of development needs in an early stage of the project.

Furthermore, FOTEC started the ESA De-Risk activity CROWN 2.0 (Advancements in FEEP crown emitter manufacturing) in July 2023. This project deals also with additive manufacturing of porous emitter structures (like the project STEPS) but is focused on Tungsten. The main objective of this project is a proof-of-concept in terms of additively manufactured Tungsten structures with adjustable porosity and sufficient mechanical integrity mainly for FEEP thruster applications. The benchmark is the conventional emitter made by PIM and it is planned to have comparable or better performance verified by thruster firing tests in the vacuum chamber. Using additive manufacturing instead of PIM offers several advantages, it shortens the lead time, offers design freedom and based

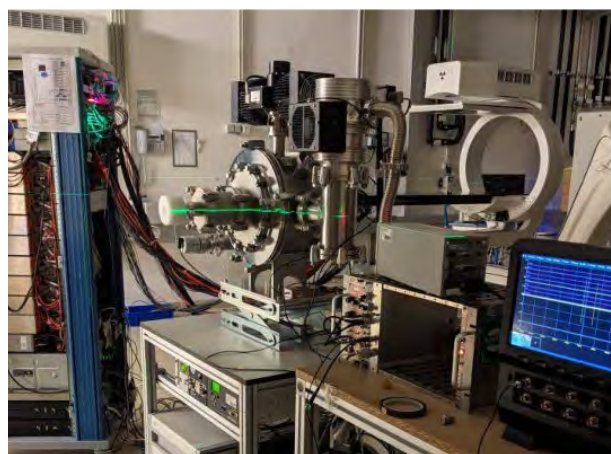
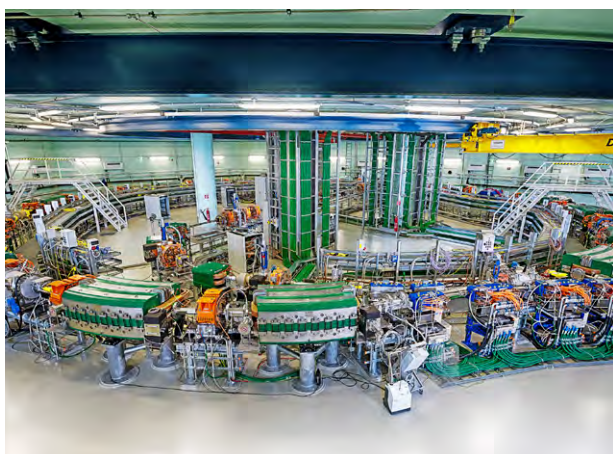
on that optimization potentials. In 2023 first Tungsten crown emitters were manufactured successfully and the focus was on iterative adjustments of the post-processing steps (debinding, sintering and etching). The sample density after sintering still needs to be optimized and within 2023 several solutions were identified, which will be addressed in the upcoming project year.



**Controlled bending of NiTi samples to investigate and verify the 2-way shape memory effect for deployment mechanisms.**

Within the ongoing ESA project 4D-Printing (Assessment of reliability of 4D printing materials due to ground/space environmental effects), which aims on investigating shape-memory metal alloys (SMA) for deployment mechanisms, FOTEC successfully manufactured several demonstrators out of an NiTi alloy ("Nitinol") in 2023. The design of each demonstrator is based on pre-tests on sample level and simulations done by the project partner Aerospace & Advanced Composites GmbH (AT). The trigger for the SMA shape transformations in this project is heating, meaning that in the teaching phase the samples and demonstrators are exposed to a defined temperature determined by differential scanning calorimetry earlier in the project. The testing is still in progress, but first results show that the teaching of the SMA was successful. However, the level of deformation is not as high as expected or predicted by simulation, this issue will be investigated.

In terms of space exploration, FOTEC is working on investigating extrusion-based additive manufacturing using Martian regolith simulant with a binding agent to create radiation shielding and/or structural components for future exploration missions to Moon or Mars. The ongoing ESA OSIP activity RAMMEC (Recycling enhanced additive manufacturing processes under Martian environmental conditions) has the objective to create a material data base for Martian regolith samples manufactured under relevant Martian environmental conditions. In 2023 the team has finished the work on the environmental test chamber including data acquisition system to log the pressure level and CO<sub>2</sub> content during sample production. Furthermore, the recycling aspect using representative polymeric waste from food packaging for space missions was investigated. For that several samples (pure polymeric waste and Martian regolith/polymer mixtures) were tested. Finally, the integration of an extrusion-based additive manufacturing device into the Martian environmental test chamber was successful and material samples were produced and forwarded for testing.



**Accelerator facility at MedAustron (left) and test setup to operate X-ray sensors together with the Max-Planck Institute for extraterrestrial physics (right)**

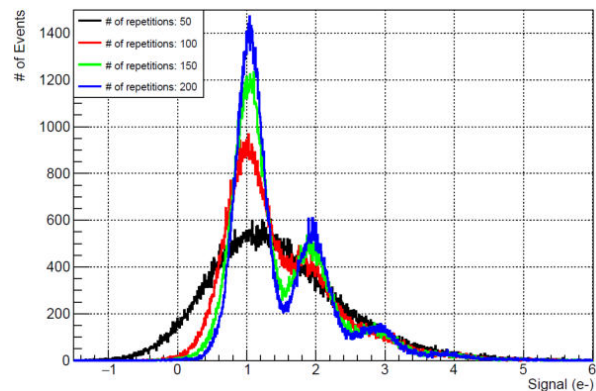


## Single Event Effects test of space components

The FHWN and FOTEC established a cooperation with Seibersdorf Laboratories to conduct and analyzes irradiation test at MedAustron. These actives involve two projects funded by FFG, in particular SEESat and SEERad, which are focusing on the commissioning and testing of a space dosimeter as well as the development of a procedure for single event effects test at MedAustron. In this context, common test campaigns were done with the Max-Planck-Institute for extraterrestrial physics and the IWF in Graz.

## Quantum detectors for light dark matter searches

Based on a cooperation with the Institute for high energy physics of the Austrian academy of sciences and the semiconductor laboratory of the Max-Planck society, FHWN is leading a FWF funded project in which RNDR-DEPFET detectors are studied for their use in direct detection experiments for light dark matter and as space based instruments. Those detectors are capable of resolving the signal of single electrons combined with a small dark count rate and a large sensitive volume. This enables the technology as well to perform photon number resolved measurements in the optical regime. Future scientific satellite missions, delectated to the direct observation of exoplanets rely on these specific properties, achievable by this technology.



**Spectrum of an optical LED, which was operated at low intensities to emit one, two or three photons, that excite the corresponding number of electrons. The signal resolved the individual number of electrons**

Fachhochschule Wiener Neustadt GmbH  
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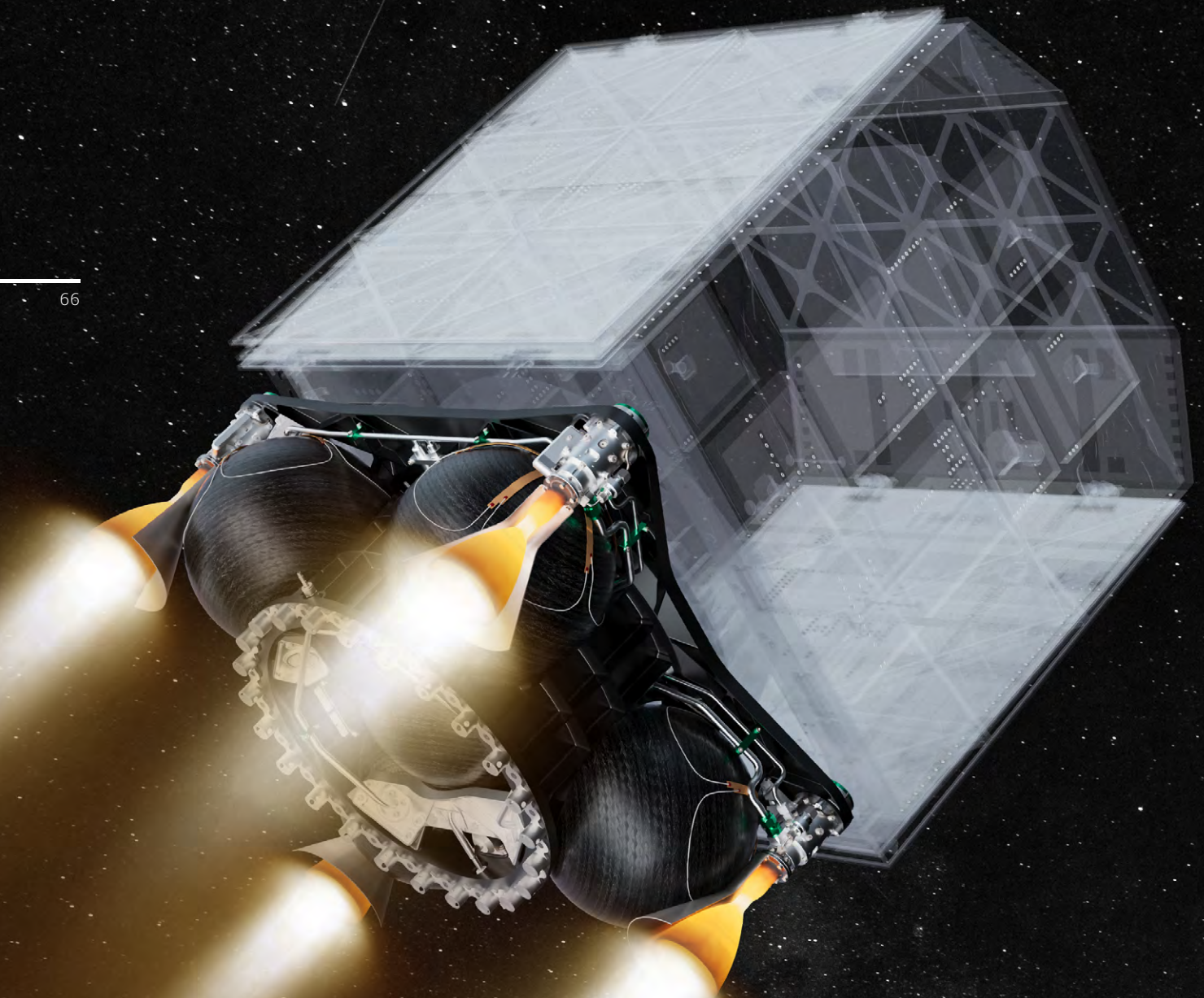
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### FACTS

Sales: 4,4 M€  
ESA Share: 1,4 M€





The new design of the GATE Jetpack introduced in 2023, featuring spherical tanks.

© GATE Space



# GATE Space Innovation GmbH

## The founding of GATE Space

The story of GATE Space began at the TU Wien Space Team, where the founders, driven by a shared passion for space technology, collaborated on ambitious projects within tight budget and time constraints. Their journey was marked by several milestones, including the development of the mobile rocket engine test stand "Franz." This facility, designed to test solid, hybrid, and liquid rocket engines with a thrust capacity of up to 24 kilonewtons, was at the forefront of student rocketry and set a new standard for international teams.

Fueled by their past successes and validation from the industry confirming the market need for innovative chemical propulsion, GATE Space was officially founded in 2022. This marked the beginning of their mission to transform the space industry with groundbreaking propulsion solutions, leveraging their years of experience and their dedication to space technology.

## The GATE Thruster

The GATE Thruster is a pioneering advancement in propulsion technology for NewSpace applications. Featuring a patented injection technology, it offers precise deep throttling capabilities at a ratio of 1:10 as the only spacecraft thruster available on the market today, granting a multitude of benefits.

A standout feature of the GATE Thruster is its ability to inherently compensate for feed system induced pressure variations – even for the simplest of feed systems. Its closed-loop linear thrust control ensures consistent performance and reliable operation, crucial for mission success. With the option to perform both short impulse bits or long continuous



Iteration 4 of the GATE Thruster. © GATE Space



Hot fire testing campaign of the GATE Thruster. © GATE Space

burns, the GATE Thruster can function as both an apogee engine and a reaction control thruster. This comes at a fraction of the price and complexity of comparable propulsion systems.

Additionally, the GATE Thruster's deep throttling capability serves as the enabling factor for differential thrust stabilization, allowing three-axis stabilized orbit transfers without additional reaction control thrusters. Apart from further reducing complexity in the propulsion system, this approach autonomously compensates for spacecraft mass distribution shifts, which is ideal for dynamic load scenarios.

## The GATE Jetpack

The GATE Jetpack is an advanced chemical propulsion system designed primarily for small satellites, powered by the GATE Thruster. The GATE Jetpack's primary appeal lies in its short lead time and swift integration process, which takes less than a day, drastically reducing deployment timelines compared to traditional propulsion systems. This efficiency not only saves valuable mission preparation time but also contributes significantly to reducing overall mission costs, operating at a fraction of the expense typically associated with legacy propulsion solutions. Designed as a plug-and-play solution, the GATE Jetpack seamlessly integrates with ESPA-class spacecraft. It is installed on ground onto the satellite's payload adapter interface following the completion of the satellite platform assembly.

Once integrated, the GATE Jetpack remains permanently attached to the satellite throughout its operational lifespan, providing mission-lasting mobility. This permanence enables the satellite to perform critical functions such as navigating the final mile to its designated orbit, executing correctional maneuvers, avoiding potential collisions, and managing end-of-life de-orbiting procedures.

## Successes of 2023

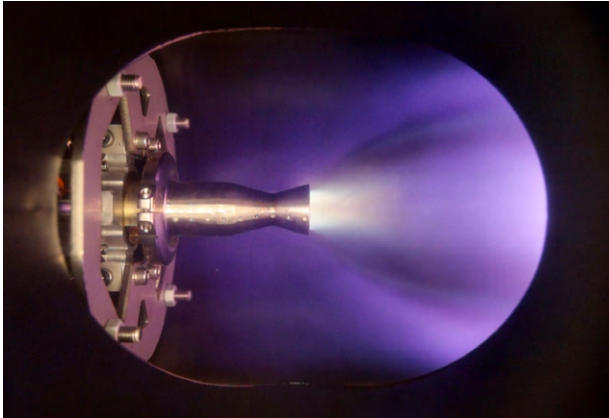
In 2023, GATE Space achieved numerous milestones, marking a year of growth and success. Early in the year, the company was selected for SpaceFounders' 3rd batch and the 2023 Amazon Web Services (AWS) Space Accelerator, highlighting its potential in the space technology sector. In May, GATE Space also secured a competitive €700,000 Seed financing – Deep Tech grant from the Austrian promotional bank (aws), strengthening its financial foundation.

The company made a strategic move by expanding to the United States, establishing GATE Space Inc. and joining the Techstars Space Accelerator. This prestigious program, run in partnership with the US Space Force and NASA's Jet Propulsion Laboratory, positioned GATE Space strategically within the global space industry. Although the company's R&D has remained in Austria, the US expansion has broadened the company's market reach and provided opportunities for collaboration with leading space organizations and experts in the US space market.

GATE Space also made significant progress in its technological and operational capabilities. During the fall of 2023, the company conducted the first successful 4-engine hot fire test of the GATE Jetpack demonstration model, and successfully proved the GATE Thruster's capabilities in vacuum conditions. The GATE Thruster also became part of the permanent exhibition at the Technical Museum Vienna, showcasing its significance in Austrian space innovation.

As a result of valuable customer input and the company's commitment to continuous improvement, the year ended with the introduction of a new GATE Jetpack design at the Techstars Demo Day featuring spherical tanks and a new center column structure. The new design provides enhanced structural integrity, increased payload capacity





**Successfully demonstrating the GATE Thruster's throttling capabilities in vacuum.** © GATE Space



**The GATE Space team in early 2024** © GATE Space

and higher manufacturing efficiency, while also increasing stiffness and reducing weight. These technological advancements were complemented by significant improvements to the company's in-house testing infrastructure and mission control facilities located near Vienna, Austria, further strengthening GATE Space's operational capabilities.

## An outlook for 2024 and 2025

Looking ahead, GATE Space anticipates significant advancements in the coming years. In January 2024, the company began a project for The Exploration Company, designing and building an advanced testing infrastructure to facilitate propulsion development for the Nyx spacecraft. Concurrently, GATE Space is further developing its own technology, with Iteration 5 of the GATE Thruster already machined and undergoing testing. Additionally, at the beginning of 2024, GATE Space has secured a significant contract with the European Space Agency (ESA) to explore the GATE Jetpack's capabilities, including hover flight.

The company has also secured 25 Letters of Intent (LOIs) from customers to deliver propulsion systems following a successful in-orbit demonstration (IOD) scheduled for 2025. The IOD will showcase the capabilities of GATE Space's technologies in a real space environment.

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Landcover Dynamics 2016-2018  
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# GeoVille

Informationssysteme und Datenverarbeitung GmbH

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GeoVille provides a wide range of value-added services derived from Earth observation data to enable GIS applications. With more than 25 years of experience, our mission is to provide turnkey geospatial intelligence solutions for efficient client operations and management. We aim at optimising the value of our spatial insights, thereby generating benefits and advances for our clients through reliable information products and related solutions. GeoVille has built up profound expertise in the field of data access, data streams, cloud-computing solutions, highly scalable production systems and interactive web user-interfaces with a strong geospatial connection.



## Our Clients

We have a global clients' base in over 140 countries world-wide. Our clients are international institutions, NGOs, public authorities, and commercial customers.

### International Institutions

European Environment Agency, European Space Agency, European Union, IFAD, United Nations Programmes

### Financial Institutions

Asian Development Bank, European Investment Bank, EuropeAid, World Bank

### Public Authorities

Various ministries and agencies for environment, agriculture, forestry, research, water and energy commissions

### Private companies

Agriculture, Financial Sector, Consulting, Construction, Oil & Gas, Telecommunication, etc.

## New Project Highlights

### European Space Agency

#### Smart Connect

72

GeoVille together with an interdisciplinary team have been awarded an ESA partnership project in the "Civil Security from Space" Program, taking on the task of addressing crisis communication challenges.

SMART-CONNECT revolutionizes crisis data exchange capabilities by swiftly and resiliently handling information during emergencies. The solution provides failsafe transmission capacity and deliver actionable insights to first responders and disaster control centres, ushering in a new era of efficiency in crisis response.

This development activity aims at closing the documented open gaps of the civil security sector by enabling uninterrupted transmission and reception of critical situational awareness situation globally.



SMART-CONNECT provides a middleware solution that allows a secure end-to-end data interconnectivity among citizens, first responders, disaster management centres, and situational awareness EO service providers. Failsafe transmission capacity is enabled via automatic selection of available transmission channels (all SatCom and terrestrial). As a user selectable service option, the solution features an open value chain for third-party situational awareness information service providers. SMART-CONNECT thereby provides an end-to-end data chain for civil-security emergency management.

SMART-CONNECT will be the first civil security one-stop-solution combining:

- fail safe, multi-channel data transmission with fully automatic failover techniques for data dissemination from and to the field,
- Bi-Directional adaptive data-streaming (even in real time) of situational awareness information from and to field,
- Access via standard commodity hardware and state-of-the-art mobile SatCom Terminal solutions,
- Broadcast solutions to address millions of users simultaneously on commodity devices in the field,
- Easy to plug in and open to existing solutions via a set of specialised APIs,
- Third party situational awareness service options (including satellite and drone data from different sensor types as well as fixed and mobile sensors on the ground) and
- Highest security standards and multi-channel data-integrity checks

Contract Value: 9.548K €

#### EO Africa DUNIA Service for enhanced Africa EO Data Access and Exploitation

EO AFRICA stands for African Framework for Research, Innovation, Communities and Applications, building an African-European partnership and will support the digital transformation and will be in line with the strategies of the African Union 2063 Agenda. The main objective of EO AFRICA is to fa-





cilitate the adoption of Earth Observation (EO) and related space technology in Africa. EO AFRICA DUNIA Service is an all-in-one, easy-to-use data processing and dissemination platform that also works on smartphones. By providing access to Copernicus Sentinels data in formats and protocols adapted to low bandwidth and fast data processing, the Dunia service will help improve data accessibility and use, facilitating the development and operation of applications over Africa.

The users of the Dunia Service have open access to Copernicus Sentinel data, relevant GIS mapping information, Digital Elevation Models, and Applicative Software developed for/by the community over Africa, as well as compatibility with other cloud computing solutions, leveraging on existing capabilities

such as the Copernicus Data Space and relevant Open Science platforms, avoiding duplication of existing data sets, yet provide a high potential for scaling of R&D services to the national/regional level.

Contract Value: 3.399K €

#### **Fast EO Co-Financing Facility (GDA FFF)**

The GDA FFF consortium (Fast EO Co-Financing Facility) comprises 13 European companies from 8 participating states in the Global Development Assistance (GDA) programme. The consortium is composed of large and well-established EO firms, SMEs with different thematic specializations and also AI applications as well as research institutes with modelling expertise. This cross-cutting activity is designed to support International Financial Institutions (IFIs) in their projects based on comparatively short-notice requests.

The GDA FFF framework establishes a co-designing and co-financing framework through the alignment of development finance resources. Meaning that the implementations of the requested services should go beyond a demonstration towards a pre-operational level in a co-design and joint implementation approach together with the stakeholders. The GDA FFF activities target stakeholders in the IFI and NDA/ODA sector.

The project provides a rapid-response mechanism for testing and aligned integration of satellite EO services in international development projects and programmes of International Financing Institutions (IFIs) and National Development Agencies (NDAs). The facility is set up to directly connect with activities implemented using aligned development finance resources. It relies on a technically pre-qualified team of EO service providers and satellite remote sensing experts in GDA participating states, ensuring flexibility and agility to meet potentially short delivery timescales required by the development partners and consequently guarantee optimal operational applicability.

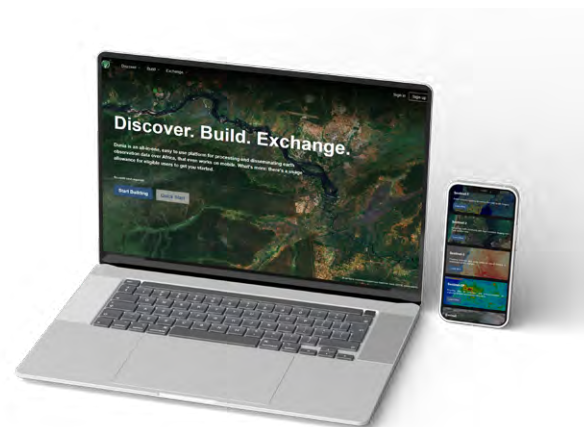
Contract Value: 1.500K €

#### **Austrian Space Application Programme**



**HeatMon**

Towards a monitoring service enabling climate change mitigation and adaption measures

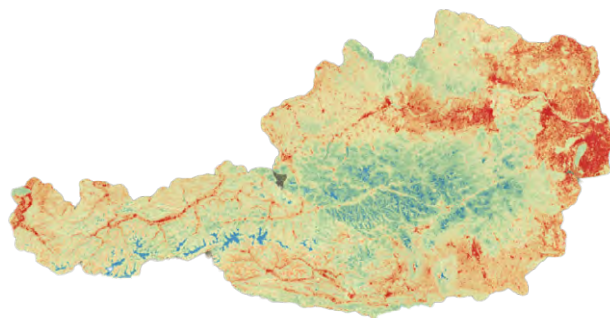


Source: DUNIA, <https://dunia.esa.int/>



Air temperature is different to the temperature of the land surface and the subjective perceived temperature. Higher air temperatures, especially during longer heat waves, cause a strong increase of surface temperatures especially in areas which are

built-up or sealed by concrete or asphalt. This is known as the Urban Heat Island effect, where an urban area is significantly warmer than its surrounding rural areas. Heat islands contribute to higher daytime temperatures, reduced night-time cooling, and higher air-pollution levels, in turn amplifying heat-related health issues and stress factors on both humans and animals.



Satellite-based analyses of global land surface temperatures span several decades and are typically provided in moderate spatial resolution (up to 0.1°), such as from the Copernicus Sentinel-3 Sea and Land Surface Temperature Radiometer (SLSTR). The upcoming Sentinel-8 Land Surface Temperature Monitoring (LSTM) mission, which will provide global observations of land-surface temperature in unprecedented spatial resolution, will allow an even more detailed assessment of heat-related issues.

Contract Value: 470K €

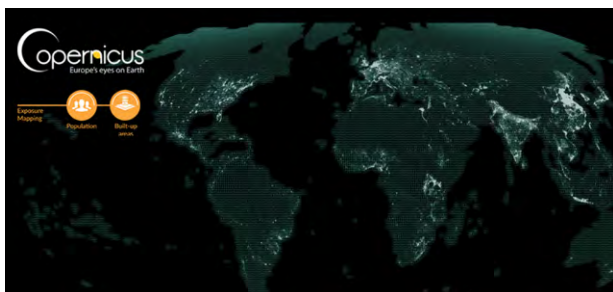
## JOINT RESEARCH CENTER (JRC)

### Global Human Settlement Layer (GHSL)

The Global Human Settlement Layer (GHSL) project produces new global spatial information, evidence-based analytics and knowledge describing the human presence on Earth. It operates in a fully open and free data and methods access policy. The knowledge generated with the GHSL is supporting the definition, the public discussion and the implementation of European policies and the monitoring of international frameworks such as the 2030 Development Agenda. GHSL is the core data set of the Exposure Mapping Component under the Copernicus Emergency Management Service. GHSL data continue to support the GEO Human Planet Initiative that is committed to developing a new generation of measurements and information products providing new scientific evidence and a comprehensive understanding of the human presence on the planet and that can support global policy processes with agreed, actionable and goal-driven metrics.



The GHSL comprises several information layers as open and free datasets covering various thematic domains to understand the characteristics of human settlements. GHSL maps contain built-up surface, the density of population, and the settlement typology. Such data characteristics provide information on how much of the Earth's surface is covered by settlements, and where, how much and how fast settlements are growing. This information baseline is essential for informing policymaking for sustainable development, and it is particularly essential for crisis management. With the operational production within the Copernicus Exposure Mapping component, new information shall be continuously produced.



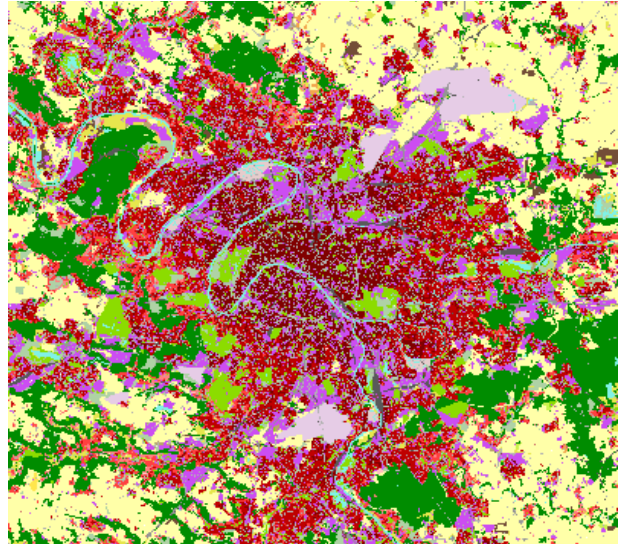
Source: European Commission, GHSL – Global Human Settlement Layer, <https://ghsl.jrc.ec.europa.eu/>

Contract Value: 1525K €



### Urban Atlas

The continuous expansion of built-up areas and migration of the population from rural to urban areas across Europe has been recognised as a long-term trend as most of the economic activities are concentrated around major urban areas. A more recent trend is the migration of population and some economic activities from city centres to the urban fringe and neighbouring rural areas encroaching onto 'greenfield' land, i.e. land that has not previously been developed. In addition, this urban sprawl is accompanied by the conversion of land to artificial surfaces resulting in soil sealing, thus further increasing the environmental consequences of urban sprawl. This poses a very serious threat to the existing nature of European landscapes and biodiversity with significant environmental problems linked to increasing transport distances and volume of traffic.



However, at the same time, there are a significant number of artificial areas that are no longer actively used and could potentially be redeveloped instead of encroaching on non-urbanised land. Vacant sites are a natural reservoir of land that can potentially be redeveloped. The identification and location of potential vacant land is only possible if harmonized and detailed land use and land cover information is available.

Therefore, the need for accurate and up to date Land Cover /Land Use (LC/LU) information is becoming increasingly important for European cities where the urban sprawl phenomenon is posing a major threat to the environment and competitiveness of the European economy. Better and more frequent provision of information on urban land use and land cover is essential to develop and monitor modern integrated urban land use planning policies.

Contract Value: 4.100K €

### Commercial Services

#### Clutter Data Iceland

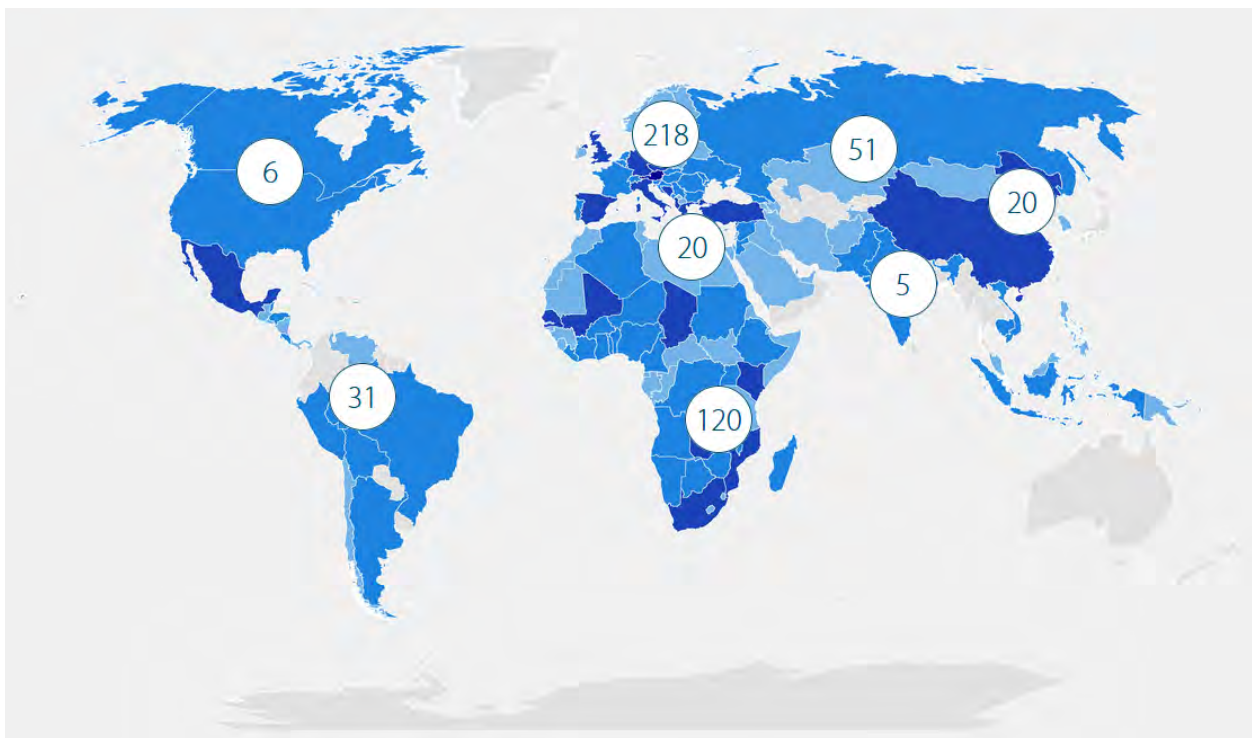
For the Icelandic telecommunications company NOVA up-to-date clutter data, detailed object elevation information, and a digital terrain model (DTM) was provided for the entire Icelandic territory (103,000 km<sup>2</sup>) by GeoVille in cooperation with our subsidiary MapOrbit.

In the context of telecommunications clutter data refer to unwanted or extraneous signals, that can degrade the transmitted information. Beside electromagnetic interference and radio frequency interference also multipath effects due to land cover and objects can occur and need to be taken into consideration. The clutter data classification consists of a 16 class nomenclature, natural classes like water, grassland, forests, and several density classes of built up area.

Since a higher level of detail is required in densely populated areas than in rural areas, the total area is divided into three zones: the city area of Reykjavik, all other urban centres, and the remainder of Iceland. For each zone, the products are offered in a different but adequate resolution in order to provide the best cost-benefit ratio.







Realised projects worldwide (excl. global projects)

## GeoVille Information Systems and Data Processing GmbH

Sparkassenplatz 2, 6020 Innsbruck  
[www.geoville.com](http://www.geoville.com)

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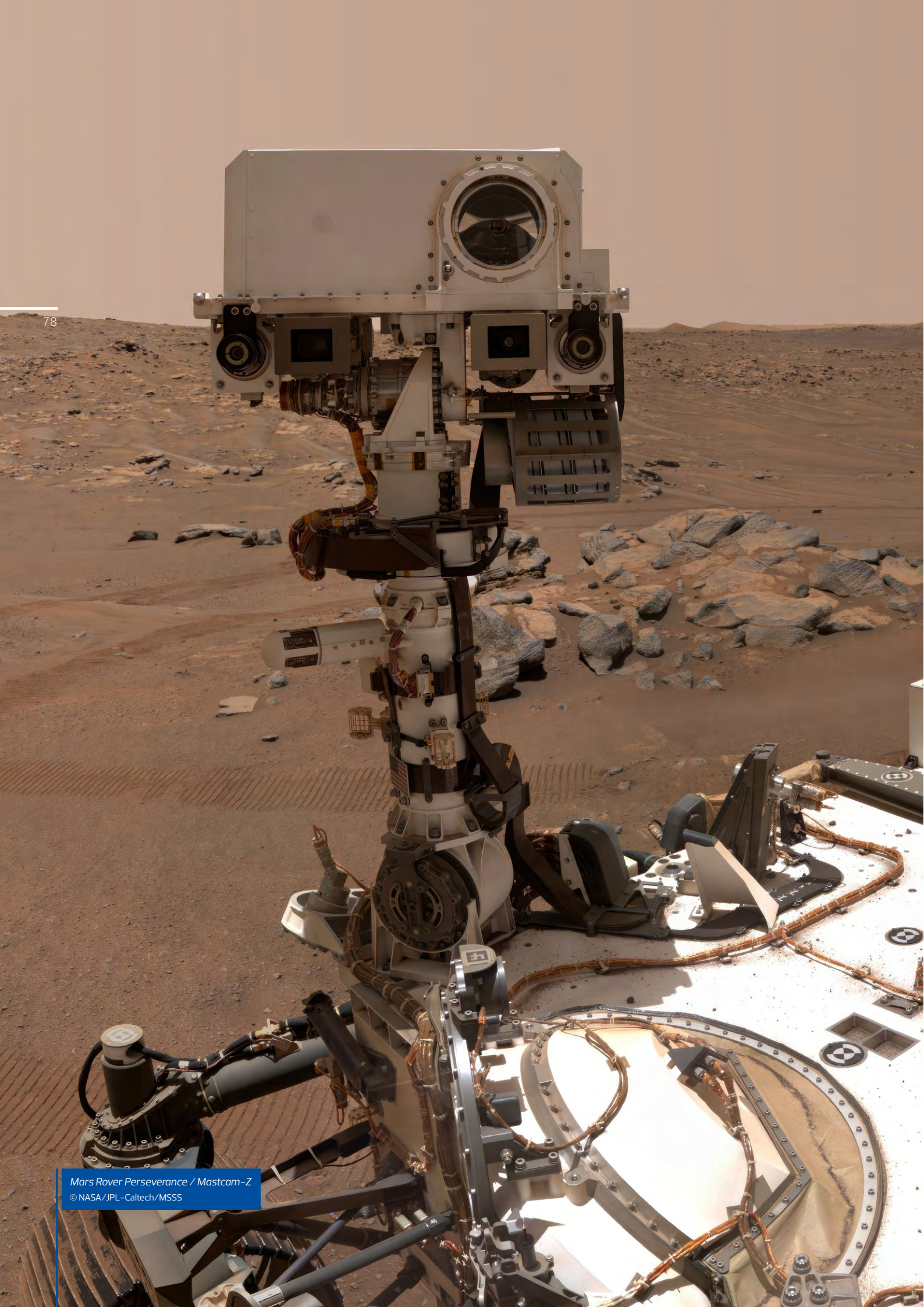
### FACTS

Sales: 10,7 M€  
ESA Share: 3,4 M€

### MORE INFO

Twitter: [https://twitter.com/geoville\\_gmbh](https://twitter.com/geoville_gmbh)  
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Mars Rover Perseverance / Mastcam-Z  
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# JOANNEUM RESEARCH Forschungsgesellschaft mbH

DIGITAL – Institute for Digital Technologies

JOANNEUM RESEARCH is dedicated to Space science, research and technology development since 1978. The Institute for Digital Technologies (DIGITAL) is focusing on the following competence areas

- Satellite communications and navigation
- Microwave propagation and radar technology
- Verification and optimisation of systems and services in field trials
- Remote sensing
- Processing of data from active and passive space- and airborne sensors
- Space robotics

JOANNEUM RESEARCH is a highly recognised technology development partner. It successfully contributes to projects funded by the European Space Agency ESA, the European Union, FFG, space industry, research establishments as well as foreign space agencies such as NASA, ASI and DLR. The capability of cooperative technology development covers prototype development as well as commercial products. Successful examples are a monitoring service for forest damage, a satellite channel emulator and satellite signal monitor, as well as 3D vision and visualization for space probes operating on planetary surfaces. Successfully developed systems are validated and further optimised in field trials and have a clear scientific or commercial perspective.

## Communications & Navigation Technologies

JOANNEUM RESEARCH's research group "Telecommunications, Navigation and Signal Processing" (TNS) holds a decades lasting successful tradition in experiments and studies improving satellite communications and satellite navigation. As for a few recent focal points, the ALPHASAT Q- V-band satellite ground station and the W-band CubeSat W-CUBE are mentioned, as well as the satellite navigation project BLIND with a high speed sampling 40 element GNSS antenna array. Many of these research activities are carried out under ESA contract, with a meanwhile substantial success in commercial exploitations. TNS manufactures and markets the small scale series products "2D-Video-Distrometer" and the "Monopulse Tracking Receiver", which are globally employed. On national level, TNS contributes significantly to activities ensuring robustness of GNSS reception and PNT availability and TNS is currently involved in the CubeSat initiative of the Austrian MoD. For sake of conciseness, in the follow-

ing one sample project is presented, actually awarded to TNS by ESA's TDE programme line. This activity to employ deep learning methods in the field of satellite services confirms TNS' forefront position in our field of science and research.

### Deep Learning for Screening Propagation Data

This project aims to automatize the processing of tropospheric and ionospheric propagation measurements by deep learning (DL), these data are of relevance for satellite communications and for satellite navigation.

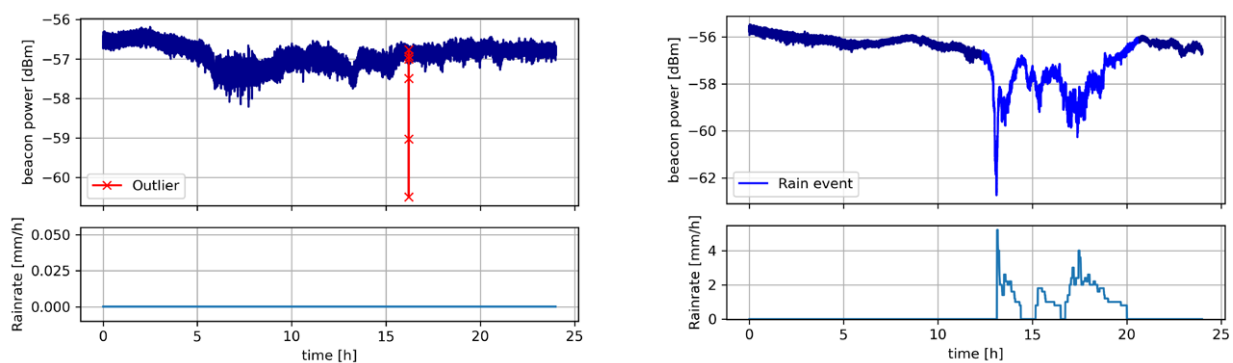
80

Currently the data processing in both fields is done manually or semi-automatically aided by visual inspection. The goal is to determine if either individual steps or even the full data processing activity can be replaced by deep learning methods to speed up the process while maintaining precision of the results.

#### Tropospheric Data Processing

The attenuation of tropospheric events is typically monitored with beacon receivers at different frequencies and locations all over the world. This information is used to plan and scale future satellite links. These beacon power measurements are then processed on time series basis. Since deep learning typically relies on large quantities of data, a tropospheric database (DB) with global coverage in terms of climate zones and a frequency range from Ka- to V-band was created in this project. The database covering approx. 30 years of beacon power and meteorological measurements was labeled for deep learning purposes flagging outliers and samples that belong to precipitation events.

The processing steps focus then on the outlier/spike detection, the detection of precipitation events, removal of the satellite template due to satellite motion and antenna opening angle, and finally the conversion to excess attenuation. The outlier detection as well as the detection of precipitation events are about to be replaced by DL approaches. The remaining steps will be executed by classical processing methods relying on DL outputs. Besides beacon power measurements, it was decided to consider only the most basic parameters for DL such as the wind speed, temperature and rain rate at the measurement station.



Outlier event (left) and precipitation event (right)

While the outlier detection task is qualified for an Autoencoder based approach or classifier, the precipitation detection rather calls for an LSTM based model (long short-term memory) due to the memory requirement for long precipitation events. Summarizing, it can be said that the challenges for the DL models lie in the data diversity since the data contains hardware, climate or location and satellite mission specific properties that sometimes mask the actual parameter of interest.

The results of the final DL model will then be evaluated on historic measurement data in terms of monthly and annual statistics and compared with ITU models (International Telecommunication Union).



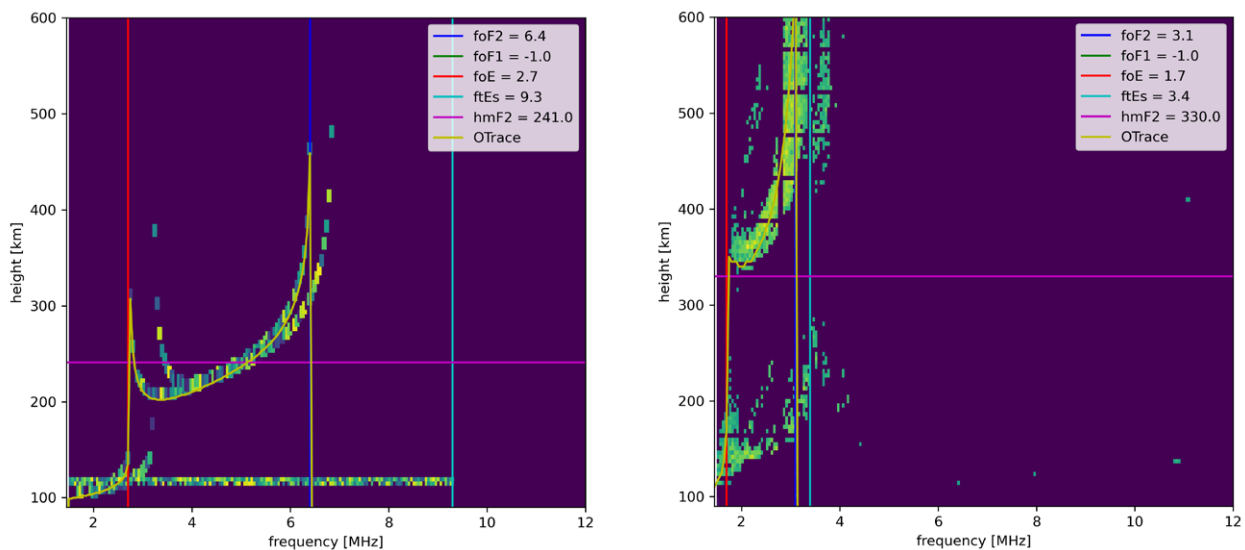
## Ionospheric Data Processing

The ionosphere is a highly dynamic medium that exhibits significant variations with altitude, latitude, longitude, local time, solar cycle, season, and geomagnetic activity.

At present, the ionogram processing tools do not use deep learning methods, and they automatically perform so-called scaling of the ionograms. The scaling of the ionograms consists in determining the main physical parameters (ionospheric characteristic) relevant for radio propagation. Furthermore these tools perform the inversion of the ionogram trace to obtain the electron density profile and the related parameters like hmF2.

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While parameters foF2, foF1, foE, foEs and hmF2 are in the focus of this activity, the most important ionospheric parameters are those concerning the F2 region.



**Ionogram simulated (left) and measured (right)**

It is known that in degraded radio propagation conditions (e.g. ionospheric storms and Spread F conditions) the ionograms become difficult to interpret. The DL must be able to interpret poor quality ionograms if this is possible, simulating as much as possible the output provided by an experienced operator acting according to the URSI standard (Union Radio-Scientifique Internationale).

An ionospheric database was created consisting of measurements and simulated ionograms with and without radio noise. In addition to the numeric ionograms, also the critical frequencies are provided as data labels for machine learning aiming to represent the variation of the layers in different conditions e.g. seasons, location, presence of layers, etc.

In this activity two deep learning approaches are implemented. The first approach focuses on the detection of the individual layers in the ionogram. Considering the properties of an ionogram, a U-net DL model could be well suitable. The identification of the critical frequencies for each of the present ionospheric layers is then done in a post-processing step.

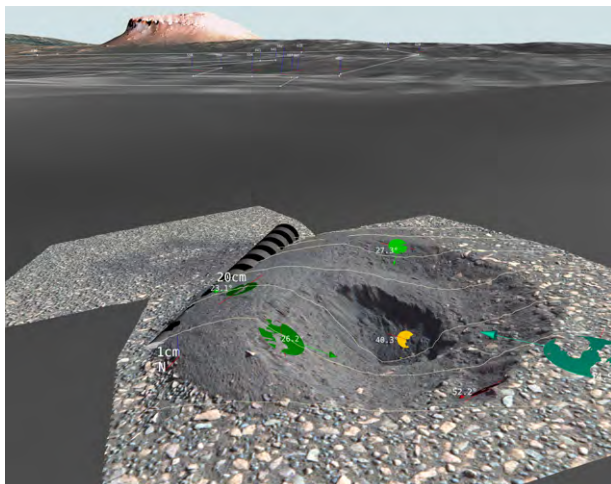
The second approach aims to extract the numeric value of the wanted parameters directly from the ionogram and builds on top of the model developed in the first attempt. The model is enhanced by a regression layer to predict the numerical values of the critical frequencies.

JOANNEUM RESEARCH leads this ESA project as the prime contractor, coordinating a team including the "Abdus Salam International Centre for Theoretical Physics" (ICTP) with the "Istituto Nazionale di Geofisica e Vulcanologia" (INGV) in Italy, "Rokubun SL" in Spain and the "Norwegian Defence Research Establishment" (FFI).

The research group “Intelligent Vision Applications” (IVA) hosts the “Space Robotics & Instruments” Team (SRI) which, for more than three decades, has been involved with imaging & 3D vision technology as well as meta data handling & field trials in several ESA missions e.g. ExoMars (PanCam, NavCam/LocCam, CLUPI, WISDOM) and Hera, and is internationally engaged in the NASA Mars 2020 (Mastcam-Z 3D Vision) and MSL missions. Data handling, 3D vision processing and visualization technology directly stems from the named mission involvements and additional dedicated Austrian space-related funding projects in the frame of 3D vision, field trials’ involvement and data handling, AI, and visualization.

### a. Mars 2020 Mastcam-Z 3D Vision

The NASA Mars 2020 Perseverance Rover mission landed on Mars on 18th February 2021 to undertake the next key steps in our understanding of Mars’ potential as a habitat for past or present life. Among other instruments, Perseverance carries Mastcam-Z, a stereoscopic zoomable multispectral camera coordinated by Arizona State University. Gerhard Paar from JOANNEUM RESEARCH (JR) is one out of about a dozen international Mastcam-Z Co-Investigators (Co-Is), with Austrian collaborators from VRVis (Dr. Christoph Traxler and Team), the Austrian Academy of Sciences (Prof. Christian Koeberl and Team), and three collaborators from Imperial College London.



**Analysis of regolith “angle of repose” on the “Atmo Mountain” sample hole, being used for characterization of important physical properties of the Martian soil. The full multi-scale context is kept by 3D vision processing of combined Mastcam-Z stereo image pairs, visualized by the PRO3D visualization tool on top of the 3D satellite-provided surface, superimposed by Perseverance’s traverse.**

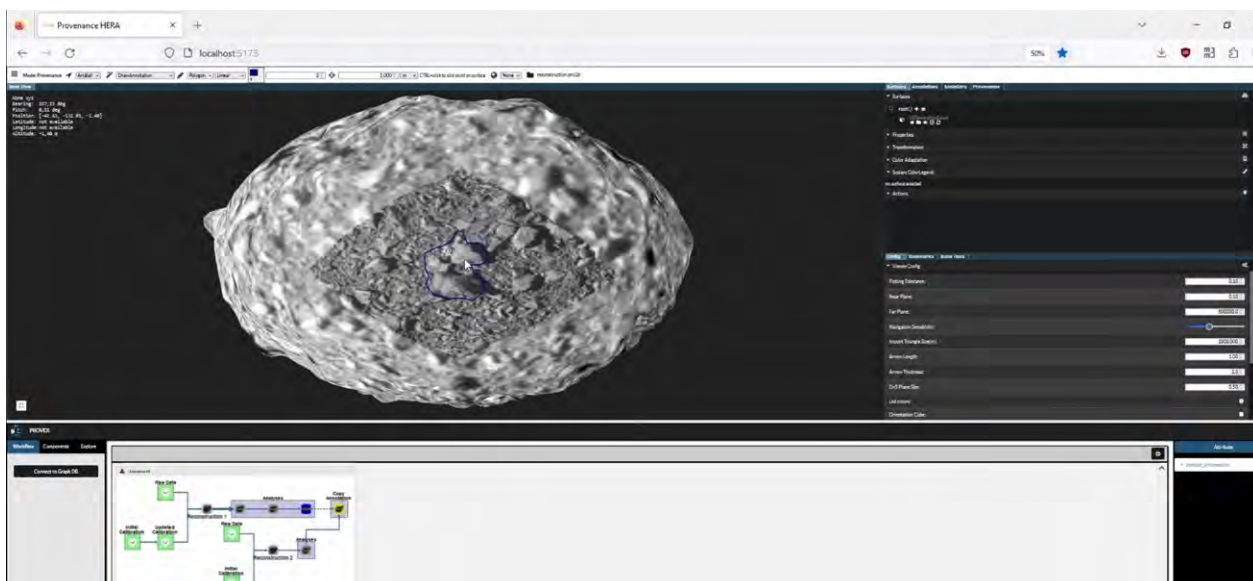
© NASA/JPL/CalTech/USGS/ASU/JR/VRVis/ÖAW

Mastcam-Z 3D Vision, in the frame of the ASAP activity Mars-3D, continued to cover 3D vision building blocks (3D vision processing PROViP and visualization – PRO3D, see Figure on left side), assembling 3D models, data fusion products and visualizations from Mastcam-Z stereo pairs in various scales for further interpretation of the Martian geology, climate, impact structures and soil during the mission in the operational time frame. The Austrian team is embedded in daily operations and is continuing to participate in the regular publication waves of the mission with a few dozens of publication contributions so far, emphasizing on impact science, aeolian, soil and geologic analysis, as well as provision of outreach data products and in particular illustrative videos as available on <https://www.youtube.com/@pro3dspace120/videos>. A Mars 2020 mission-overarching publication, describing its 3D vision and visualization landscape, was led by JR, see <https://agupubs.onlinelibrary.wiley.com/doi/pdf-direct/10.1029/2022EA002532>.

### b. Hera 3D GIS & PROVEX

In 2024, ESA’s European Hera spacecraft will launch and approach the double asteroid system Didymos to study the effects of the DART impact in September 2022, a NASA probe that via its high-speed collision with the Didymos moon Dimorphos had started the exploration of possibilities to influence the orbit of near-Earth asteroids. The Austrian consortium consisting of JOANNEUM RESEARCH and VRVis (Centre for Virtual Reality and Visualisation) is developing 3D vision processing and visualisation technologies to provide a 3D-GIS (Geographic Information System) as major tool for scientific investigation of the DART impact. In 2027, when HERA will slowly approach Didymos and Dimorphos, the interpretation of the observations obtained by the Hera instruments within its 3D-GIS will gain important insights into the first step towards protecting our Earth from devastating asteroid impacts.





**Dimorphos 3D model assembled from DART (DRACO-) camera images, superimposing the very last complete DRACO image taken before impact, by JR's Hera 3D vision processing chain. The 3D model was imported into the Pro3D Hera 3D-GIS in its late 2023 status demonstrating the polygonal 3D annotation of a major boulder, and the associated provenance tree (bottom) as developed in the PROVEX activity, to document the user's step from data formation until the successful annotation.**

The activity is supported by a technology demonstration "PROVEX" (See Figure above for an example, based on DART data) to address the maintenance and visualization of data provenance during scientific investigation and interpretation cadences, that had been successfully demonstrated by the end of 2023.

### DIGITAL-IVA-SRI Outlook for 2024-2026

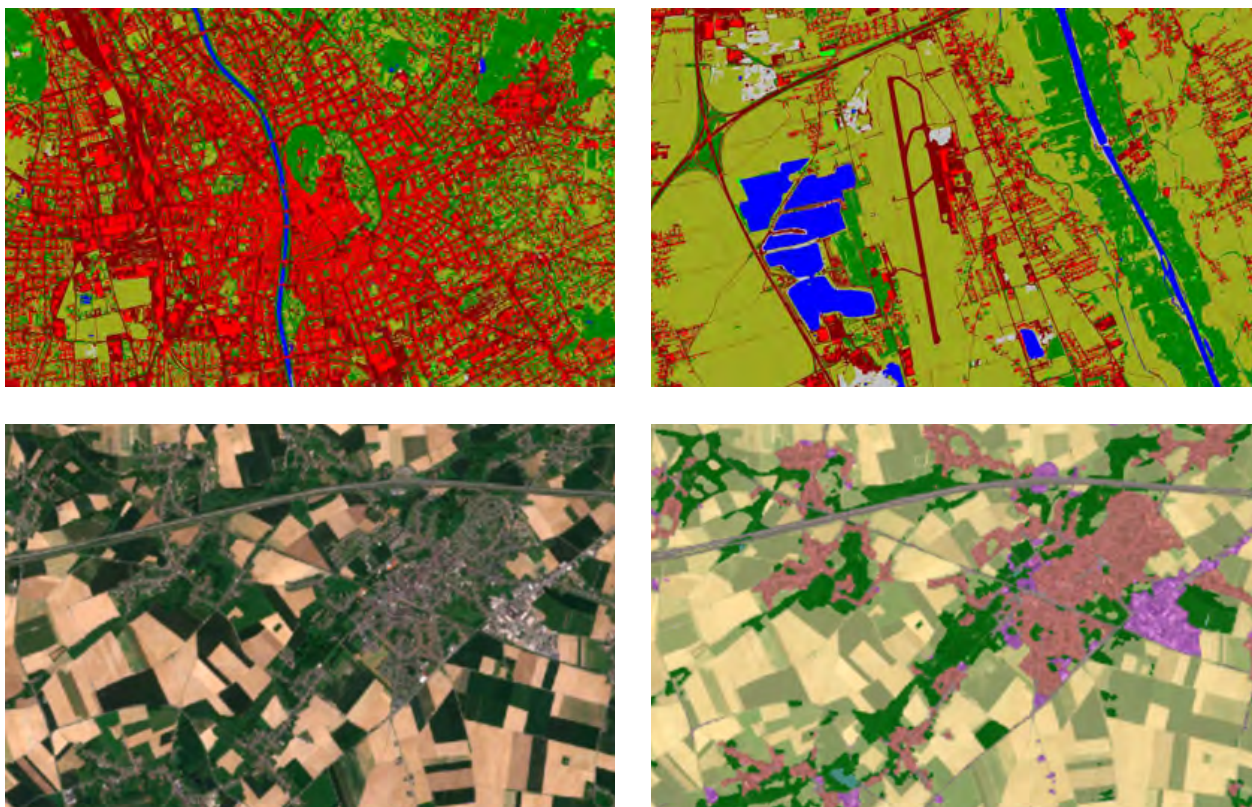
The participation in the Mars 2020 mission with 3D vision data processing and visualization for the Mastcam-Z instrument will go on with JR, VRVis and ÖAW until the end of 2024 in the frame of the joint ASAP contract "Mars-3D". In that activity, also light bridging and testing for ExoMars PanCam 3D vision and visualization (in strong embedding in semiannual ExoMars mission simulations), as well as regular processing for the Mastcam instrument on board the MSL Rover Curiosity will be supported. Scientific processing and visualization / 3D-GIS contributions for the Hera 3D vision framework will be implemented to verify nominal 3D GIS operations in the Hera Mars fly-by early in 2025. A follow-on for PROVEX will address novel usability, deployment and multi-cue elements, and attach further to the Hera 3D-GIS use case. Within the temporarily suspended DIARY field trials archiving activity, the implementation and testing phase will use trials data from an ESA-led field trial activity on Mount Etna 2022 (AMEDS) to demonstrate a generic toolbox to be used for archiving of regular robotic planetary exploration field trials' data.

## Remote Sensing & Geoinformation

The research group "Remote Sensing and Geoinformation" develops solutions and products for environmental monitoring, safety-related monitoring and mobile, multi-sensoral data collection and analysis. A recent R&D focus is on developing Earth Observation based monitoring systems that support the green transition by exploiting AI-based solutions for image segmentation and analysis. Related research activities are carried out under national FFG contracts, ESA contracts or Horizon Europe projects. In the following, we present results of two selected AI projects from the past year.

### Artificial Intelligence for Automated Mapping of Land Use and Land Cover

The AI4LULC project, a cooperation between Blackshark.ai GmbH as project coordinator and Joanneum Research, embarked on an exploration of AI-based Land Use and Land Cover (LULC) mapping methodologies across a spec-



**Exemplary results: (top) VHR LULC classification for two regions in and around the city of Graz, Austria. (bottom) Urban (red) vs. industrial area (purple) classification as one significant project outcome for potential commercialization for Sentinel-2 data.**

trum of scales, ranging from global to local scenarios. This endeavour was structured around three distinct objectives: firstly, at a global scale, the plan was to map megacities outside Europe, utilizing Sentinel-2 data. Secondly, at the pan-European scale, the project aimed to support the COPERNICUS HR Urban Atlas using COPERNICUS VHR Image Mosaic alongside Sentinel data for selected European cities. Lastly, at the national scale, the investigation sought to assess the applicability of the AI-based methods developed for urban structure mapping in automated LULC mapping on a larger scale, leveraging Very High Resolution (VHR) data in tandem with Sentinel data. The potential is exemplified by the following LULC results from the Austrian and the European use-cases.

### AI-driven Forest Health Risk Indicator

In the past years, biotic forest disturbances have caused substantial economic damages in Austria and Central Europe. The research project AIDForHeRI (AI-driven Forest Health Risk Indicator), funded by FFG (ASAP18), explored capabilities of AI-based predictive tools to estimate bark beetle infestation risk from satellite imagery. Current solutions for bark beetle disturbance mapping by satellite are mostly limited to an infestation stage (red attack) where the bark beetles have already damaged and left the host tree and spread to undetected vital trees in the vicinity. Recent studies in modelling bark beetle infestation report that the number of infested trees in the vicinity is the most important feature for short-term ecological modelling of bark beetle outbreak risk. JOANNEUM RESEARCH with partners Beetle ForTech and GeoSphere Austria, therefore designed a holistic AI-based bark beetle infestation risk prediction that builds on continuously updated time series of Sentinel-2 satellite imagery, monthly classified maps of new infestation and forest changes, additional site-specific parameters relevant to bark beetle infestation (percentage of spruce trees, distance to forest border and new infestations) and high-resolution gridded meteorological data provided on a daily basis. The Standardized Precipitation Evapotranspiration Index (SPEI) is used as the meteorological input data as it reflects the climatic water balance and hence potential drought stress. Monthly SPEI estimates are based on the daily SPARTACUS datasets for Austria. The AI networks are trained on a rule-based risk map (using an empirical weighting of influencing factors) which we validated with reference data collected by aerial

imagery and field data. We tested the performances of two modified implementations of U-Net, a widely used deep learning architecture and convolutional neural network developed for image segmentation. Compared to the traditional U-Net, the U-Net 3D implementation adds an additional time dimension  $z$ , thus increasing the complexity of the model. Examples of data inputs and predicted infestation risks are illustrated in the Figure below.

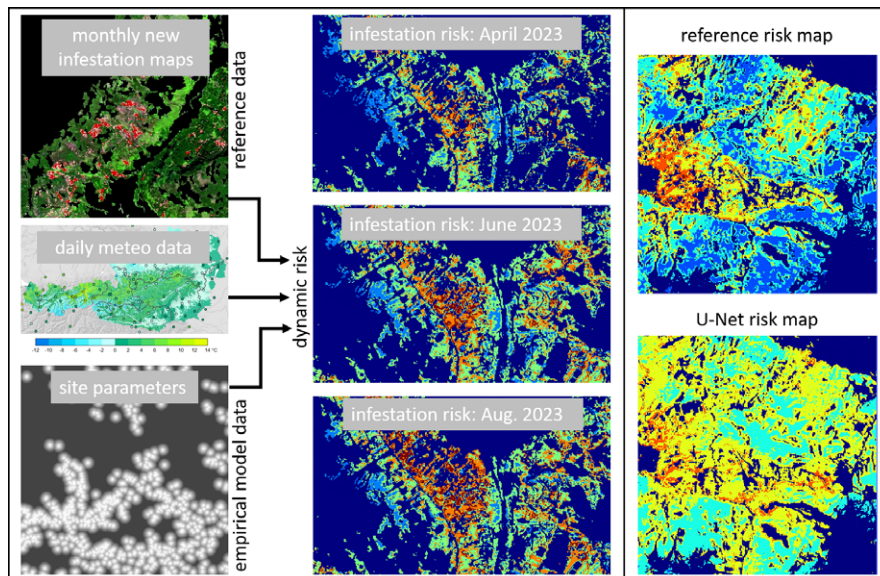


Illustration of dynamic bark beetle risk estimation based on newly classified forest change areas, daily meteorological data, and various site parameters (left). Comparison of empirical rule-based risk estimation and U-Net risk prediction (right). Dark blue colours represent lowest risk, dark red colours represent highest risk.

## JOANNEUM RESEARCH Forschungsgesellschaft mbH

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[www.joanneum.at](http://www.joanneum.at)

### FACTS

Sales: 3,8 M€  
ESA Share: 1,6 M€

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*Hubble Picture of spiral galaxies NGC 1356,  
LEDA 467699 and LEDA 95415*

© ESA/Hubble & NASA, J. Dalcanton, Dark Energy  
Survey/DOE/FNAL/NOIRLab/NSF/AURA; CC BY  
4.0 Acknowledgement: L. Shatz



# Magna Steyr Fahrzeugtechnik GmbH & Co KG

Division Aerospace

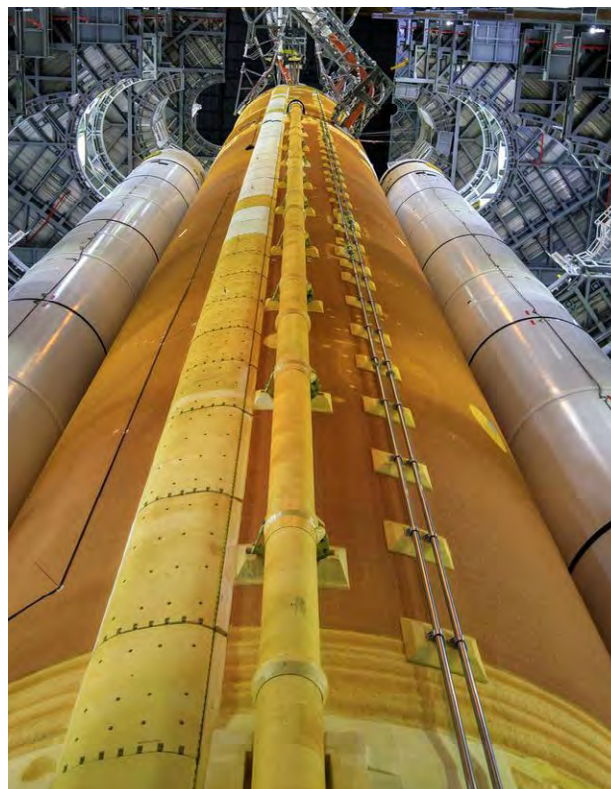
## SLS (Space Launch System) Propulsion Systems Lines and Flexible Joints

We are extremely proud to serve NASA's Space Launch System! Accessing the program with the initial contract from our customer represented an important milestone for the company in 2015 and contributions made by Magna since then are a hallmark of our capabilities.

Magna is the supplier for **Pressurization Lines** and **Bleed Ducts**, including compensators for the **SLS Core Stage (CS)**. The Core Stage is the first stage of the launch vehicle and carries the Interim Cryogenic Propulsion Stage (ICPS) and eventually also the Exploration Upper Stage (EUS) and spacecraft.

The line assemblies delivered by Magna are used for LOX and LH2 transfer. They are semi-rigid lines and include compensators for angular and axial displacement. As operations mature, so does our workshare on the SLS program. As a one-stop-shop we serve both build-to-print and build-to-spec contracts.

In addition to the Core Stage activities, we are manufacturing Feedlines for the Exploration Upper Stage (EUS). Those lines comprise compensators, which are designed and manufactured by Magna.



NASA's Space Launch System © NASA



The EUS is the future second stage of the Space Launch System © NASA

This renewed trust by BDS marked another major milestone in the development of the company. The BTS work package for the EUS shall witness design completion in 2024 and first deliveries in 2025.

### AVIO's VEGA-E – Liquid Propulsion Module Engine lines and LPM propellant lines & compensators

Contrary to VEGA-C, the incremental development of the latter, also dubbed "VEGA Evolution" or simply "VEGA-E" features a cryogenic stage (LOX & LCH<sub>4</sub>) as the third and last stage of the launch vehicle. This new architecture is an improvement over VEGA-C as the design provides flexibility for the delivery spacecrafts in multiple orbits (engine re-ignition).

Magna has been entrusted by AVIO with the responsibility for 2 work packages on this variant:

- the M10 engine lines and
- the propellant lines and corresponding compensators

of the so-called VEGA Upper Stage (VUS), also referred to as the Liquid Propellant Module (LPM).

The Engine Lines activity is about a hybrid work package (a Build-to-Print activity with a strong contribution by Magna for Development and Production Engineering). Activities during 2023 were all centered around the third Development Model and design iteration. It is now foreseen that an extensive quantity of specimens must pass stringent process qualifications before DM3 production readiness during 2024. If successful, DM3 represents the final test standard foreseen for the M10 engine line set before design freeze and moving over to the qualification phase of hardware produced by Magna.

Contrary to the VUS M10 engine lines, activities for the LPM propellant lines are a full scope Build-to-Spec development that also includes hardware production by Magna. The design of the liquid oxygen and liquid methane feed and fill lines includes application-specific compensating elements to ensure integrity of the fluid conveyance pipework.



2023 saw a progress for compensator prototyping in preparation of test campaigns foreseen for 2024 for the so-called Breadboard Models.



Vega-E © ESA-J. Huart

## Magna Steyr Fahrzeugtechnik GmbH & Co KG

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# OHB Austria GmbH

## Our mission: reliable navigation

Reliable navigation, and specifically Global Navigation Satellite System (GNSS) positioning and timing services, form the backbone of many applications and markets. Examples are navigation in aviation and the maritime sector, time synchronization of power grids, communication systems, and stock exchanges, localizing accident victims or rescue units, tracking goods and vehicles, etc. GNSS is relied on by many stakeholders. Civilian GNSS services are free of charge and globally available but insufficiently protected against unintentional and even intentional disturbances. OHB Austria provides solutions and services to ensure the safety and security of key functions of our society.

## Our company

Our company originally was created as a spin-off of the Graz University of Technology in 1999. Since that moment OHB Austria has been realizing more than eighty complex Research & Development projects in the area of reliable navigation. Many of these projects were funded by stakeholders like European Space Agency ESA, Austrian Research Promotion Agency FFG, etc. Close cooperation with other specialized companies and research institutions is a key element of these activities.

Based on the expert know-how, created and permanently renewed within the framework of these R&D projects, OHB Austria has developed several ready-to-market products that have been gaining increasing interest and success in the market in the last years. OHB Austria is focusing on two key product families: GNSS signal simulation and GNSS quality assurance.





## Area of Work

The major activities of OHB Austria GmbH comprise the field of GNSS quality assurance and GNSS signal simulation, in particular precise positioning, reliable navigation, and applications in the satellite downstream market. We are specialists in the development and combination of navigation, telecommunications, and information technologies as well as services for a wide variety of applications in the context of satellite-based navigation systems. With the know-how of our team members, we develop solutions, services, and applications according to customer and market needs.

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## Project Highlights in 2023

### Analysis of GNSS Spaceborne Resilience

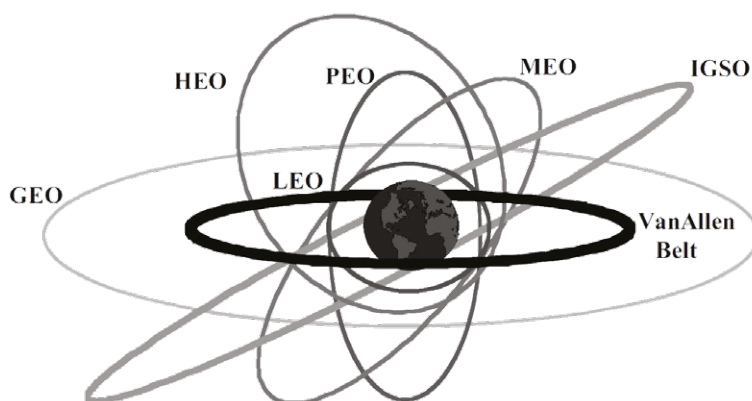
#### Project Description

From 2021 to 2023, we worked together with BEYOND GRAVITY AUSTRIA GMBH (former RUAG Space GmbH) under the leadership of JOANNEUM RESEARCH Forschungsgesellschaft mbH on the ESA project "Analysis of GNSS spaceborne resilience". The project aimed to perform an RFI (Radio Frequency Interference) risk assessment for spaceborne GNSS receivers and derived products, as well as to investigate RFI mitigation techniques, considering different types of missions and scenarios. This included the performance of a comprehensive RFI risk assessment and the usage of signal generators to assess the RFI effects before and after mitigation for the most likely and critical risks.

Spaceborne GNSS receivers have become a mission-critical element in most LEO (Low-Earth Orbit) missions and their use is being extended to other types of missions including GTO (Geostationary Transfer Orbit) / GEO (Geostationary Orbit) and highly elliptical-orbit missions.

It is well-known that GNSS receivers are vulnerable to Radio Frequency Interference (RFI) and spaceborne receivers are not an exception. While there have been some studies on RFI effects on spaceborne GNSS receivers, no comprehensive RFI risk assessment for spaceborne receivers has been carried out so far.

After identifying and assessing the various RFI and spoofing threats for spaceborne GNSS missions, the vulnerability of the GNSS receiver was analyzed exploiting the detailed insight into the design of real spaceborne GNSS receivers within this project.



GEO: Geostationary Earth Orbit  
GSO: Geo Synchronous Orbit  
IGSO: Inclined Geo Synchronous Orbit  
MEO: Medium Earth Orbit  
HEO: Highly Elliptical Orbit  
PEO: Polar Earth Orbit  
LEO: Low Earth Orbit  
SSO: Sun Synchronous Orbit

Common orbits (source: Peter Schrotter, Graz University of Technology)

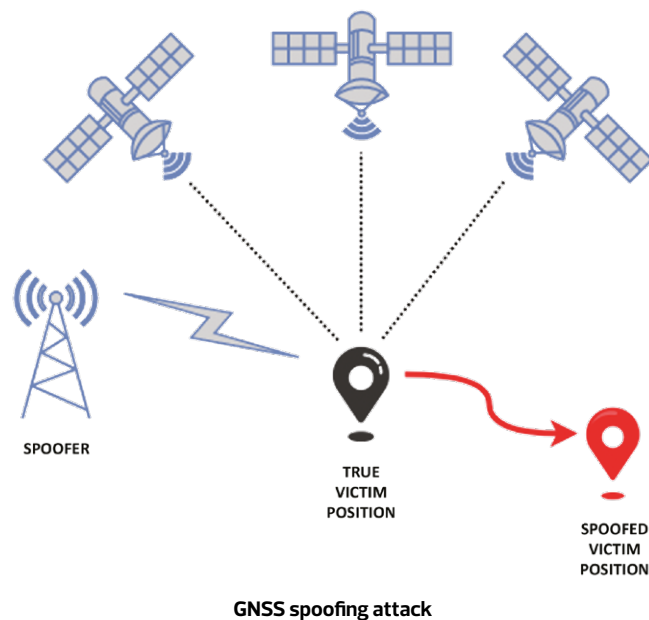
The main tasks of OHB Austria within this project comprised among others the survey of spaceborne GNSS applications covering all relevant orbits (e.g. LEO, GEO, etc.), the assessment of the impact of RF interference and spoofing on various user and interference scenarios, and the simulation of spoofing.

### **GNSS Spoofing**

GNSS spoofing is the act of producing a falsified version of the GNSS signal with the intent of taking control of a target receiver's position, velocity, and time solution. Spoofing aims to set a receiver to a defined but wrong position and/or time through the transmission of deliberately manipulated signals.

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A self-consistent spoofer is designed to attack the Receiver Autonomous Integrity Monitoring (RAIM) in GNSS systems. This is done by synthesizing false code phases that induce a false position/timing fix while maintaining small pseudorange residuals. A self-consistent ensemble of spoofing signals can be produced by any good GNSS signal simulator. One challenge for the spoofer is to induce the victim receiver to lock onto the false signals.



With our mobile GNSS spoofing system NavTD M23, we had already established a fully operative product that was able to cope with this challenge. NavTD M23 was developed for military purposes and allows mobile testing of GNSS open service applications against intentional interference, such as jamming or spoofing in real environments and real-time. The system consists of hardware and software capable of performing sophisticated jamming and spoofing scenarios for GPS, Galileo, and GLONASS signals in selected GNSS frequency bands. Thus, it is possible to assess the vulnerability of existing GNSS solutions or the performance of countermeasures.

In this project, the L1 frequency was used for spoofing. The spoofing signal starts based on the correct user spacecraft trajectory with respect to the reference scenario, but with increasing run time the error concerning the reference user spacecraft orbit (height) was gradually increased. A spoofing attack of 5 minutes duration was simulated.

### **Interference detection and mitigation**

Interference detection and possibly classification is the first and essential step towards interference mitigation. Detection and mitigation usually go hand in hand as mitigation relies on knowledge about the signal structure of the interference. The use of spreading codes in GNSS signals is already a natural defense against interference,

especially against narrow-band types of interference, but this activity aimed at the implementation of more sophisticated RFI mitigation techniques, suitable for all kinds of interference.

The results of the spoofing tests indicate the difficulties to spoof a receiver in LEO. GNSS receivers implementing a Kalman filter exploiting the fact that the movement of the satellite can be modeled rather accurately have a good possibility to detect spoofing attacks. What may be improved is awareness!

### **Results and conclusions**

Spaceborne GNSS receivers implement mechanisms to detect divergence of the navigation solution. As spoofing was traditionally not considered a threat, spaceborne GNSS receivers mostly assume calculational errors, single event effects, or unheralded orbit correction maneuvers as potential root causes for such a divergence. As spoofing is nowadays identified as a potential threat, the GNSS receiver needs to issue alarms in case it detects a mismatch between the model and the measured trajectory.

Given the conclusions of the simulations, some promising detection and mitigation algorithms could be identified. For spaceborne GNSS receivers, the authentication approaches are considered more appropriate for spoofing detection than encrypted signals. Secure modules for the reception of PRS signals need to be tamper-proof, a realization that is considered very complicated and demanding for a spaceborne receiver. A major improvement concerning robustness against interferences is the use of multi-frequency receivers and antennas. For bigger spacecrafts with nadir-pointing antennas, the implementation of array antennas would provide the possibility of several additional detection and mitigation techniques.

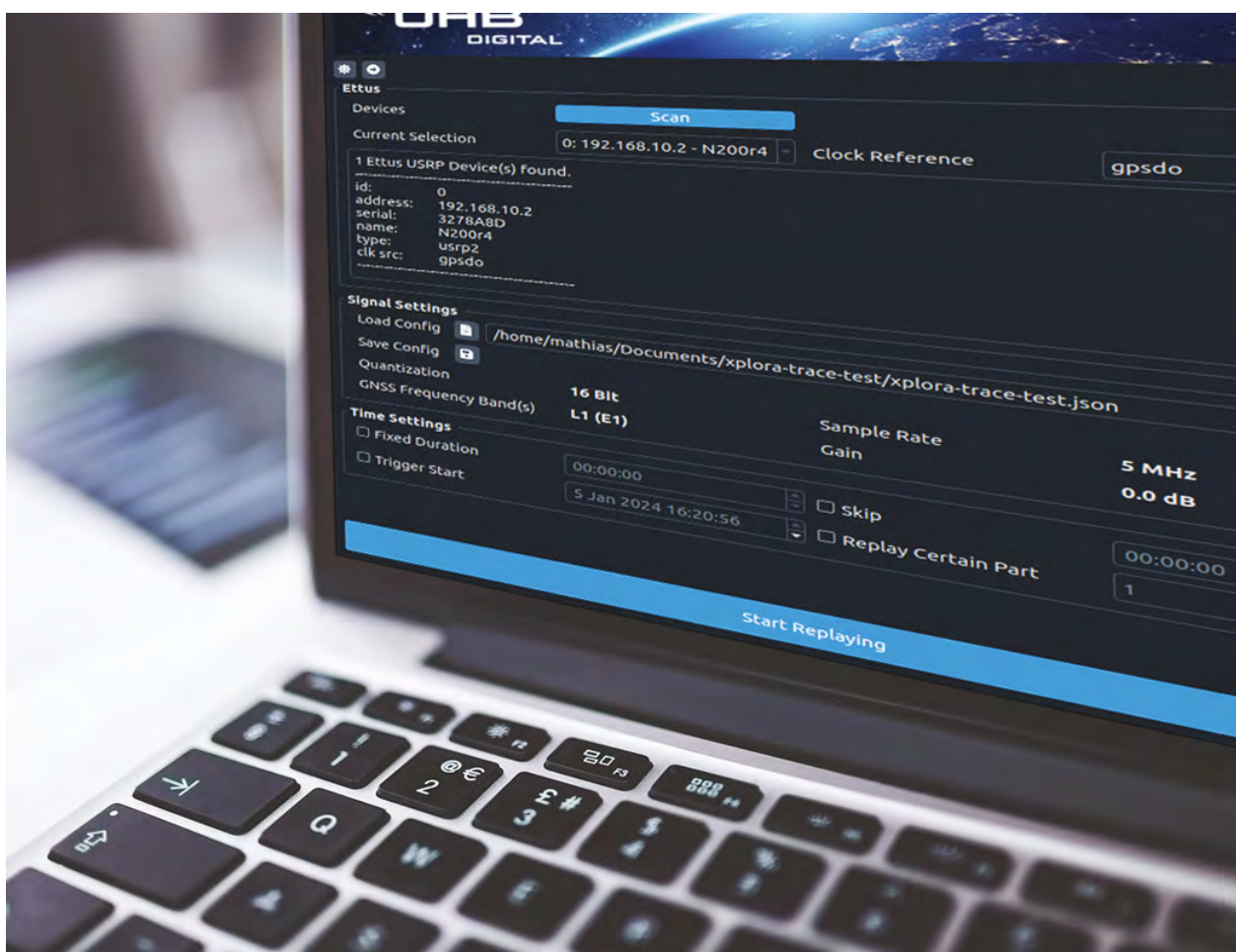
### **XPLORA Trace: GNSS Record & Replay**

The GNSS spoofing system NavTD M23 mentioned above is part of our flexible and exceptional GNSS simulation product family which we expanded in 2023 by adding a record & replay functionality to our product portfolio: XPLORA Trace.

In many industries, relying on GNSS signals for positioning and timing, the demand for real test scenarios is essential. XPLORA Trace, from OHB Austria, addresses precisely this challenge. Unlike idealized or theoretical modes, XPLORA Trace captures GNSS signals as they occur in real life, recording signals with real-world imperfections inherent to specific locations and times. This approach is indispensable to meet the challenges of ADAS testing, consumer goods development, timing and synchronization solutions, GNSS receiver testing, various R&D projects, and more.

XPLORA Trace enables controlled recording of GNSS signals, allowing users flexibility in defining parameters for static or dynamic scenarios at specific locations and times. Seamlessly operating on COTS laptops, desktop PCs, or servers, XPLORA Trace utilizes COTS SDR hardware in single or dual-channel configurations and provides an easy-to-use interface for highly efficient testing. In synergy with XPLORA Core (GNSS signal simulation software), the same hardware is capable of not only allowing the recording and playback of GNSS signals but also the simulation of arbitrary GNSS scenarios.





GNSS Record & Replay: XPLORA Trace

## OHb Austria GmbH

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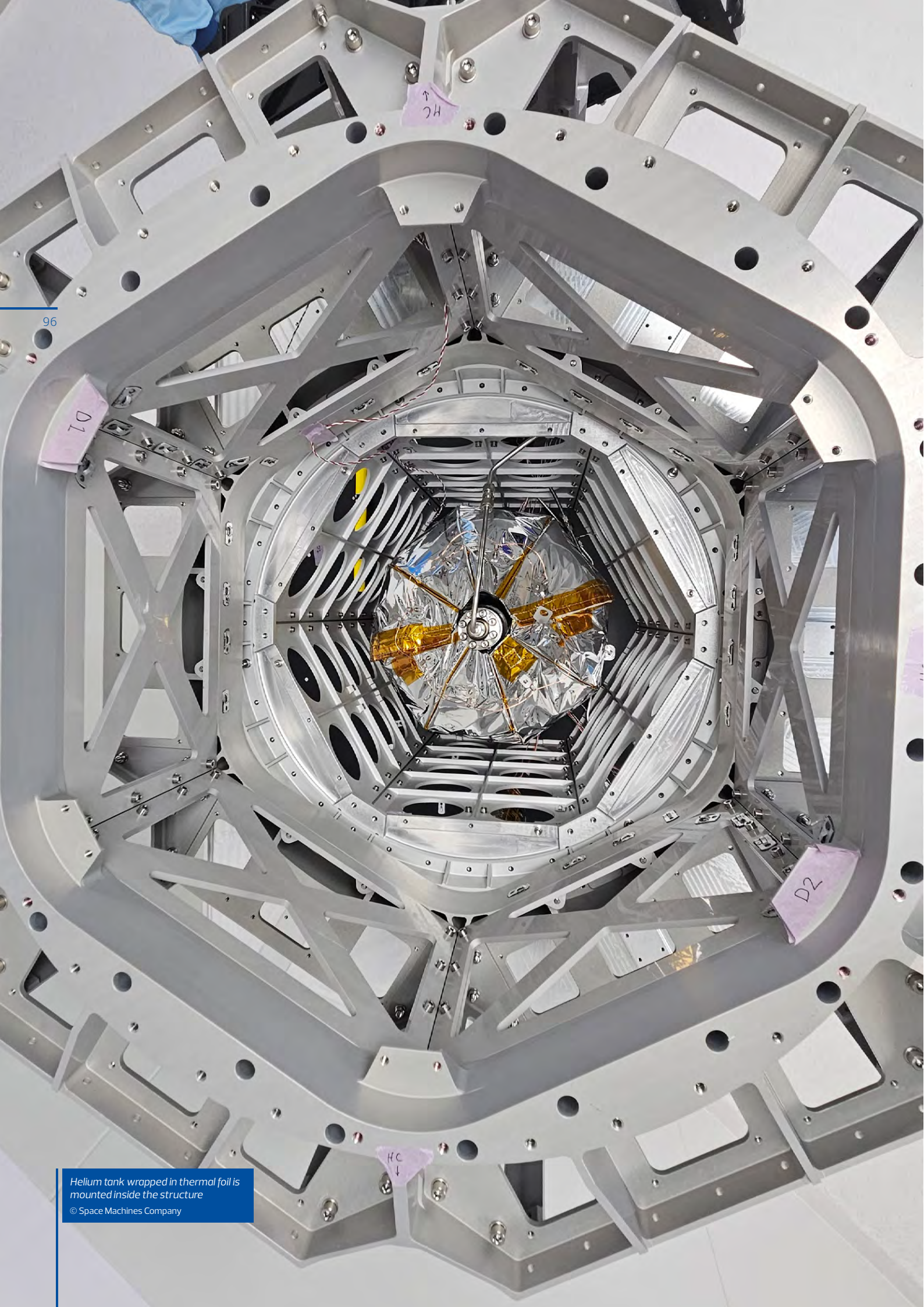
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[office@ohb-austria.at](mailto:office@ohb-austria.at)

### FACTS

Sales: 0,8 M€  
 ESA Share: 0,3 M€







# PEAK Technology GmbH

In 2023, PEAK Technology GmbH continued to expand its strategic role as a key supplier of Composite Overwrapped Pressure vessels (COPV) and structures for the European and international space industry, and proving to be an innovative, competitive and reliable partner withing commercial and European Space Agency (ESA) programs.

The scope of projects encompasses not only comprehensive, multi-year development activities for complex space missions, but also high-paced, spin-off projects for “new space”, where PEAK Technology not only supplies key components but also contributes as a system architect.

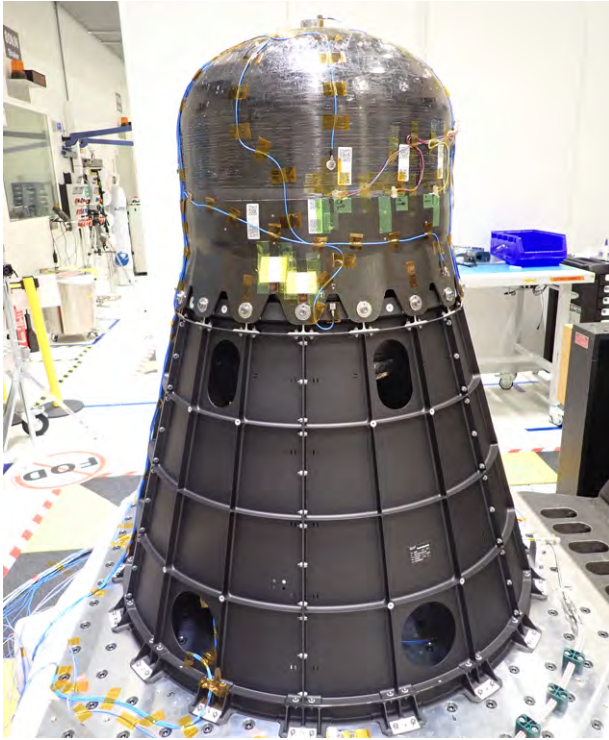
## First Helium Tank in Orbit

Beginning of 2024, a momentous milestone was achieved – the first flight of a COPV “made in Holzhausen” for the Australian start-up Space Machines Company was successfully launched into orbit aboard a SpaceX Falcon 9 rocket for the Optimus satellite mission.



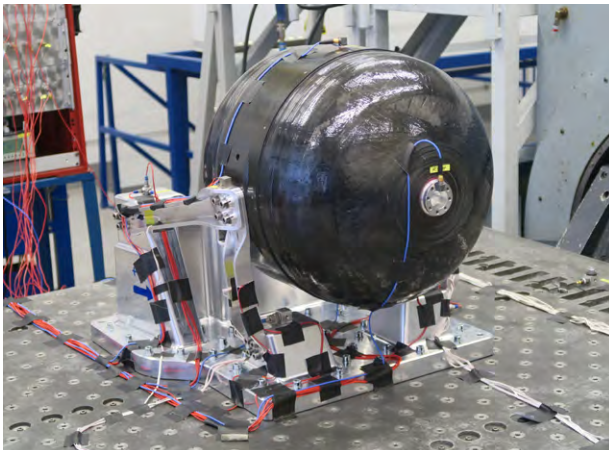
**Falcon 9 lifts off from Space Launch Complex 4E at Vandenberg Space Force Base, California, with PEAK's helium tank on board.**  
© Space X





### Galileo Second Generation (G2G)

Culminating the successful conclusion of a four-year development, dedicated testing of the Qualification Model (QM) of the 175L Xenon Storage Tank (XST) was completed, included vibration testing together with the system-level satellite interface structure performed at Airbus Defence and Space (AD&S) in Toulouse, France. After manufacturing and successful performance of acceptance testing, delivery of the first Flight Model (FM) to AD&S served as an additional notable milestone.



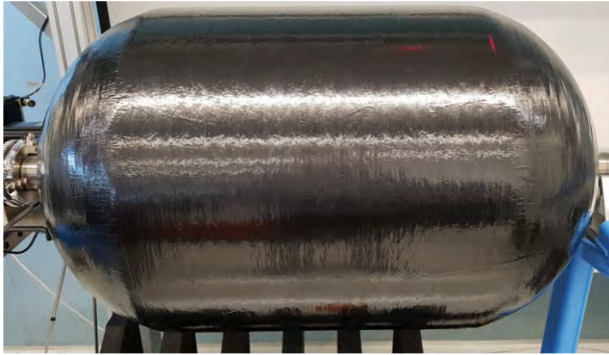
### ELSA-M

Under contract to Thales Alenia Space, UK and their customer ASTROSCALE, development of a 40L Krypton COPV is progressing and will lead to the delivery of first flight models in 2024. During the concluding qualification phase, vibration testing of the tank and its innovative mounting struts demonstrated not only its structural integrity but also the analytical prediction of its dynamic performance.



### HummingSat

Development of a 115L Xenon Tank for the HummingSat small GEO telecommunications satellite product line for OHB Sweden, SWISSto12 and ESA has successfully passed its Preliminary Design Review (PDR) milestone. Manufacturing of qualification models as well as first flight models is in progress with foreseen delivery beginning of 2025.



## VEGA-E

For the next generation "Evolution" of the VEGA launch vehicle, Peak is developing high-performance, 155L, 400 bar Helium tanks in close collaboration with AVIO S.p.A. and ESA. This tank is further advancing the state-of-the-art of aluminium-based COPVs, where for example the wall thickness has been reduced as well as alternate manufacturing and welding processes introduced for producing its liner. The development program is currently in its CDR phase during which first development models have been manufactured, demonstrating the feasibility of the selected processes.

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## ATHENA

An enabling component of the ATHENA FMS (Fixed Metering Structure) for the ESA is the Advanced Telescope for High-ENERgy Astrophysics) for which PEAK Technology is developing the composite telescope structure. Manufacturing and testing of a subscale demonstrator are currently nearing completion and serves as a concept validation prior proceeding to the full-scale program phase.

## PEAK Technology GmbH

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CEO

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### FACTS

Sales: 22 M€

ESA Share: 1,8 M€

Commercial Space: 11,5 M€





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Launch of Selbersdorf Laboratories' dosimeter payload SATDOS onboard the Austrian CubeSat PRETTY in Vega's 23rd flight on October 9, 2023, 03:36 CEST  
© ESA/CNES/Arianespace

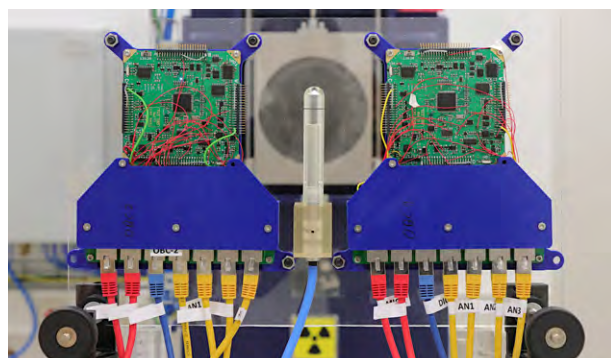
# Seibersdorf Labor GmbH

Seibersdorf Labor GmbH, operating under the brand name Seibersdorf Laboratories, is known for its commitment to providing high quality laboratory analysis and cutting-edge measurement technologies. Our space activities focus on the study of space radiation and its effects on humans, electronic components, systems, and materials. Recognized as a premier provider of space weather, radiation testing and consulting services, our team specializes in dosimetry of flight personnel, total ionizing dose (TID), displacement damage (DD) and single event effect (SEE) testing, meeting the high standards set by governmental institutions, ESA and the aerospace industry.

Strategically located on the Tech Campus Seibersdorf, approximately 30 kilometers south of Vienna, Austria, Seibersdorf Laboratories operates with a dedicated team of over 160 skilled professionals and trainees to ensure excellence in its endeavors.

In the following, we present our space related public projects and studies carried out during 2023:

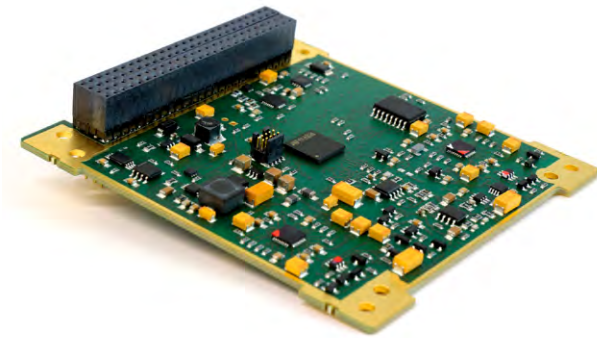
- **SATDOS** – A reference dosimeter payload for nanosatellite applications
- **CORHA** – Radiation screening of COTS components and verification of COTS radiation hardness assurance approach
- **SEERad** – Single Event Effect Studies for Aerospace applications
- **AVIDOS** – Human exposure to cosmic radiation due to space weather on board aircraft



Our projects benefit from the extensive infrastructure and test facilities on our campus. A prominent example is our state-of-the-art TID testing facility, the TEC-Laboratory. Here we offer accredited services for radiation hardness testing of electronic components and systems according to the stringent requirements of EN ISO IEC 17025, ECSS, ESCC and MIL standards.

In addition, Seibersdorf Laboratories organized the 8th edition of its annual RADHARD Symposium in 2023, further demonstrating its commitment to advancing knowledge and collaboration in the field.



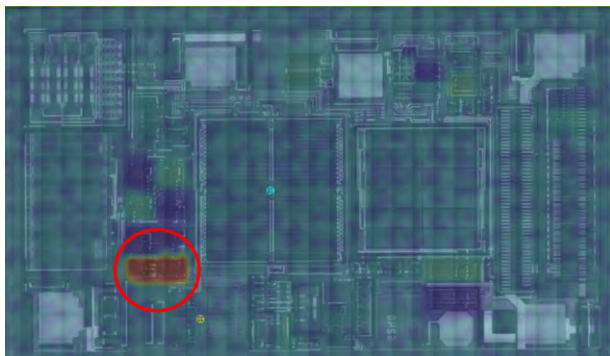


**SATDOS reference dosimeter payload for the Austrian CubeSat PRETTY**

## SATDOS – Reference Dosimeter onboard PRETTY

The Austrian CubeSat PRETTY was successfully launched on October 9, 2023. PRETTY features SATDOS, a novel reference dosimeter platform for nano-satellites developed by Seibersdorf Laboratories. It assesses total ionizing dose (TID) and single event effects (SEE) in orbit, bridging the gap between commercial off-the-shelf (COTS) components and real-time radiation data. SATDOS will be available for purchase, aiding in-orbit qualification and satellite lifetime analysis.

<https://www.ait.ac.at/blog/technologie-aus-seibersdorf-im-weltall>



**Sensitive area of the LTC6240 operational amplifier identified during SEE laser testing**

## CORHA – Radiation Testing of COTS

CORHA is an ESA project study on radiation screening of commercial off-the-shelf (COTS) components and verification of COTS radiation hardness assurance. The first phase has been completed with TID and SEE testing of complex electronic parts and the creation of technical guideline documents. The next phase is under preparation and will utilize additional laser testing and investigate novel radiation hardness techniques using AI machine learning.



**Single Event Effect (SEE) Testing at the MedAustron particle accelerator © MedAustron**

## SEERad – Single Event Effect Studies for Aerospace Applications

Seibersdorf Laboratories and the University of Applied Sciences Wiener Neustadt have jointly launched SEERad, an FFG-funded 3-year research project. Using innovative irradiation techniques at MedAustron, Austria's leading particle accelerator facility, SEERad aims to comprehensively understand electronic device responses to Single Event Effects (SEE). By bridging industry's SEE testing needs with MedAustron's expertise, SEERad advances early-stage technology development and strengthens Austria's aerospace sector.

<https://projekte.ffg.at/projekt/4373981>



**AVIDOS-EDU 3.1 on the ESA Space Weather Service Network**



**Book of Abstracts of 8th RADHARD Symposium**

## AVIDOS – Human Exposure to Cosmic Radiation onboard Aircraft

Seibersdorf Laboratories participates in ESA's Space Safety Programme in its Space Weather segment, contributing to the Space Radiation Expert Service Center. With AVIDOS-EDU we provide to the ESA Space Weather Service Network an informational and educational tool for assessment of cosmic radiation exposure at civil flight altitudes. We recently released the brand new AVIDOS-EDU 3.1 with improved usability and the latest scientific achievements.

<https://swe.ssa.esa.int/avidos-federated>

## 8th RADHARD SYMPOSIUM, June 6–7, 2023

The mission of the RADHARD Symposium is to facilitate the exchange of practical experience in radiation hardness assurance. The 8th of Seibersdorf Laboratories' annual Symposium focused on automotive and space as well as COTS components with the support of keynote speakers. The symposium is aimed at a diverse audience including space system integrators, electrical and electronic equipment manufacturers, industry professionals, researchers and students interested in understanding the effects of radiation on components and systems.

[www.radhard.eu](http://www.radhard.eu)

## Seibersdorf Labor GmbH

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The Atmosphere-Space Interactions Monitor or ASIM, mounted outside the European laboratory of the International Space Station  
© ESA/NASA

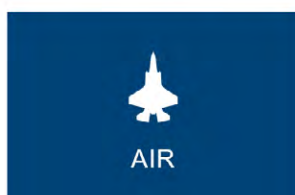
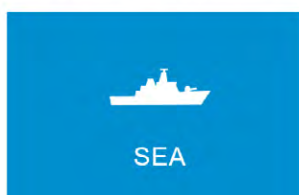
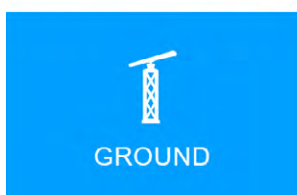
# Terma Technologies GmbH

Terma is a global company owned by a commercial foundation, with roots in Denmark, about 1.700 employees and total annual revenue in 2023 of € 350 millions. We develop, manufacture and service solutions for ground (e.g. airport radars), sea (e.g. maritime safety), air (e.g. aerostructures) and space (e.g. well proven electronics, software, and services for all phases of space missions) and provide advice to customers around the world.

In 2022, Terma Space celebrated 50 years in Space. Since our first mission in 1972, we have been part of more than 75 space missions – including the first Danish satellite in space Ørsted, which marked the beginning of a new era in measuring and monitoring the Earth's magnetic field and the ASIM project, which is a climate observatory installed on the International Space Station (ISS).

Terma Technologies GmbH focuses on the Space market and exclusively works for the Space Business Area Terma Space. Terma Technologies hosts the headquarters for Terma Space and the activities conducted by Terma Technologies from its premises in Vienna, Austria, focus on the topics: Satellite Testing, Satellite Control and Automotive Battery Cell Testing.

On top of being the HQ for Terma Space, it is also the seat of the Business Unit Ground Systems, and as such functions on the one hand as the in-house R&D hub for all Terma Ground Systems product developments such





as ProUST FrontEnd, ProUST univerSAS®, ProUST SLP, the Battery Cell Tester product suite and the SDR Modem, and on the other hand as the main design centre for the majority of the project solutions and services related to cutting-edge Electrical Ground Support Equipment (EGSE).

The tailored solutions empower our customers with reliable, innovative technologies crucial for successful space missions, ensuring seamless operations and robust performance throughout the entire space exploration journey, but particularly, the solutions support the testing of Satellites and Launchers in their Manufacturing, Assembly and Integration phase. Thus, Terma Technologies provides products, solutions and services for

- **Satellite and Launcher Manufacturers**
  - Electrical Ground Support Equipment (EGSE)
    - Instrument EGSEs
    - Payload EGSEs
    - Spacecraft Platform Simulators
  - Special Check-Out Equipment (SCOE)
    - RF SCOE
    - Power SCOE
      - Solar Array Simulators
      - Battery Simulators
      - Load Simulators
      - Launch Power Supplies (COTEs)
      - Data Handling SCOE
  - AOCS SCOE
  - RF Suitcases
- **Satellite Controllers**
  - Ground Segment Solutions and Integration
  - Mission Control System Maintenance and Evolution
- **E-mobility Car Battery Cell Manufacturers**
  - Battery Cell Cyclers (technology transfer from Space)



Diane Galbe, Atos Board Member and Jes Munk Hansen, CEO Terma at the Danish embassy in Paris on the 21st September 2022

In financial year 2023 the Business Unit achieved a revenue of € 14.8 million, based on commercial space markets, ESA, and Galileo activities. The share of Austrian ESA sales therein accounted for € 4.5 million.

In September 2022, Atos SE and Terma A/S signed an agreement, whereby Terma shall take over all the Atos Satellite Testing activities, including all rights and obligations, projects, outstanding offers, employees and assets.

The newly founded company is Terma Technologies GmbH and is in operation as of March 1, 2023.

## Satellite Testing:

### Electrical Ground Support and Special Check-Out Equipment (EGSE & SCOE)

Continuing to provide valuable solutions to support our customers' Assembly, Integration and Testing (AIT) processes, Terma Technologies provided Electrical Ground Support and Special Check-Out Equipment for various institutional and commercial European, non-European and cooperation missions.

In addition to the well-renowned Radio Frequency and Power Subsystem testing solutions from Terma, more and more projects include one of our Radio Frequency Suitcase and/or Instrument respectively Payload EGSE solutions. The ProUST product family ("Protection and Unification in Satellite Testing"), developed over the last years, co-funded by the ESA GSTP and ARTES programmes and the National ASAP programme, and its seamless integration with standard 3rd party equipment, provides the hardware and firmware core of most of our solutions. Strong focus was again laid on the proliferation of our EGSE solutions into the global commercial and military satellite manufacturing market. Further deliveries and upgrades to the RF communication, payload and power testing equipment for Galileo resulted from those efforts.

### Power SCOE, Instrument and Payload EGSE Test Systems

In the Power SCOE domain, Terma worked on missions such as OneWeb – mainly on the upgrade of the production lines, HummingSat (new customer), SpaceRider, Hera, Comet-I, Copernicus CO2M, Copernicus CIMR and Juice. HummingSat, SpaceRider, Hera, Comet-I and Copernicus CO2M & CIMR are based on our product UniverSAS® 2.1.

In the Instrument EGSE domain, we have started or continued the work on the ROSE-L Instrument Frontend, the Instrument Backend and PDHT EGSEs, Ariel SimFe as well as the CHIME Thermal SCOE.



ProUST UniverSAS® 2.1 © Terma

### Innovation: Battery Cell Cycler (Technology transfer from Space)

Terma is driven by a strong motivation to enter the Electric Mobility market with an innovative and integrated solution, the ProUST UniverSAS® (Our Digital Power Supply), which is derived from our Space product. This product represents a significant leap in integration, cost-effectiveness, and environmental sustainability. Leveraging cutting-edge technologies like GaN MosFET, digital control, and efficient power conversion methods, this solution is perfectly poised to meet the demanding environmental standards set by electric vehicle manufacturers.

In 2023 the product development phase was in full swing. We have been working closely with our partners, achieving significant milestones in product development. Terma's objective is to unveil the initial version of the battery cell testing product by Q3 2024 and the final product in Q2 2025.



Battery Cell Cycler

### Radio Frequency, Telemetry/Telecommand and RF Suitcase Test Systems

In 2023, the Terma RF department continued its 'go digital' strategy. The aim is to replace expensive COTS equipment with software. In close cooperation with FFG and ESA, Terma continued one funding project in this field, which is to develop an SDR modem (SDR – Software Defined Radio), consisting of a frontend (USRP – Universal Software Radio Peripheral) + backend (PC), which offers several benefits since it can be easily reprogrammed, supports frequencies up to 6 GHz and supports different modulation schemes without the need of



extra external equipment. Moreover, new features can be implemented through software keeping the same hardware.

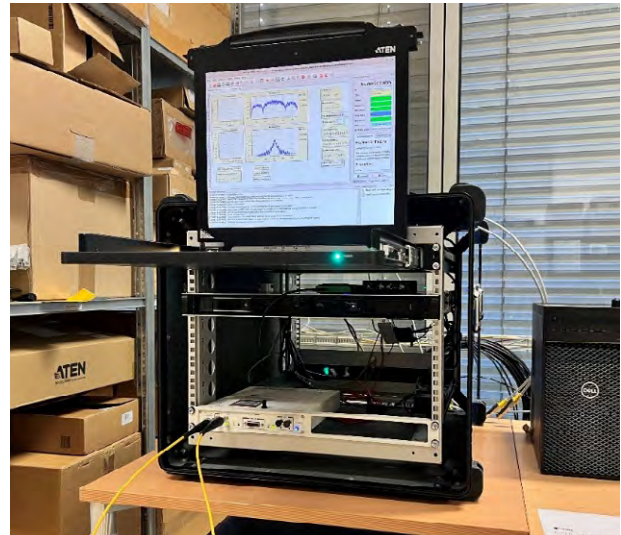
Terma's RF mission related work in 2023 was for: OneWeb, a UK Constellation, SpaceRider, FLEX, Mass Change, Platino/Iride, Copernicus CO2M, Copernicus CRISTAL, Copernicus LSTM, Copernicus ROSE-L, Copernicus CIMR, Galileo G2G, Comet-I, Hera, Mars Sample Return, Euclid, Juice, and Plato.

### Innovation: Software Defined Radio Modem

In the frame of a GSTP (initially) and now an ARTES contract, Terma is developing a modem that is mainly implemented in software (SDR – Software Defined Radio). This modem is aimed to be used in TT&C SCOE's as well as in Satellite Ground Stations. This development was started at the end of 2019 and we finished the prototype phase in 2021. In 2021, a technology desirability phase was started.

In 2022, after an analysis phase, with the aim of improving the modem's performance and reducing its size, the modem hardware was updated, and a technology development phase was started that is still ongoing.

The backend (PC) was replaced by a new 1U PC with better CPU, GPU, faster storage, new serial (RS422) and SFP+ NIC (so that the FE and BE can be connected through optical fiber and use DPDK to improve latency). Moreover, some of the signal processing blocks developed during the initial phase were moved from the CPU to the GPU using Nvidia parallelization technology. The frontend (USRP) was updated to make use of the remaining space in its FPGA, moving some of the signal processing done by the PC to the USRP. ESA-Code ranging is implemented in the SDR modem as well.



Current prototype of SDR Modem © Terma

### Satellite Control: Ground Segment Systems and Mission Control Software

Also, in the year 2023, the main focus of Terma's activities in the Ground Segment Systems and Mission Control Software domain was in the following areas:

- Evolution of generic Mission Control and EGSE SW architectures and building blocks
- Performance Evaluation and Improvements of the ESA Common Core developments



ESA Main Control Room © ESA

Various studies have been and are being performed together with ESOC Operations, to cover offline and near-real-time data analysis, new ground segment test automation in the mission control context, as well as several aspects of ground station SW interfaces.

Terma Space is part of the European initiative to design a new EGSE SW and Mission Control SW core, both being represented in the ESA Common Core activities as well as in industry-driven showcase projects. These activities show the close synergy between EGSE SW and Mission Control SW.



**Impressions from the Paris Air Show 2023**

**Above: ProUST univerSAS® 2.1 exhibited at Paris Airshow**

**Left: Brigadier General HRH Prince Joachim of Denmark visiting the Terma booth**

© Terma

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### FACTS

Sales: 14,8 M€  
ESA Share: 4.5 M€





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# TTTech Computertechnik AG

As a leading global supplier of dependable networking solutions and modular safety platforms. The company's products simplify and reduce development cycles while enhancing the reliability of networked electronic systems in transportation and industrial automation markets. The company was established in 1998. The TTTech Group employs more than 2,300 employees worldwide of which the majority works in engineering and development (with a focus on software development). The Group is headquartered in Vienna, Austria. TTTech Auto AG is its largest subsidiary and works mainly on software platforms for advanced driver assistance systems enabling also future autonomously driving cars.

TTTech Aerospace offers avionics platforms solutions for aviation and space applications. These platforms consist of complex silicon chips, hardware, software and tools. TTTech Aerospace products for the space sector are used in the largest international space programs, including NASA Artemis and ESA Ariane 6.

TTTech Aerospace delivers high-performance, dependable safety-critical networked computing platforms (the 'brains' and the 'nervous system') that ensure the reliable and safe operation of spacecrafts and launchers. TTTech Aerospace's computing platforms guarantee highly reliable operation and allow the integration of different systems such as guidance navigation and control, tele-communication and tele-command, life support, environmental control, or other systems.

## Artemis I – first mission successfully completed

November 2022 marked the launch of the Artemis I mission. This is the next step in NASA's return to the Moon under Artemis and preparing the way for human missions to Mars. Artemis I is an uncrewed test flight of NASA's Orion spacecraft and ESA's European Service Module (ESM) around the Moon. After completion of this first uncrewed test flight, a crewed flight test (Artemis II) will take place, with more missions to follow in the coming years.

TTTech is on board the avionics system (the 'central nervous system' of the spacecraft) of NASA Orion and the European Service Module with its TTEthernet® products. TTTech has been working with US companies Honeywell (provider of the avionics systems – Orion's 'brain'), Lockheed Martin (NASA's prime contractor for Orion) and NASA since 2006. The first successful NASA Orion Exploration Test Flight (EFT-1) was completed in 2014 and NASA Orion has since undergone a series of tests and adaptations in preparation for the launch of Artemis I.



## Artemis – Gateway

The Artemis program consists of multiple key building blocks which together will bring humanity back to the moon with a sustainable permanent presence as well as the prove all technologies for a later mission which will bring humans to safely Mars and back.

A corner stone of this program is the Gateway which is a human rated station in the moon orbit which is able to host astronauts on its way to the moon and back. This station is currently in development with TTTech providing network and compute equipment to the different modules. As lessons learned from the international space stations, where hundreds of low performance communication buses have been used which were cascaded to be able to deliver the quality of service needed to control and operate the stations, the Gateway uses a solution which allows to integrate multiple modules in a modular way by not losing these services. The integration of this modules is quite complex and needs technologies and products to master it and keep the possibility to add and upgrade the overall station.

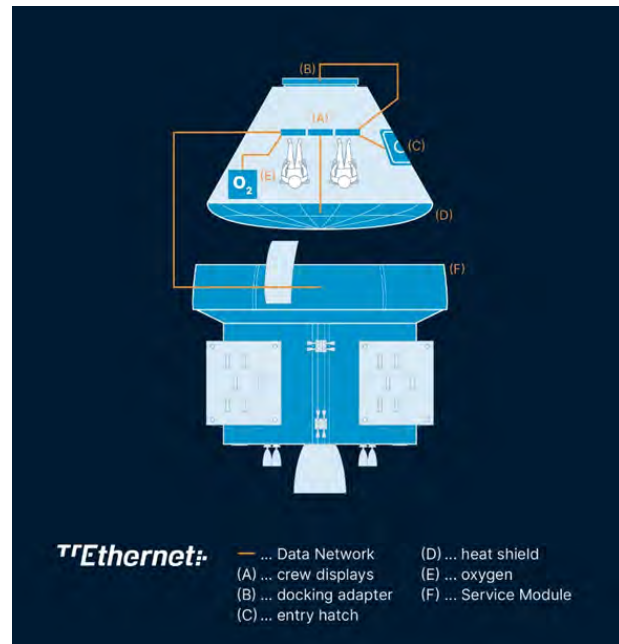


Illustration showing a simplified picture of how the TTETHERNET® data network connects Orion and the European Service Module, reliably transferring all data needed for communication within the spacecraft as well as between the spacecraft and space stations, launch vehicles and ground stations. © TTTech Computertechnik AG

## European Space Activities 2022

Europe's new flagship launcher Ariane 6 will ensure independent access to space for the European space sector. TTTech contributed substantially to the creation of the avionics backbone system in Ariane 6. Its "chips" and the related software are integrated into more than 50 avionic units handling functions such as guidance navigation and control, telemetry and telecommand, power management, video streaming or thrust-vector actuation, which all connect to a single, redundant TTETHERNET network, the launcher's "nervous system". TTTech also contributed to Ariane 6 with firmware development and qualification as well as integration support. In March 2022, the launcher's fully integrated avionics network was qualified at ArianeGroup's development center near Les Mureaux and signed the exploitation agreement including series production and maintenance, France. This was a key milestone ahead of the first launch, which is expected to take place in late 2023.

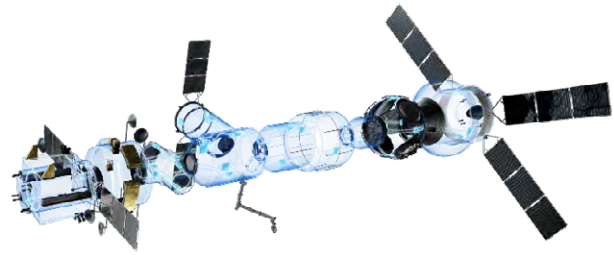


**Onboard Data Network – Launch Vehicle**  
© TTTech Computertechnik AG

In addition, European Space Agency (ESA) and its partners have, with support from TTTech, established the open ECSS Time-Triggered Ethernet standard for space applications (ECSS-E-ST-50-16C) which ensures compatibility and interoperability between different Time-Triggered Ethernet hardware components that are used.

ESA early partnered with NASA, the Canadian Space Agency and the Japanese Space Agency on the international Artemis program. To ensure the availability according to the needed technology readiness level (TRL) in Europe, ESA and the Austrian Space Agency ALR as part of FFG) have together with TTTech and Beyond Gravity decided to start a development and

qualification activity to de-risk ESAs Gateway modules and ensure compliance to ESAs ECSS standards. This ESA GSTP activity for the qualification of key TTEthernet® avionics elements – space-grade TTEthernet switches and network interface cards was executed reaching the critical design review. These elements are developed in close cooperation between TTTech and Beyond Gravity which is also responsible for the production and qualification of these deep space equipment. The support from FFG and the Austrian government allowed to multiple programs outside of ESA and shows the impact of Austrian technology.

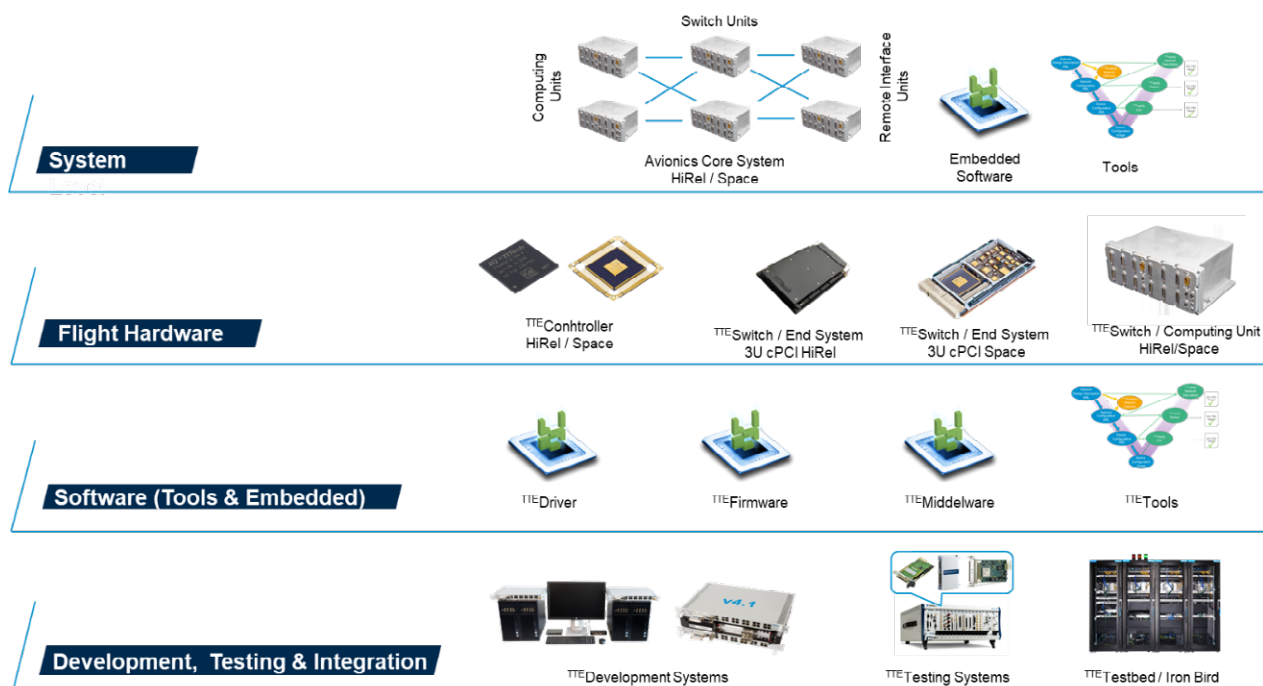


**Onboard Data Network – Human Space Flight / Space Station**  
© TTTech Computertechnik AG

In 2023 TTTech has made major progress on the contracts for ESA's Gateway modules "International Habitat" and "ESPRIT Refueling Module". Thales Alenia Space (TAS) is the prime contractor for both modules. This also offers the opportunity to work with TAS on the use of the same building blocks in other space applications like Earth observation.

## Product Portfolio

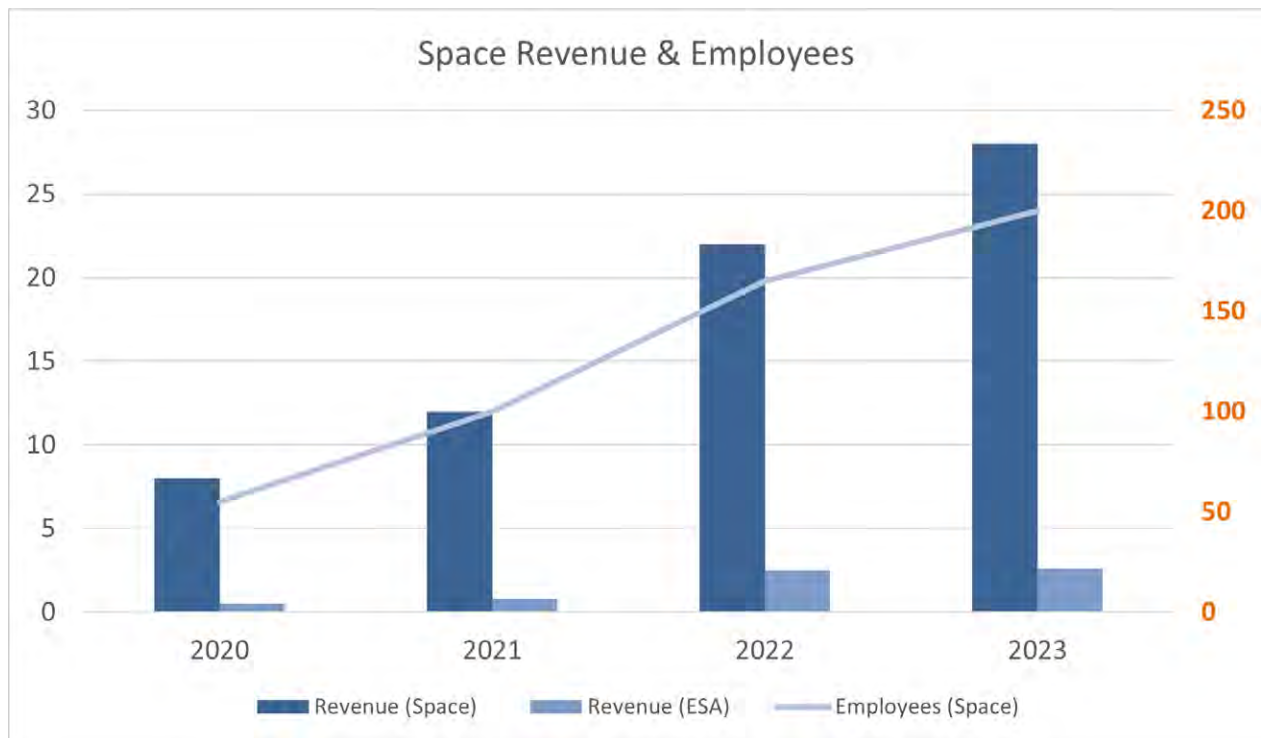
TTTech Aerospace provides network and avionics core systems for the use in safety critical applications. These products are comprising development and testing, embedded software, configuration and verification tools, fight hardware and integrates system solutions. The products are certified to the highest quality and safety requirements and have passed safety reviews for multiple application such as human space flight, launchers and satellites and have therefore been certified to the related standards and with multiple authorities.





## Revenue

Total European space revenue of 2023 grew to Euro 4,5 million with an ESA share of 2,6 million. Clearly outnumbered by sales in the other regions (mainly North America) which more than doubled in comparison to 2021. Further growth in 2023+ is planned based on TTTech's contracts and opportunities in the human space flight, launcher and also satellite market.



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### FACTS

Sales: 4,5 M€  
 ESA Share: 2,6 M€







[www.austrospace.at](http://www.austrospace.at)

Photo: NASA, ESA, CSA, STScI, K. Pontoppidan (NASA's Jet Propulsion Laboratory),  
J. Green (Space Telescope Science Institute)