AUSTROSPACE

VEREINIGUNG ZUR FÖRDERUNG
DER ÖSTERREICHISCHEN WELTRAUMINDUSTRIE

AUSTRIAN SPACE INDUSTRY ASSOCIATION

Annual Report 2024

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If you ever wonder why it's important to explore space — other than to satisfy your curiosity— one critical reason is that Earth is not an isolated globe under a protective cover. It is part of our solar system and embedded in the cosmos.

— Lisa Kaltenegger, Austrian astrophysicist and astrobiologist, from her book "Alien Earths: The New Science of Planet Hunting in the Cosmos"

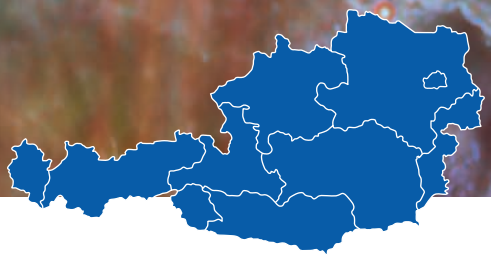
The current AUSTROSPACE Annual Report comprises an up-to-date list of members, including their contact information, along with contributions from industrial members and research organizations detailing their space activities throughout the year 2024.

Holzhausen , August 2025

Dieter Grebner
President

Hans-Martin Steiner
Vice President and Managing Director

Why Space Matters for Austria



Resilience and Security – Europe's Sovereignty Begins in Space

The geopolitical reality of today—from military conflicts to digital threats—makes one thing clear: Europe must become more independent. Only through sovereign access to space via European launch vehicles, secure communication systems (Starlink is not European infrastructure), as well as autonomous navigation and Earth observation, can resilience for critical infrastructure be ensured. Austria's contribution to ESA secures strategic capabilities for crisis prevention, disaster management, and national security. Without independent access to space, resilience becomes an illusion—and autonomy an empty shell.

Highly Skilled Industrial Jobs for the Next Generation

Austria's space sector employs around 1,300 highly specialized professionals, with 75% working in research and development. Space activities drive not only innovation but also create future-proof jobs in high-tech industries—providing a vital and transformative boost for Austrian industry and a major opportunity for the next generation.

A Global Growth Market with Double-Digit Expansion Rates

According to reports by ESPI and McKinsey, the space sector is one of the fastest-growing global industries, with annual growth rates exceeding 10%. Europe has seen record investments in space companies in recent years—a clear signal of structural transformation toward an innovation-driven global market of the future. This is a momentum Austria cannot afford to miss.

Space as an Export Engine: €1 Generates €4

Studies show that every euro invested in ESA programs yields four times the value in export revenues for domestic companies. Austria's space economy already generates around €240 million in gross value added annually.

Fiscal Return: €1 In, €1 Back

The return on public investment through tax revenues is nearly 1:1. In 2024, the total fiscal impact of Austria's space sector amounted to €67 million—demonstrating highly efficient use of public funds.

© ESA – Philippe Sebirot

Statement by

Josef Aschbacher

ESA Director General

Europe is at a crossroads in space. Recent geopolitical changes have affected how Europe engages globally. The space sector is not immune to these changes while, at the same time, we have become ever more reliant upon space for our everyday lives.

A strong Europe in space benefits society and economy and is necessary to enable the continent to rise to current challenges. The European Space Agency, ESA, plays a central role in helping European States achieve this objective.

As an ESA Member State, Austria has always been a strong promoter of the use of space. Austria is particularly engaged in programmes related to Earth observation, telecommunications, and science, and in the development of European launchers. Thanks to this strong commitment, ESA contracts have accelerated the growth and development of specialist expertise of the Austrian space industry, represented by Austrospace. This 2024 Annual Report illustrates once again the innovativeness and competitiveness of this ecosystem to the benefit of not only European but also international programmes.

The ESA Council at ministerial level to be held in Bremen, Germany, in November 2025 represents a key opportunity to continue investment in the sector. ESA will present a comprehensive proposal to develop programmes that will bolster the economy and security of all its Member States; reinforce the capacity of their industry to innovate; and help tackle climate change. With over 30 upcoming Missions, ESA offers a broad range of opportunities to invest into the future of the sector to achieve the five goals that demonstrate the important role space plays in every aspect of citizens' lives across Europe:

- Protect our Planet and Climate
- Explore and Discover
- Strengthen European Autonomy and Resilience
- Boost Growth and Competitiveness
- Inspire Europe

As the Director General of ESA, and as an Austrian, I am very proud to see that Austrospace companies contribute actively to our joint European space efforts and reassert ESA's readiness to support the European and the Austrian space sector's competitiveness and ambition to innovate. I look forward to seeing the future of the Austrian Space sector and what we can achieve together.

Austrospace Members

Industrial members

BEYOND GRAVITY AUSTRIA GMBH

Stachegasse 13
1120 Wien

DI Kurt Kober,
Ing. Wolfgang Pawlinetz
+43-1-80199-0
info.at@beyondgravity.com

www.beyondgravity.com

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.

ENPULSION GMBH

Office Park 2
1300 Wien-Flughafen

Martin Sarret, MSc
+43 (1) 3435400
martin.sarret@enpulsion.com

www.enpulsion.com

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.

EODC EARTH OBSERVATION DATA CENTRE FOR WATER RESOURCES MONITORING GMBH

Franz-Grill-Straße 9, 1030 Wien

Dr. Christian Briese
+43-699-1668-7511
office@eodc.eu

www.eodc.eu

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.

EOX IT SERVICES GMBH

Thurngasse 8/4
1090 Wien

DI Stephan Meißl
+43-664-9688701
stephan.meissl@eox.at

eox.at

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.

EVIDEN AUSTRIA GMBH

Wagramerstraße 19/Stock 16
1220 Vienna

Ing. Erwin Greilinger
+43-664-88551479
erwin.greilinger@eviden.com

www.eviden.com

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.

FANTANA GMBH

Meravigliagasse 4/1
1060 Wien

Dr. Thomas Riel
+43-650-9976443
riel@fantana.at

www.fantana.at

As a dynamic opto-mechatronics company, Fantana GmbH offers innovative solutions for the aerospace and defence industry, specializing in software-dominated applications. The focus is on optical sensor systems for remote sensing and intelligent data processing systems. The range of services covers the entire development process – from the concept idea to mechanical and electrical design through to software integration. The solutions are used in satellite-based earth observation, optical wind measurement, drone systems and drone defense.

GATE SPACE INNOVATION GMBH

Office Park 2 / 5.OG
1300 Wien-Flughafen

Moritz Novak
CEO
+43-660-3420250
moritz.novak@gate.space

www.gate.space

Founded in 2022, GATE Space develops green, chemical in-space propulsion solutions for the NewSpace economy. The company's main product is the GATE Jetpack, 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

Sparkassenplatz 2
6020 Innsbruck

Dr. Christian Hoffmann
+43-512-562021-0
info@geoville.com

geoville.com

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.

MAGNA STEYR FAHRZEUGTECHNIK GMBH & CO KG, DIVISION AEROSPACE

Puchstraße 85
8020 Graz

DI (FH) Armin Scheinost
+43-316-404-7122
armin.scheinost@magna.com

magna.com/aerospace

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.

OHB AUSTRIA GMBH

Kärntnerstraße 7b/1
8020 Graz

DI Bernhard Czar
CEO
+43-316-890971-30
office@ohb-austria.at

ohb-austria.at

OHB Austria is a leading European aerospace company specializing in satellite-based navigation technologies, space systems, and scientific research. As part of the OHB Group, the company contributes to cutting-edge space projects, including satellite mission planning, satellite development, GNSS technology, and scientific development for space exploration. With the know-how of its team members, the company develops solutions, services, and applications according to customer and market needs.

PEAK TECHNOLOGY GMBH

Technologieparkstraße 6
4615 Holzhausen

DI Dieter Grebner
CEO
+43-7243-50343
dieter.grebner@peaktechnology.at

www.peaktechnology.at

The company was founded in 2007 and is headquartered in Upper Austria. By now Peak Technology 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.

QUANTUM TECHNOLOGY LABORATORIES GMBH

Clemens-Holzmeister-Straße 6/6
1100 Wien

Dr. Rupert Ursin
CEO
+43-664-88476595
rupert.ursin@qtlabs.at

www.qtlabs.at

qtlabs is an Austrian SME based in Vienna specialized on optical and quantum space communication. Relying on over 20 years of experience in pioneering free-space and satellite-based quantum communication, qtlabs is leveraging this expertise to develop and deliver technology for optical-communication systems for space. qtlabs' portfolio covers, optical ground stations, quantum-communication sources, simulation tools, post-processing software, system design and security analysis.

SCIENCE PARK GRAZ GMBH

Sandgasse 36/4th floor
8010 Graz
www.sciencepark.at

+43-316-873-9101
info@sciencepark.at

www.sciencepark.at

Driven by passion for business and innovation, Science Park Graz and ESA BIC Austria support more than 70 start-ups each year, guiding them toward international success. As a key hub for entrepreneurs, start-ups, SMEs, researchers, and students, ESA BIC Austria focuses on turning cutting-edge space technologies into market-ready products and services that enhance life on Earth. With tailored support, expert mentoring, and a strong network, ESA BIC Austria provides the ideal environment for transformative technological developments.

TERMA TECHNOLOGIES GMBH

Autokaderstraße 29
1210 Wien

DI Hans Martin Steiner
+43-664-88551471
hmst@terma.com

www.terma.com/products/space/

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.

TTTECH COMPUTERTECHNIK AG

Business Unit Aerospace
Kettenbrückengasse 16
1040 Wien

DI (FH) Christian Fidi
+43-676-849372880
christian.fidi@tttech.com

tttech.com/markets/space

The TTTech 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

AEROSPACE AND ADVANCED COMPOSITES GMBH (AAC)

Viktor-Kaplan-Straße 2, Objekt F
2700 Wiener Neustadt

Dr. Andreas Merstallinger
Senior Expert Space-Tribo
+43-664-8251136
andreas.merstallinger@aac-research.at

Dr. Michael Scheerer
Head of Strucutral Analysis, VEO
+43-664-88606181
michael.scheerer@aac-research.at

www.aac-research.at

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 1989 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.

AUSTRIAN ACADEMY OF SCIENCES (ÖAW), SPACE RESEARCH INSTITUTE (IWF)

Schmiedlstraße 6, 8042 Graz

Prof. Dr. Christiane Helling, Director
Space Research Institute
+43-316-4120-301
christiane.helling@oeaw.ac.at

www.oeaw.ac.at/iwf

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, 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

Johannes Gutenberg-Straße 3
2700 Wiener Neustadt

Dr. Carsten Scharlemann
+43-5-0421-1235
carsten.scharlemann@fhwn.ac.at

www.fhwn.ac.at
www.fotec.at

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 GRAZ UNIVERSITY OF TECHNOLOGY

Inffeldgasse 12
8010 Graz

Prof. Dr. Franz Teschl
Dean of Studies for Space Sciences and Earth from Space
+43-316-873-7447
franz.teschl@tugraz.at

www.tugraz.at

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 hard- and software. Responsible for the first Austrian satellite TUGSAT-1/BRITE-Austria and follow-up missions OPS-SAT and PRETTY. Home of the Aerospace Team Graz, an interdisciplinary student team that develops and constructs rockets and rocket components and participates in international competitions.

JOANNEUM RESEARCH FORSCHUNGSGESELLSCHAFT MBH
DIGITAL – INSTITUTE FOR DIGITAL TECHNOLOGIES

Steyrergasse 17,
8010 Graz

DI Dr. Matthias Rüther
Director DIGITAL
+43-316-876-5001
matthias.ruether@joanneum.at

www.joanneum.at

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.

SEIBERSDORF LABOR GMBH

TECH Campus Seibersdorf
2444 Seibersdorf

DI Dr. Peter Beck
Head of the Business Unit
Radiation Protection Dosimetry
+43-50550-4305
peter.beck@seibersdorf-laboratories.at

seibersdorf-laboratories.at

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

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

Mariahilfer Straße 37–39
1060 Wien

Dr. Klaus Bernhardt, MBA
+43-1-58839-32
bernhardt@feei.at

feei.at

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.

FACHVERBAND DER FAHRZEUGINDUSTRIE
AUSTRIAN VEHICLE INDUSTRY ASSOCIATION

Postfach 337
Wiedner Hauptstraße 63
1045 Wien

Mag. Andreas Gaggl, MSc
+43-5-90900-4800
kfz@wko.at

fahrzeugindustrie.at

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%.

FACHVERBAND METALLTECHNISCHE INDUSTRIE
METALTECHNOLOGY AUSTRIA

Wiedner Hauptstraße 63
1045 Wien

Dipl.-Iur. Sabine Hesse, MBA
+43-5-90900-3358
hesse@fmti.at

metalltechnischeindustrie.at

The metal technology industry (MTI) forms the backbone of Austrian industry. More than 1,100 member companies are active in the fields of mechanical engineering, metal goods, plant construction, steel construction and foundries. The export-oriented sector is medium-sized, consists of more than 85% of family businesses and accounts for a quarter of all Austrian exports.

FFG ÖSTERREICHISCHE FORSCHUNGSFÖRDERUNGSGESELLSCHAFT MBH (FFG)
THE AUSTRIAN RESEARCH PROMOTION AGENCY

Sensengasse 1
1090 Wien

Dr. Andreas Geisler
Agentur für Luft- und Raumfahrt
+43-5-7755-3001
andreas.geisler@ffg.at

ffg.at/weltraum

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, EUMETSAT and UN-COPUOS.

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

Wiedner Hauptstraße 63
1045 Wien

Mag. Andreas Mörk
+43-5-90900-3436
andreas.moerk@wko.at

wko.at/industrie

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 260 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 66%.

Overview of Competencies

	AAC	Beyond Gravity	ENPULSION	EODC	EOX	Eviden	FH Wiener Neustadt	Fantana	GATE Space	GeoVille	Joanneum Research	MAGNA STEYR	OHB Austria	ÖAW – IWF	Peak Technology	Science Park Graz	Seibersdorf Labor	TU Graz	Terma	TTTech	qtlabs
Space Transportation, Manned Flights and Infrastructures																					
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											×						×				
Satellite																					
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	Fantana	GATE Space	GeoVille	Joanneum Research	MAGNA STEYR	OHB Austria	ÖAW – IWF	Peak Technology	Science Park	Seibersdorf Labor	TU Graz	Terma	TTTech	qtlabs
Satellite																					
Structural Elements							×								×						
Propulsion		×	×				×		×			×			×						
Passive Instruments		×																×	×		
Telecommunication and Navigation Payloads		×						×			×		×			×		×	×		×
Planetary Lander		×							×						×						
Planetary Lander Payloads											×			×							
Ground Segment																					
Ground Segment of Operating Spacecrafts							×				×							×	×		
Development and Construction of Space Segment		×											×		×			×	×		×
Development and Construction of Ground Segment						×	×		×		×				×			×	×		×
Operations support				×						×	×		×			×		×	×		×
Data dissemination and access solutions				×						×	×		×					×			
Services																					
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				×	×					×			×	×		×	×	×			

Executive Committee

EXECUTIVE COMMITTEE PRESIDENT

DI Dieter Grebner
dieter.grebner@peaktechnology.at
+43-7243-50343 -0

EXECUTIVE COMMITTEE VICE PRESIDENT, MANAGING DIRECTOR

DI Hans Steiner
hmst@terma.com
+43-664-8855-1471

ADVISORY COMMITTEE

DI Kurt Kober
kurt.kober@beyondgravity.com
+43-1-80199-5778

ADVISORY COMMITTEE

Dr. Heinz Mayer
heinz.mayer@joanneum.at
+43-316-876-1001

ADVISORY COMMITTEE

DI (FH) Christian Fidi
christian.fidi@tttech.com

Member Reports

This image from the NASA/ESA/CSA James Webb Space Telescope features an H II region in the Large Magellanic Cloud (LMC), a satellite galaxy of our Milky Way. This nebula, known as N79, is a region of interstellar atomic hydrogen that is ionised, captured here by Webb's Mid-InfraRed Instrument (MIRI).

Euclid shows us a spectacularly panoramic and detailed view of the Horsehead Nebula, also known as Barnard 33 and part of the constellation Orion.

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.

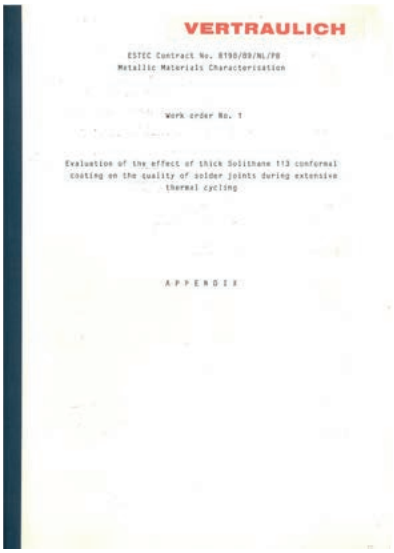
AAC's Liquid Nitrogen Tank labelled „AAC" at the TFZ in Wiener Neustadt © Daniel Hinterramskogler

AAC's aerospace research started in 1989 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.

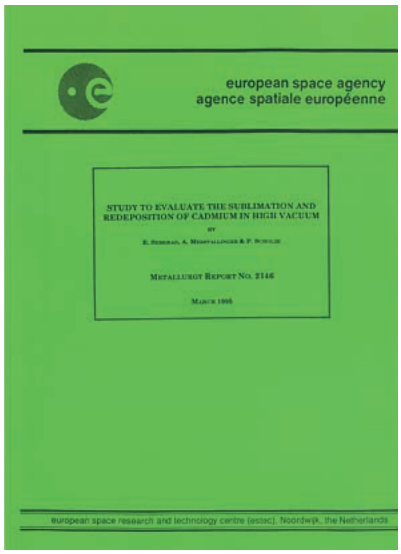
In 2012 AAC moved to its new premises in Wiener Neustadt, which is based on strategic decision: in this area several new research entities and one University of Applied Sciences are located which provide for AAC a more prosperous growth. The infrastructure covers one building with labs and offices and 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 extended the liquid nitrogen supply with a nicely visible tank.

New test services to space industry and ESA/ESTEC – 35 Years anniversary of the "Materials testhouse" @ AAC

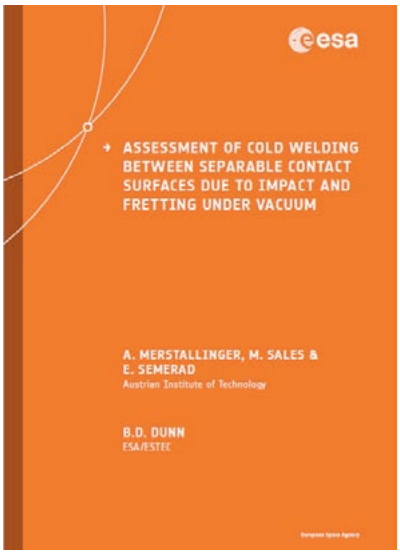
AAC is proud to announce, that its frame contract to ESTEC on Metallic Material Characterisation ("ESA testhouse") has achieved in 2024 an anniversary of 35 years: The first contract of our space group to ESA/ESTEC could be established in 1989. At that time the space group was part of the Austrian Research Centers in Seibers-



Testhouse: First Report (WO-1, 1989) – typed and with real photos



First study using the advance outgassing device (WO-9)



Test standard by AAC on Cold welding

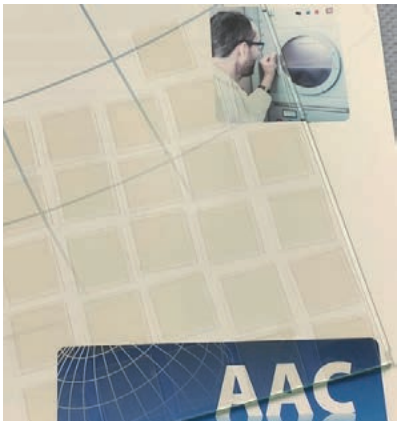
dorf (now AIT). Since then, AAC was 4 times successful to restablish this contract in open competition. The aim is to validate new materials and processes for use in space. The contract shall provide data necessary for space engineers to apply new materials or processes in their missions. As qualification for space is cost and time consuming, this is usually not possible within missions.

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.

One of the key competences within this contract is "Cold Welding" having be initiated by ESA in 1990ies. Finally ESA agreed with AAC on a test method to benchmark contact pairs for their risk to cold welding and published it as "STM-279". Meanwhile, several pairs were screened and the data generated is available via an online data base. Due to upcoming new needs, the standard was recently updated by AAC and is in review at ESA.

Premiere – First AAC material goes to space for IOV – SIMID launched to ISS ...

The low Earth orbit (LEO) environment includes altitudes up to several hundred kilometres above the Earth's surface. Under the microgravity environments of the low earth orbit (LEO), highly reactive atomic oxygen (ATOX) is the most of the abundant elements in space environment. In addition, there are UV radiation, micrometeoroid particulates and temperature cycling on orbit. The effects of all these constituents make the LEO environment extremely harsh and results in significant degradation of polymeric materials. Although polyimides (PIs) belongs to the group of the most applicable organic materials in space, they still suffer from long term ATOX induced erosion. Following previous ESA-activities (NanoHTM, TPFfTOA), AAC has developed a new type of polyimide based foil, named as "SIMID S20". It was selected for IOV



SIMID S20 a new type of polyimide based foils launched to ISS on the "Euro Material Ageing" activity

within the "Euro Material Ageing" on-board the International Space Station ISS, after promising pre-flight ATOX test performed in the ESTEC TEC-QEE Laboratory LEOX facility: the SIMID_20 remained transparent and additionally had significant lower erosion yield compared to commonly used Kapton H. In 2024, specimens of the SIMID 20 were launched to ISS. After 6 months IOV, return to earth is foreseen for 2025.

LabMaT – Ball Bearing Labyrinths Modelling and Testing

This ESA project develops an improved methodology for predicting lubricant evaporation losses through labyrinth seals. The primary failure mechanism for liquid-lubricated space bearings is oil insufficiency and the resulting lubrication failure. Actual calculation methods for lubricant losses are inaccurate and may lead to early mechanisms failure. An accurate prediction tool is crucial for sustainable and reliable amounts of lubrication and can be used to optimize the design of labyrinth seals. The role of AAC is to measure the evaporation losses through different labyrinth seals to verify the new model which is designed by CIM-mes. AAC designed a novel test setup and improved it's facility to measure lowest amounts of evaporation losses in thermal vacuum. A follow-up project is already on track to provide improved calculation methods for space engineers.

New test services to space industry – Cryogenic mechanical testing

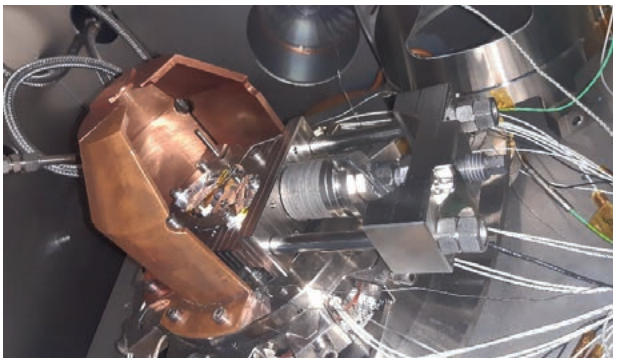
AAC has strong capabilities and heritage in mechanical testing at cryogenic temperatures. To further strengthen these USP, AAC invested in a new LHe-Cryostat. It enables not only testing of material specimens, but also investigation of components down to 4,2K.

New test services to space industry – TVAC testing of "small bushings"

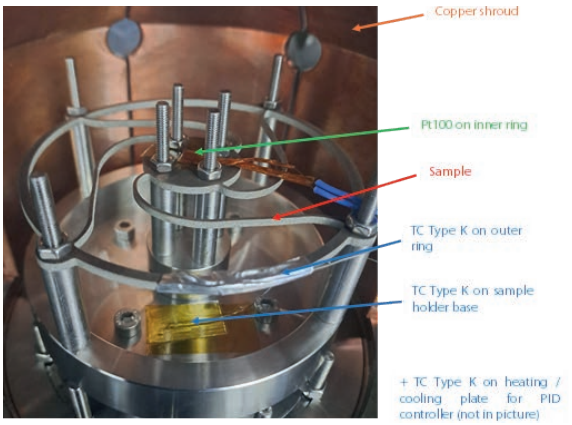
AAC offers testing of plain bearings (bushings) at TVAC. The setup was recently upgraded to test "small bushings" with inner diameters of 6-12mm. The applicable radial loads were extended to 30kN the measurable running torque ranges from 0,01Nm up to 50Nm.

AAC's device for advanced outgassing

New LHe-Cryostat inside large mechanical testing machine



Setup for testing of "small bushes" in TVAC



SMA rotary actuator (3D-printed by RHP) under performance test in TVAC@AAC.

New test services to space industry – Performance of "compliant mechanisms"

The term "Compliant mechanisms" refers to bulk components that can replace tribological components like bearings or gears. The advantage would be that bulk components offer more easy qualification and lower risk: in contrast to a bearing or a gear, they do not need lubrication, which is always certain risk as it may not offer enough life or may cause contamination. For certain cases, the compliant mechanism may also become an active one: using Shape Memory Alloys (SMA) motion can be generated without use of a classical motor.

With in the ESA project 4Dprint, RHP (AT) manufactured a compliant mechanism. A rotary actuator was designed with assistance of simulation by AAC. RHP manufactured this component out of SMA by 3D-printing. The performance was tested under TVAC at AAC. Therefore, the gear test rig HADES was adapted to measure stiffness, output torque and output angle in TVAC.

Aerospace & Advanced Composites GmbH (AAC)

Viktor-Kaplan-Straße 2, Objekt F, 2700 Wiener Neustadt
www.aac-research.at

CONTACT

Dr. Andreas Merstallinger
Senior Expert Space-Tribo
+43 (0) 664 8251136
andreas.merstallinger@aac-research.at

Dr. Michael Scheerer
Head of Structural Analysis, VEO
+43 (0) 664 88606181
michael.scheerer@aac-research.at

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Cluster satellite reentering Earth's atmosphere.

Austrian Academy of Sciences

Space Research Institute

The Space Research Institute (Institut für Weltraumforschung, IWF) in Graz focuses on the physics of our solar system and the diversity of extrasolar planets. 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 develops and builds space-qualified instruments and analyzes and interprets the data returned by the space missions. Its 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 Lustbühel 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 2024, the IWF was involved in 24 active and future international space missions.

Scientific Highlights in 2024

- In a series of four papers in "Astronomy and Astrophysics" the first detailed 2D chemical models for planet-forming disks were presented that can explain, fit, and interpret the new mid-IR molecular spectra obtained with the James Webb Space Telescope. Some of these disks, very surprisingly, show a strong oxygen depletion in the inner disk, which produces rich spectra full of hydro-carbon molecules.
- In "Astronomy and Astrophysics" P. Barth et al. studied the effect of lightning on the atmospheric chemistry of exoplanets and potential biosignatures. It was shown that in an oxygen-rich atmosphere lightning rates only a few times higher than modern Earth's can mask the O_3 biosignature.
- In "Nature Astronomy" T.J. Bell et al. revealed in hitherto unprecedented high details the atmospheric properties of the eternal nightside of the 1500 K hot extrasolar gas planet WASP-43 b. The night side is shrouded in clouds and lacks methane, indicating chemical disequilibrium.
- M. Hosner et al. presented evidence for reconnection inside a dipolarization front of a diverging Earthward fast flow in the "Journal of Geophysical Research: Space Physics".
- Based on extensive studies, H. Lammer and M. Scherf derived a new formula for predicting Earth-like

habitats in the galaxy, which was published in a special issue of "Astrobiology".

- In "Astronomy and Astrophysics" P. Woitke et al. studied calcium-aluminium-rich inclusions (CAIs), which are the oldest dated solid materials in the solar system. They are found as light-colored crystalline ingredients in various types of meteorites, yet their formation in the solar nebula still is a mystery.

The Year 2024 in Numbers

Members of the institute published 165 papers in refereed international journals, of which 38 were first author publications. During the same period, articles with authors from the institute were cited 10029 times in the international literature. In addition, 57 talks (13 invited) and 26 posters were presented by IWF members at international conferences. Institute members lead or co-organized 16 international meetings, e.g. EANA, EGU General Assembly, ISSI Team Meetings, and two PLATO Workshops.

In the following, some mission highlights are summarized for each research field. For details and scientific papers published in 2024 please refer to oeaw.ac.at/en/iwf/publications/annual-reports.

Solar Wind and Geospace

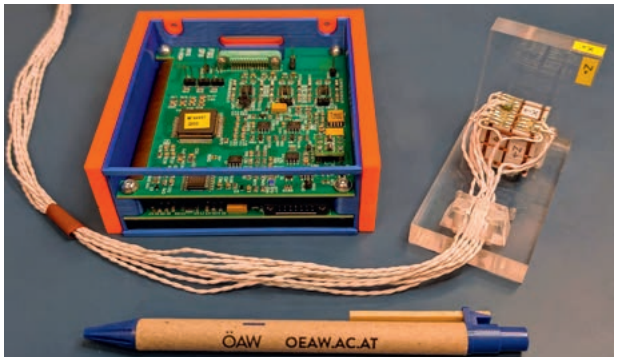
After the 24 years of successful observation, the first of four **Cluster** space science satellites successfully deorbited on 8 September over the South Pacific and Cluster ended its science operation. This reentry marks the end of a unique mission to better understand plasma processes in near-Earth space. The other three spacecraft are planned to perform reentries between October 2025 and August 2026.

NASA's four **Magnetospheric MulitScale (MMS)** spacecraft perform multi-point measurements to study the dynamics of the Earth's magnetosphere. A study based on multi-point multi-scale analysis of data from two four-spacecraft missions, MMS and Cluster, separated at different spatial scales revealed the structure and evolution of a new type of transient magnetic reconnection at a thin electron-scale current sheet embedded in a front layer of the high-speed plasma jets in the night-side magnetosphere. The existence of such small-scale, transient reconnection was not known until data from the high-resolution measurements by MMS have become available.

The first **China Seismo-Electromagnetic Satellite (CSES-1)** is studying the Earth's ionosphere, **CSES-2** will follow in 2025. The magnetometer sensors of CSES-1 have completed the sixth year of successful operation in low Earth orbit in February 2024. This is particularly important for the newly developed CDSM, as its reliability could be demonstrated for another year in space. The CDSM sensor manufactured for CSES-2 was integrated on the magnetometer boom in April 2024 followed by several functional and environmental tests together with the entire spacecraft to demonstrate flight readiness.

2024 was the first full year of the science phase of **Macau Science Satellite 1**. All instruments, including the Austrian CDSM, operated absolutely nominally, confirming a successful first mission phase.

FORESAIL is a CubeSat program conducted by Aalto University in the frame of the Finnish Centre of Excellence in Research of Sustainable Space. In 2024, the IWF focused on the construction and test of the Proto-Flight Model of the FORESAIL-2 magnetometer. The core component of the electronics is based on a hybrid-microchip, which includes three newly developed Magnetometer Front-end ASICs (MFAs) within a single package.



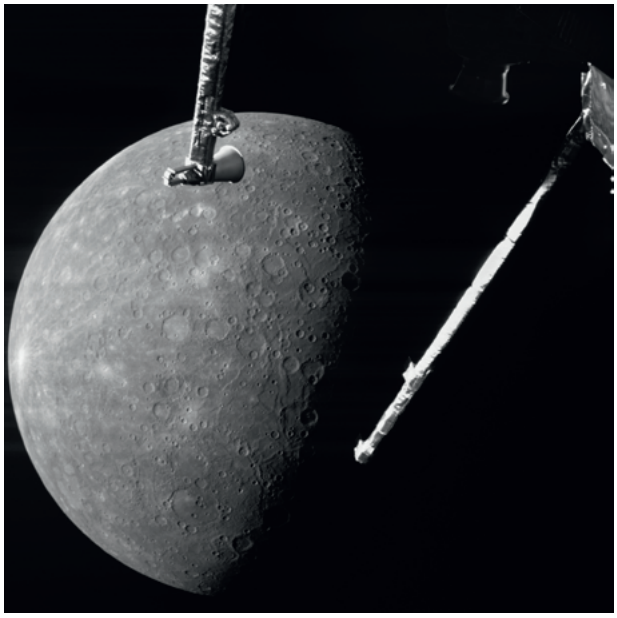
Proto-Flight Model of the FORESAIL-2 magnetometer with the CubeSat size electronics (left) and fluxgate sensor (right).
© OeAW / IWF / Valavanoglou

The **Space Weather Follow-On (SWFO)** mission is a joint undertaking by NASA and the National Oceanic and Atmospheric Administration (NOAA). The main activities at the IWF in 2024 included remote support of the magnetometer tests at UNH, the integration of the instrument on the spacecraft and the finalization of all the documentation for the flight readiness review of SWFO-MAG.

The **Solar wind Magnetosphere Ionosphere Link Explorer (SMILE)** will study the interaction between the solar wind and Earth's magnetosphere. The IWF participates in two instruments: the Soft X-ray Imager (SXI) and the magnetometer. In 2024, the EBox for SXI was integrated at Airbus Madrid and has since then passed all the functional and environmental tests without reported issues.

Solar System

The **BepiColombo** mission encountered challenges with solar panel degradation during 2024, resulting in a one-year delay to its planned arrival at Mercury. The new expected arrival date is now set for November 2026. With the fourth gravity-assist on 4 September 2024, BepiColombo achieved the closest swing-by ever performed by a spacecraft at a distance of just 165 kilometers from the planet's surface. All three payloads contributed by the IWF were operational during the flyby. The magnetometers MPO-MAG (under IWF technical management) and Mio-MGF (under IWF PI-ship) provided valuable scientific measurements of Mercury's internal magnetic field. The Planetary Ion Camera (PICAM) successfully monitored the upstream solar wind conditions, including capturing one CME (Coronal Mass Ejections) and a SEP (Solar Energetic Particles) event.



This image was captured during BepiColombo's fourth Mercury flyby on 5 September 2024 at 00:11 CEST, when the spacecraft was about 3459 km from the planet's surface.
© ESA/BepiColombo/MTM

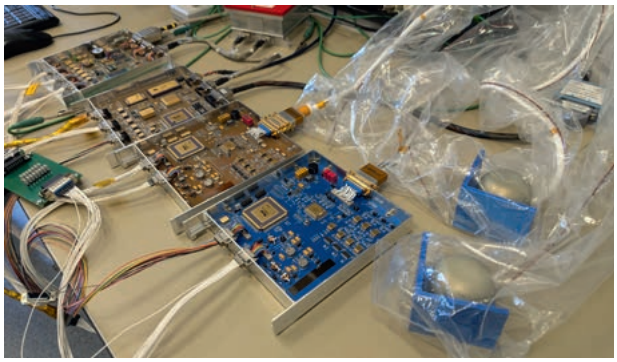
The fifth swing-by, conducted on 1 December 2024, took BepiColombo on a trajectory 37,626 kilometers from Mercury. This maneuver was notable for its groundbreaking observations in mid-infrared light, revealing novel details about the planet's surface composition and temperature variations. During this swing-by most of the instruments were switched off, except the remote sensor instruments and the two magnetometers.

ESA's **JUpiter ICy moons Explorer (JUICE)** is on its way to Jupiter and its icy moons Ganymede, Callisto, and Europa. On 19 and 20 August 2024, just under 18 months after the launch of JUICE, the first-ever lunar-Earth double gravity assist maneuver was performed through which the spacecraft was braked and redirected towards Venus. The IWF participates on Co-Investigator basis in three of the ten scientific instruments aboard JUICE: the Jupiter MAGnetometer (J-MAG), the Particle Environment Package (PEP), and the Radio and Plasma Wave Investigation (RPWI). In accordance with the operating and test specifications of the JUICE space probe, two functional checks of J-MAG were carried out in January and July 2024. These were based on measuring the interplanetary magnetic field, which is only a few nanotesla in magnitude. During the Earth flyby on 20 August 2024, the JUICE space probe plunged deep into the Earth's magnetic field, causing the measured magnitude to rise to over 4,000 nanotesla.

Comet Interceptor will characterize in detail, for the first time, a dynamically-new comet or interstellar object. The mission will consist of three spacecraft: mother spacecraft A and daughter spacecraft B2 under the respon-

sibility of ESA and daughter spacecraft B1 under the responsibility of JAXA. The IWF develops and builds the Data Processing Unit (DPU) for the Mass Analyzer for Neutrals in a Coma (MANiaC) on spacecraft A and the electronics for the Flux Gate magnetometer (BFG) as part of the Dust, Fields and Plasma suite (DFP) on spacecraft B2.

In 2024, the Electrical Functional Model (EFM) of the BFG electronics and sensors were successfully integrated into the common electronics box at CBK. In autumn 2024 the entire DFP suits of spacecraft A and B2 were successfully subjected to comprehensive EMC tests at ESTEC, which cleared the way for manufacturing and assembly of the first of three Flight Model/Spare (FM/FS) boards.



DFP-B2 EFM at integration with two magnetometer boards (blue and brown) in the foreground, data processing unit and power supply in the background and two Engineering Model sensors packed into plastic for contamination protection prepared for thermal vacuum testing. © OeAW/IWF/Valavanoglou

The first Engineering Model EM1 of the MANiaC DPU was delivered to the University of Bern in March, where it was integrated with the rest of the EM instrument. This EM has been used for integration campaign on the platform at OHB in May and in November. EM2 completed its board level tests in April and has been used at the IWF since then to support the development of the FPGA configuration and the MANiaC Application Software. The EFM was completed at the end of the year. In parallel, the layout of the PCBs for the Protoflight Model was completed and the boards were ordered. Finally, the development of the DPU Boot Software was concluded this year.

Diversity of Exoplanets

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

In 2024, **CHEOPS (CHaracterizing ExOPlanets Satellite)** continued operations as part of the first extended mission, which will last until the end of 2026. The IWF contributed the Back-End-Electronics, which is responsible for controlling the data flow and the thermal stability of the 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 observations. The institute hosts two members of the CHEOPS board and two of the CHEOPS science team. The European consortium in charge of the majority of CHEOPS observing time in 2024 made use of CHEOPS observations to publish about 20 refereed publications.

Despite it being a CubeSat, **CUTE (Colorado Ultraviolet Transit Experiment)** is still delivering scientifically valuable data three years after launch. The IWF is the only technological contributor to this NASA mission outside of the University of Colorado (Boulder). In 2024, the IWF finalized the preparation of the data for archiving, which has become live in December.

During its four-year mission, **ARIEL (Atmospheric Remote-sensing Infrared Exoplanet Large-survey)** will observe 1000 exoplanets ranging from Jupiter- and Neptune- down to super-Earth-size in the visible and infrared with its meter-class telescope. The IWF co-leads the upper atmosphere working group, is part of the laboratory data working group and 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.

PLATO (PLAnetary Transits and Oscillation of stars) is a space-based observatory to search for planets orbiting alien stars. It will emphasize on the properties of terrestrial planets in the habitable zone around solar-like stars, but also detect and characterize at least 200 gas giant exoplanets. PLATO has also been designed to investigate

seismic activity of stars, enabling the precise characterization of the host star, including its age. The IWF (co-) leads the work package aiming at studying planetary habitability, cloud and gas chemistry, as well as multi-dimensional properties of planetary atmospheres. Additionally, the institute takes part in the work packages on stellar characterization and on planetary evolution. The IWF contributes to the development of the Instrument Control Unit (ICU) by delivering the Router and Data Compression Unit (RDCU). The RDCU Flight Model boards (FM1 as nominal, FM2 as redundant and FM3 as spare) were completed in 2024. FM1 and FM2 were delivered to INAF in Italy in September, while the testing of the FM3 spare was completed by the end of the year.

NEWATHENA (Advanced Telescope for High ENergy Astrophysics) is an observatory in the X-ray range of the electromagnetic spectrum with the aim of understanding the high energetic processes close to the event horizon of black holes and provide more details for the baryonic component locked in ultra-hot gas. The science redefinition team added stars hosting exoplanets to the mission's science drivers, addressing the contribution of stellar activity to exoplanet habitability. The mission is now in the study phase. The IWF is part of the consortium for the Wide Field Imager (WFI) and will provide the DPU as part of the Instrument Control Unit (ICU). The design work for the DPU prototype was completed in 2024 and the electrical components were ordered. Assembly, testing and finalization of the DPU prototype is expected to be completed in 2025.

ARRAKIHS (Analysis of Resolved Remnants of Accreted galaxies as a Key Instrument for Halo Surveys) will explore the nature of dark matter, by observing the ultra-low surface brightness halo and stellar streams for a representative sample of Milky Way-type galaxies in the nearby Universe. The IWF is leading the development of the main electronics sub-system (EBOX), which controls the instrument, communicates with the spacecraft, collects the scientific data from the four imaging sensors and maintains the telescopes at their optimal temperature. The institute will provide the Common Data Processing Unit, as well as the EBOX housing, and is in charge of integrating the other EBOX units as well as conducting the required environmental tests. Similar to NEWATHENA, the high sensitivity of the instruments may enable progress also in exoplanet research, and thus extending CHEOPS' legacy beyond the 2030s.

Planet-Forming Disks

New stars are born when the cold cores of molecular clouds eventually collapse under the pull of their own gravity and the remaining dust and gas form a flat disk known as a protoplanetary disk. These disks have lifetimes of only a few million years, and it is believed that all planets form in such disks during this short time interval.

In 2024, studies on disk and dust evolution as well as on the observational appearance of disks in young star-forming clusters have continued. Common topics this year were magnetic winds and their effect on disk evolution and the impact of external UV-irradiation on the evolution and physico-chemical state of the disks, which can be probed with ALMA observations. However, the main topic of this year was the application of various models to observations by the MIRI instrument of the James Webb Space Telescope. IWF's collaboration with the University of Groningen and the membership in the MIRI consortium enabled testing existing and developing new models for protoplanetary disks in 2024.

Satellite Laser Ranging

As one of the world-leading Satellite Laser Ranging (SLR) stations, IWF's SLR station at the Lustbühel Observatory is continuously tracking more than 150 satellites equipped with retro-reflectors. Diffuse reflections of laser light from space debris are measured to perform Space Debris Laser Ranging (SDLR) measurements. In parallel, the reflected sunlight of space objects is recorded to gather Single Photon Light Curves (SPLC). The data of these three techniques form the unique catalog IWF SPARC, which is utilized for different approaches to characterize space debris. Machine learning (ML) is used to classify satellites or space debris based on single photon light curves. Based on SLR simulations, a technique is developed allowing for full attitude determination based on the data of two SLR stations simultaneously observing a single space debris target.

New Developments

The development of new instrument technologies is essential for competitive excellence in space research.

An ESA-funded technology development project started in mid-2024 with the goal of manufacturing and testing a first laboratory model of the new Hanle magnetometer. Three different sensor concepts were proposed to find out the solution with the best signal-to-noise floor especially below 1 Hz.

The IWF and the Institute of Electrical Measurement and Sensor Systems of the Graz University of Technology (TU Graz) have been collaborating on the next generation of the space proven Magnetometer Front-end ASIC (Application Specific Integrated Circuit). It includes the readout electronics for magnetic field sensors which is optimized in terms of size and power consumption. The upgraded ASIC shall feature an improved dynamic range and increased radiation hardness. It will be space qualified in the frame of the FORESAIL CubeSat mission. In 2024, a detailed evaluation of the entire feedback path with digital-to-analog converter and current amplifier was performed with the second prototype microchip.

Public Outreach

The "Lange Nacht der Forschung" on 24 May 2024 attracted about 1,600 people visiting 16 stations in the Schmiedlstraße and at the Lustbühel Observatory. The 70-strong team was made up of IWF employees, who were actively supported by the "Steirischer Astronomen Verein", the Aerospace Team Graz, Norbert Steinkellner with his multi-level astronomy course from BRG Kepler and students from TU and NAWI Graz.

Ready for the Lange Nacht der Forschung to come. © OeAW/IWF

As part of the EANA 2024 astrobiology conference, Carmen Possnig, member of the ESA astronaut reserve, and Cyprien Verseux, a researcher at the University of Bremen, gave a public lecture at the IWF on how to get "from the ice to the stars".

In the IWF colloquium and seminar series, international – including Kavli Prize winner Sara Seager from MIT – and local speakers informed about current research topics and scientific results. Throughout the year, the IWF was invited to give talks or participate in discussion rounds inside and outside Austria.

Martin Volwerk contributed to space blog in the newspaper DER STANDARD with an article on the space adventures of the participants of the Alpbach Summer School, Manuel Scherf – in search for a second Earth – described the complex conditions for the emergence of life and Günter Kargl recalled the historic landing of Rosetta/Philae on comet 67P/Churyumov-Gerasimenko 10 years ago.

The Radio Steiermark-Kinderreporter:innen visited the IWF twice in 2024, talking to Günter Kargl and Ruth-Sophie Taubner about the moon of our Earth and possible life on the icy moons of the outer solar system.

More information and pictures of the events are found at www.oeaw.ac.at/en/iwf/latest/events and a selection of reports in print, radio and TV is summarized in our media review at www.oeaw.ac.at/en/iwf/latest/iwf-in-the-media.

Carina, Timo, and Andreas interviewing Günter Kargl in IWF's astro-lab. © OeAW/IWF/Scherr

Young Researcher Program

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

Throughout the year, students from eight primary and high schools visited the institute. They heard about IWF's science activities and were guided through the labs. Following the OeAW young science initiative "Akademie im Klassenzimmer" IWF members visited (primary) schools in Styria, Lower Austria, and Vienna.

During summer time, two students from University of Vienna and Universidad de Guadalajara, Mexico, performed a two-months internship, funded by the City of Graz. Via FFG's funding project for female students the IWF could offer a three-months internship for a student from NAWI Graz. Additionally, four high-school students conducted FFG-funded internships at the IWF or completed their practical work experience days at the IWF.

Recognition

Rumi Nakamura, head of IWF's Space Plasma Physics group, was elected a full member of the Austrian Academy of Sciences. Peter Woitke, head of IWF's Planet-Forming Discs and Astrochemistry group, successfully completed his habilitation in the field of astrophysics at the TU Graz.

Meetings

On 29 April 2024, the PLATO Follow-Up Meeting (1) was held online, showing the synergies between PLATO and the CHAMELEON MC-ITN in the developments of virtual laboratories for present and future space mission applications. From 7-8 October 2024, the Follow-Up Meeting (2) held at the IWF discussed projects for the atmosphere characterization of gas planets with PLATO.

More than 20 years after the first meeting in Graz, the annual meeting of the European Astrobiology Network Association (EANA) was again hosted by the IWF. The meeting took place at TU Graz in September 2024 and was organized by Ruth-Sophie Taubner.

The participants of EANA 2024. © OeAW/IWF

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. GVESM IV was held on 3 May 2024 at the IWF.

Christiane Helling served as chair of the Program Committee of the Summer School Alpbach, dedicated to "Giant planets and their moons". Every year, 60 students and about 25 lecturers and tutors from ESA's member states are invited to this meeting. This year also ESA Director of Science, Prof. Carole Mundell, gave an invited talk and participated in a fireside chat. In November 2024, the Post Alpbach event took place at ESEC–Galaxia in Transinne, Belgium, in which all Austrians who had attended the summer school were selected to participate.

In June 2024, the OeAW celebrated the official start of the MLA2S – Machine Learning at the Austrian Academy of Sciences platform. Its objective is to serve as a catalyst for inter–institutional collaboration on the use and development of machine learning for scientific research at the OeAW and beyond. In December 2024, the second MLA2S networking seminar was hosted by the IWF in Graz.

Lecturing & Theses

In summer 2024 and in winter term 2024/2025 IWF members gave (online) lectures at the University of Graz, TU Graz, FH Wiener Neustadt, TU Braunschweig, University of Jena, and Kyushu University and supervised six PhD and two master theses.

Austrian Academy of Sciences

Schmiedlstraße 6, 8042 Graz
www.oeaw.ac.at/iwf

CONTACT
Prof. Dr. Christiane Helling, Director
Space Research Institute
+43 316 4120–301
christiane.helling@oeaw.ac.at

MORE INFO
More information about IWF's research activities and publications during the year 2024 is found in the IWF Annual Report: oeaw.ac.at/en/iwf/publications/annual-reports
LinkedIn: linkedin.com/company/iwf-graz/

AUSTROSPACE

Austrospace unites Austria's leading space industry players and research institutions, fostering collaboration and innovation in the exploration and application of space technologies, while actively representing and advocating their interests to national authorities.

Interested in becoming a member? Contact the committee.

The SpaceX Falcon 9 rocket carrying ESA's EarthCARE satellite is poised patiently on the launch pad at the Vandenberg Space Force Base in California.

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 and employs around 1800 people in Switzerland, Sweden, Austria, Finland, Portugal 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 2024 include the inauguration of the expanded mechanisms cleanroom in Vienna and key products for several missions, which were launched in 2024. In June, ESA Director General Josef Aschbacher visited the headquarters in Vienna.

Precise positioning for NASA climate satellite

In February 2024, a new NASA climate satellite was launched to monitor the health of the world's oceans and global air quality. A navigation receiver from Beyond Gravity in Vienna determines the satellite's position in space. This improves the accuracy of the climate data sent back to Earth. One of the three instruments on the NASA satellite is protected by thermal insulation from Beyond Gravity Austria.

NASA's PACE climate mission monitors changes in global marine biology, aerosols (such as dust, pollen and smoke) and clouds. PACE also provides a better insight into ocean health by measuring the distribution of phytoplankton.

NASA's climate satellite PACE with navigation receiver and thermal insulation from Beyond Gravity Austria. © NASA

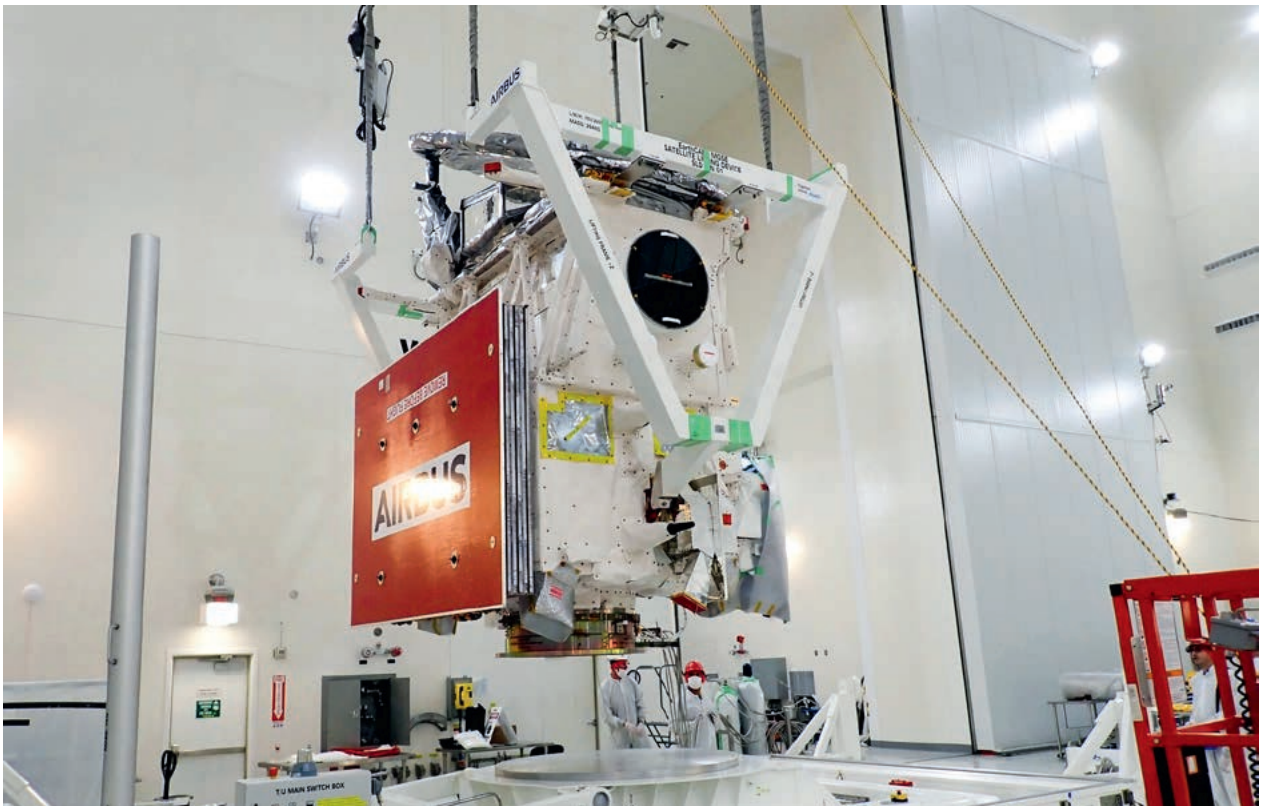
Expanded mechanisms cleanroom inaugurated

Ceremonial ribbon cutting to mark the expansion of Austria's largest space company in Vienna-Meidling © Beyond Gravity

In April, Beyond Gravity Austria inaugurated its expanded production for pointing mechanisms for electric satellite thrusters. The cleanroom area in Vienna doubled in size.

The company is the world's largest manufacturer of pointing mechanisms for electric satellite engines. European and US satellite manufacturers are among the customers. Satellites are increasingly using electric propulsion instead of chemical propulsion, in which ionized gases are accelerated by strong electric fields. Precise mechanisms are needed to control these electric satellite engines.

European cloud satellite



Satellite container and ground support equipment from Beyond Gravity for EarthCARE. © ESA

In May 2024, the European climate satellite EarthCARE launched into space to observe the Earth and shed new light on the role that clouds and aerosols play in regulating the Earth's temperature balance.

EarthCARE provides data for climate research, improves the accuracy of climate models and supports weather forecasting. Thermal insulation from Beyond Gravity Austria protects the Earth observation satellite from the extreme heat and cold in space. The satellite's thermal insulation consists of several layers of ultra-thin special plastic films that achieve highly efficient thermal protection in the vacuum of space.

A navigation receiver from Beyond Gravity in Vienna determines the position of the EarthCARE satellite in orbit to within one meter while the satellite is moving around the Earth at around seven kilometers per second. The more precisely the satellite's position in orbit can be determined, the more precise the data that the satellite sends back to Earth will be. Beyond Gravity Austria was also responsible for developing and manufacturing the complete mechanical ground support equipment for the climate satellite, such as satellite lifting devices, transport and test adapters and integration frames. The EarthCARE satellite was transported in a satellite container from Vienna.

Position determination for European sun mission

In December, two small European satellites for the Proba-3 mission were launched towards the sun. The two small satellites will take the first-ever pictures of the sun together and test new technologies in space. The exact position of the two space probes is being determined by navigation receivers from Vienna. Currently, 25 satellites in orbit use Beyond Gravity navigation receivers.

Four new Galileo satellites in space

In April and September 2024, a total of another four European Galileo navigation satellites were launched into space to join the fleet of around two dozens satellites. All Galileo satellites are protected by thermal insulation from Beyond Gravity Austria form the harsh temperatures in space. In parallel, work is ongoing on the next generation of Galileo satellites. The Galileo Second Generation satellites will use thermal insulation from Austria (for the six satellites built by Airbus) and electric propulsion pointing mechanisms and drive electronics from Vienna (for the six satellites built by Thales Alenia Space).

Four Galileo In-Orbit Validation satellites in medium-Earth orbit.
© ESA – P. Carril

Integrated GNSS receiver for commercial constellations

In August 2024, Beyond Gravity was awarded a contract by the Canadian company MDA Space to provide more than 200 integrated software-based navigation receivers integrated into the Beyond Gravity "constellation On Board Computer" for the MDA Aurora supply chain, which supports deliveries for the Telesat Lightspeed internet satellite constellation, among others. This high-volume contract marks the first time Beyond Gravity has delivered a software-based product.

Testing the benefits of Positioning, Navigation, and Timing in low earth orbit

In 2024, Beyond Gravity was chosen as a key payload partner for an ESA mission to prove in orbit the benefits of low earth orbit satellites for Positioning, Navigation, and Timing. Working alongside GMV (Spain) and OHB System AG (Germany) the end-to-end demonstration activity comprises design and development of 5 to 6 satellites, the payloads, the procurement of launch services, the provision of a ground segment, the development of a test user receiver and finally the operation of the system for experimentation, validation and demonstration. Beyond Gravity delivers technology for the digital signal generation and the payload-system clock. This critical component ensures unparalleled navigation signal integrity alongside timing accuracy and stability, underpinned by our advanced payload self-calibration techniques.

Technology for two European environmental satellites

In September and December, two European environmental satellites (Sentinel-2C and Sentinel-1C) were sent to space. Both satellites use technology from Beyond Gravity Austria to determine the satellite's position in orbit. The Beyond Gravity navigation receiver can process both US GPS and European Galileo signals. With post-processing, the Vienna-developed navigation receiver allows for an accuracy of a few centimeters. Furthermore, the Sentinel-1C satellite is protected by thermal insulation from Beyond Gravity Austria from the extreme cold and heat in space. The multilayer insulation was developed in Vienna and manufactured at the production site in Berndorf (Lower Austria). Almost every European ESA satellite is protected by thermal insulation from Beyond Gravity.

Enabling maiden flight of Europe's Ariane 6 rocket

Several products from Beyond Gravity Austria were used for the maiden flight of the new European launch vehicle Ariane 6 in July 2024. The company provided the high-temperature insulation for the lower and upper stage of Ariane 6. The high-temperature insulation for the lower stage is made of glass and ceramic fabrics. During the journey from Earth into space, the rocket engines have to withstand extreme heat of up to 1,500 degrees Celsius for several minutes. The insulation protects the rocket's exhaust systems around the rocket engine, which is fueled by oxygen and hydrogen.

In addition, the company supplied high-temperature insulation for the upper stage of the Ariane 6 launch vehicle near the re-startable Vinci engine. This insulation consists of glass fabric and polymer films. The insulation was used on the upper stage of the Ariane 6 launch vehicle. For Ariane 6, the company also produces a gimbal mechanism for the upper stage of the rocket. The mechanism serves as a joint to align the engine for the thrust vector control of the rocket's upper stage.

Ariane 6 with high-temperature insulation and gimbal mechanism from Beyond Gravity Austria. © ESA

First data from PRETTY climate cubesat

In 2024 the Austrian climate cubesat PRETTY (launched in October 2023) sent its first data. Austria's fifth satellite delivers data on the height of the glacier ice in Greenland, the wave height of the oceans and analyzes 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.

Beyond Gravity Austria GmbH

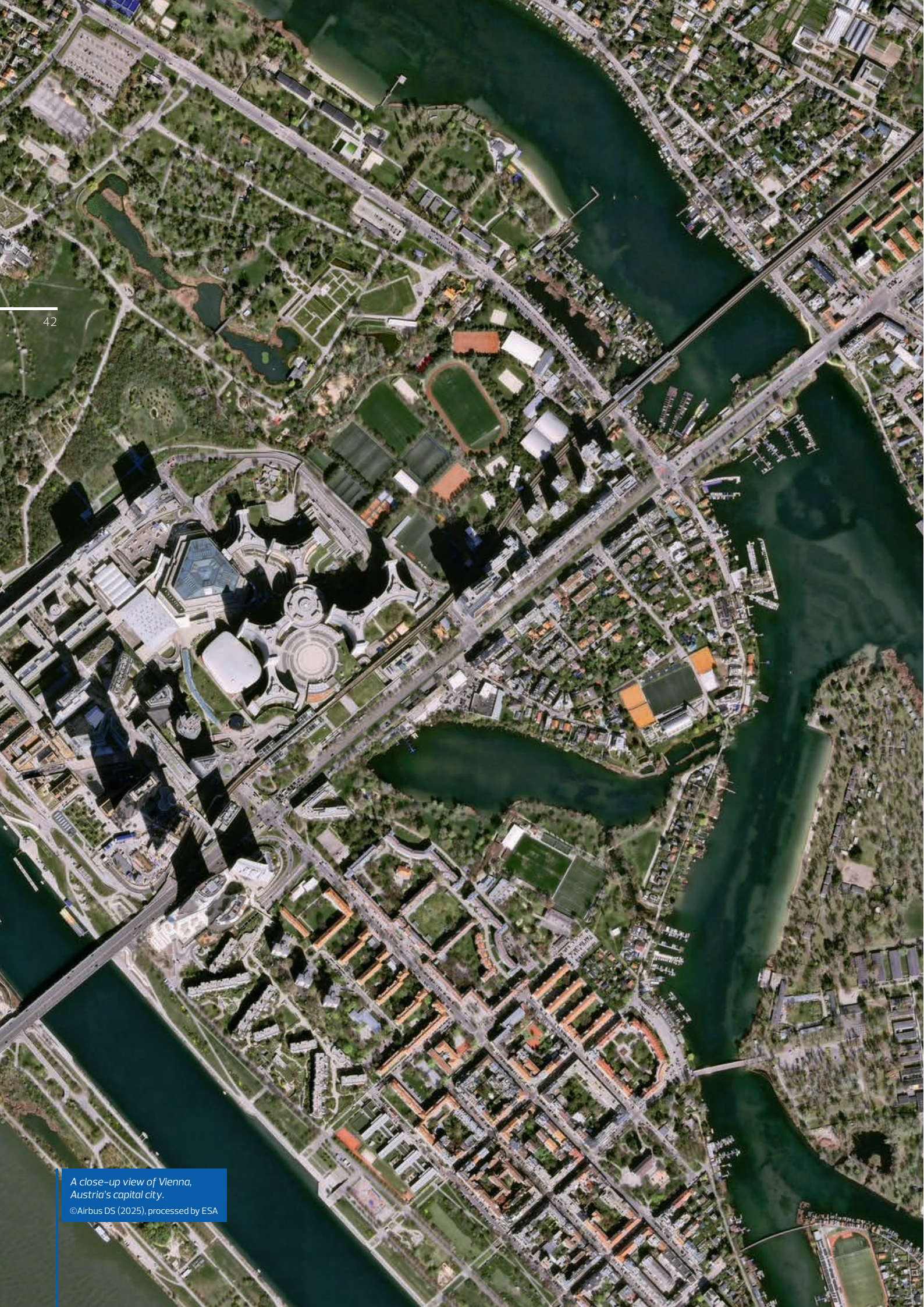
Stachegasse 13, 1120 Wien
www.beyondgravity.com

CONTACT

DI Kurt Kober, Wolfgang Pawlinetz
+43-1-80199-0
info.at@beyondgravity.com

FACTS

Sales:	64 M€
ESA Share:	18 M€



A close-up view of Vienna, Austria's capital city.

ENPULSION GmbH

In 2024, ENPULSION achieved significant milestones as part of its growth strategy. After the completion of its strategic move from January onwards, ENPULSION officially inaugurated its new headquarters and production facility at Vienna Airport in April.

This expansion tripled the company's operational space to 4,000 square meters, significantly increasing its production output, innovation capacity which also helped facilitating customer interactions. The move reflects ENPULSION's commitment to advancing in-space mobility solutions on global markets and meeting the growing demand for its propulsion systems.

Integration of a thruster into a vacuum chamber © Ben Leitner

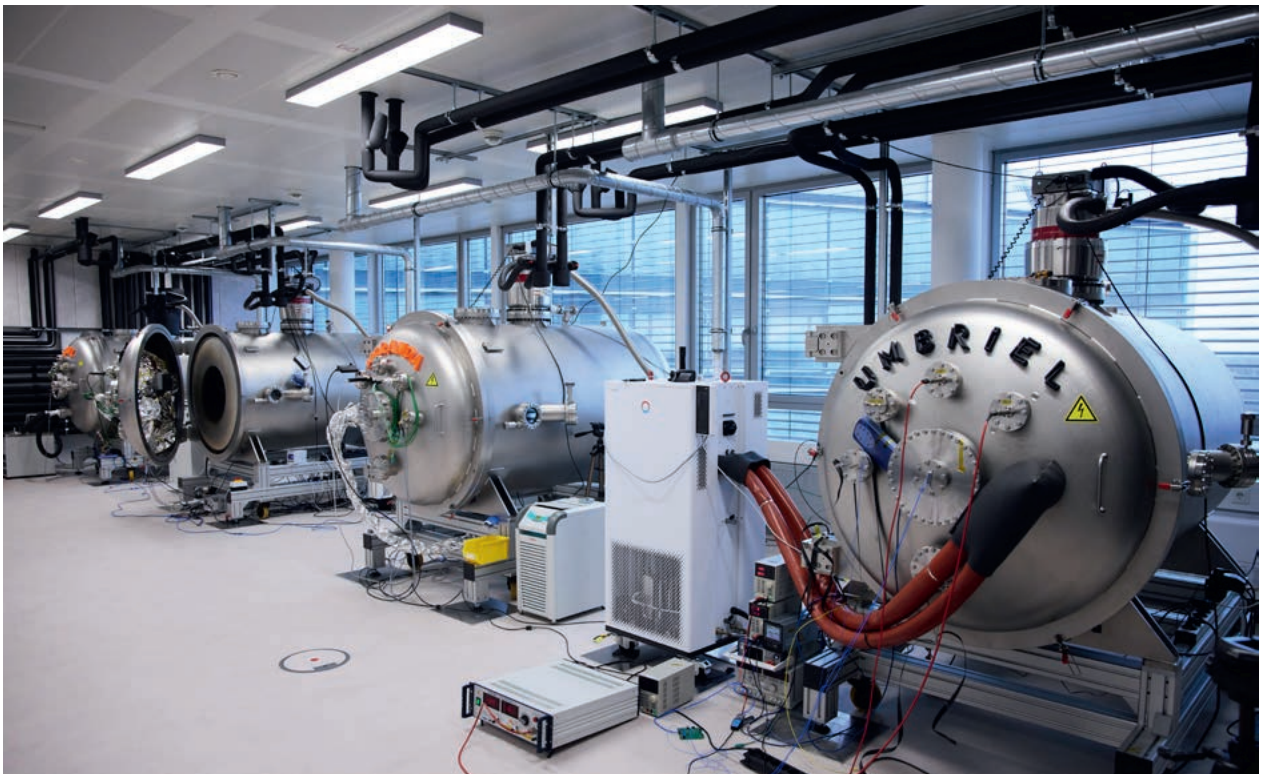
In March, the company celebrated the deployment of its 200th propulsion system into space, following the successful SpaceX Transporter-10 launch. This accomplishment came just a year after reaching the 100-unit mark, highlighting the product leadership of ENPULSION' s technology.

By November, ENPULSION secured a €4 million contract with the European Space Agency to further develop the NextGen FEEP MICRO R^3 Thruster. This funding aims to enhance the performance of the thruster, reinforcing the company's position at the forefront of electric propulsion technology.

Production Facilities © Ben Leitner

Later that month, ENPULSION entered a contract with EnduroSat for the delivery of 100 fully integrated electric propulsion systems. The agreement stipulated that the first 30 units would be delivered within 12 months, with an initial batch expected by the end of the year.

Throughout 2024, ENPULSION has been growing rapidly, with many new talents joining the company, reinforcing the company's role as a key player of the Austrian space industry and especially within the flourishing ecosystem of the Vienna Space Hub.



Vacuum Chambers of the Engineering Department © Ben Leitner

ENPULSION GmbH

Office Park 2, 1300 Wien-Flughafen

ENPULSION Inc.

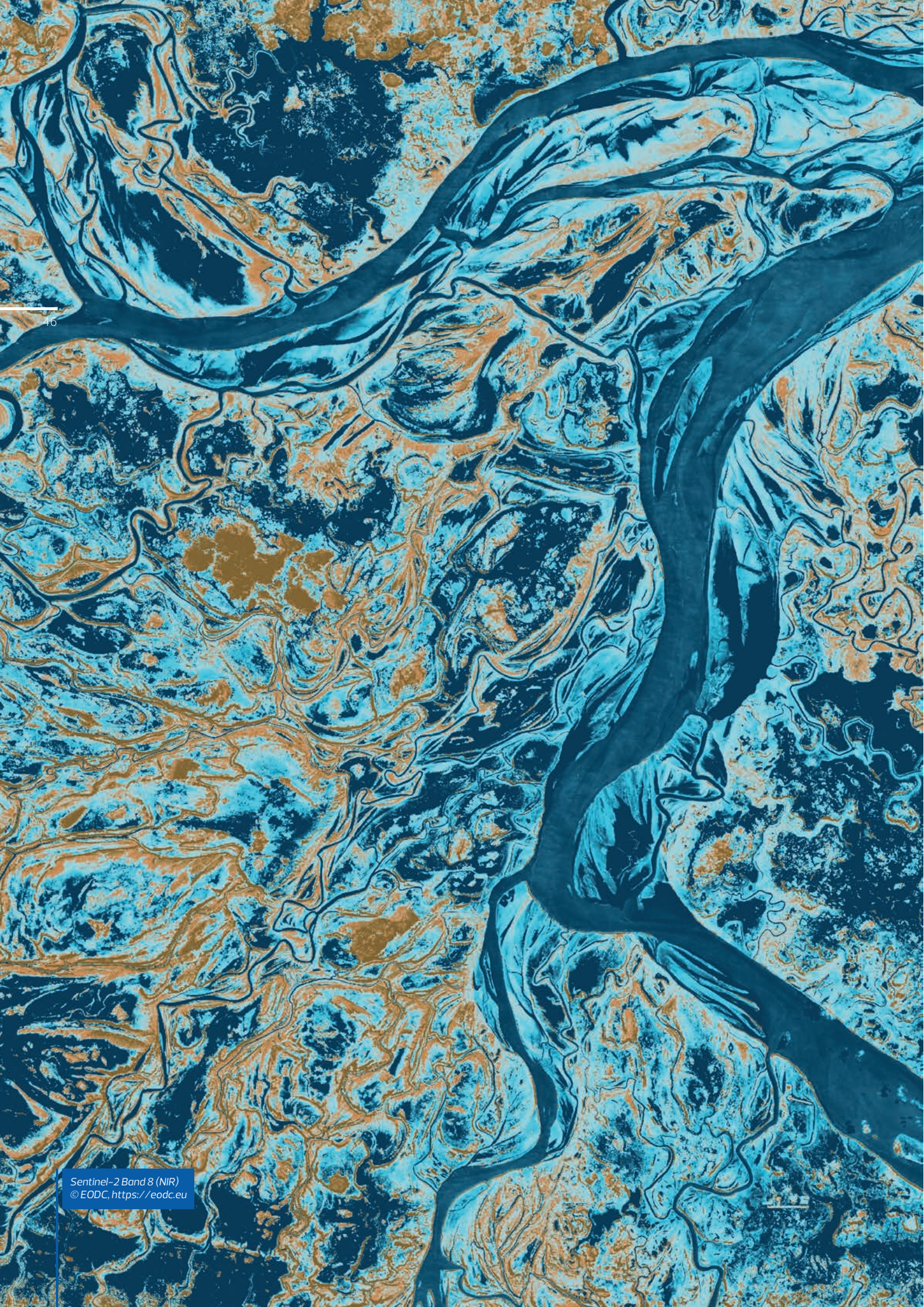
One Boston Place, Suite 2600, 201 Washington Street, Boston, MA, 02108

www.enpulsion.com

CONTACT

Martin Sarret, MSc.
Market Intelligence and Sales Strategy Manager
martin.sarret@enpulsion.com

EU Office: +43 (1) 3435400
USA Office: +1 (408) 599-3030



Sentinel-2 Band 8 (NIR)
© EODC, https://eodc.eu

EODC

Earth Observation Data Centre for Water Resources Monitoring GmbH

The EODC 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 setup 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 collocated 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 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 2024

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.

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.

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.

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.

EOPF Sentinel Zarr Samples Service

The new Earth Observation Processing Framework (EOPF) Zarr Samples Service is funded by ESA through the Copernicus Space Component programme. It aims to futureproof data from Copernicus Sentinel satellites by shifting away from machine processing and towards a cloud-based, interoperable solution. zarr.eopf.copernicus.eu

EU – Copernicus

C3S2 313c LH Service – The provision of Essential Climate Variable (ECV) Products and Services for the Land Hydrology Domain.

The service focuses on Terrestrial ECV's in the land hydrology and will operationally produce and deliver a suite of Climate Data Records (CDRs) and Intermediate Climate Data Records (ICDR) for the ECV variables of Soil Moisture, Lakes, and Terrestrial Water Storage & Groundwater.

Global Flood Monitoring (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

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.
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. www.greatproject.eu

EODC Earth Observation Data Centre for Water Resources Monitoring GmbH

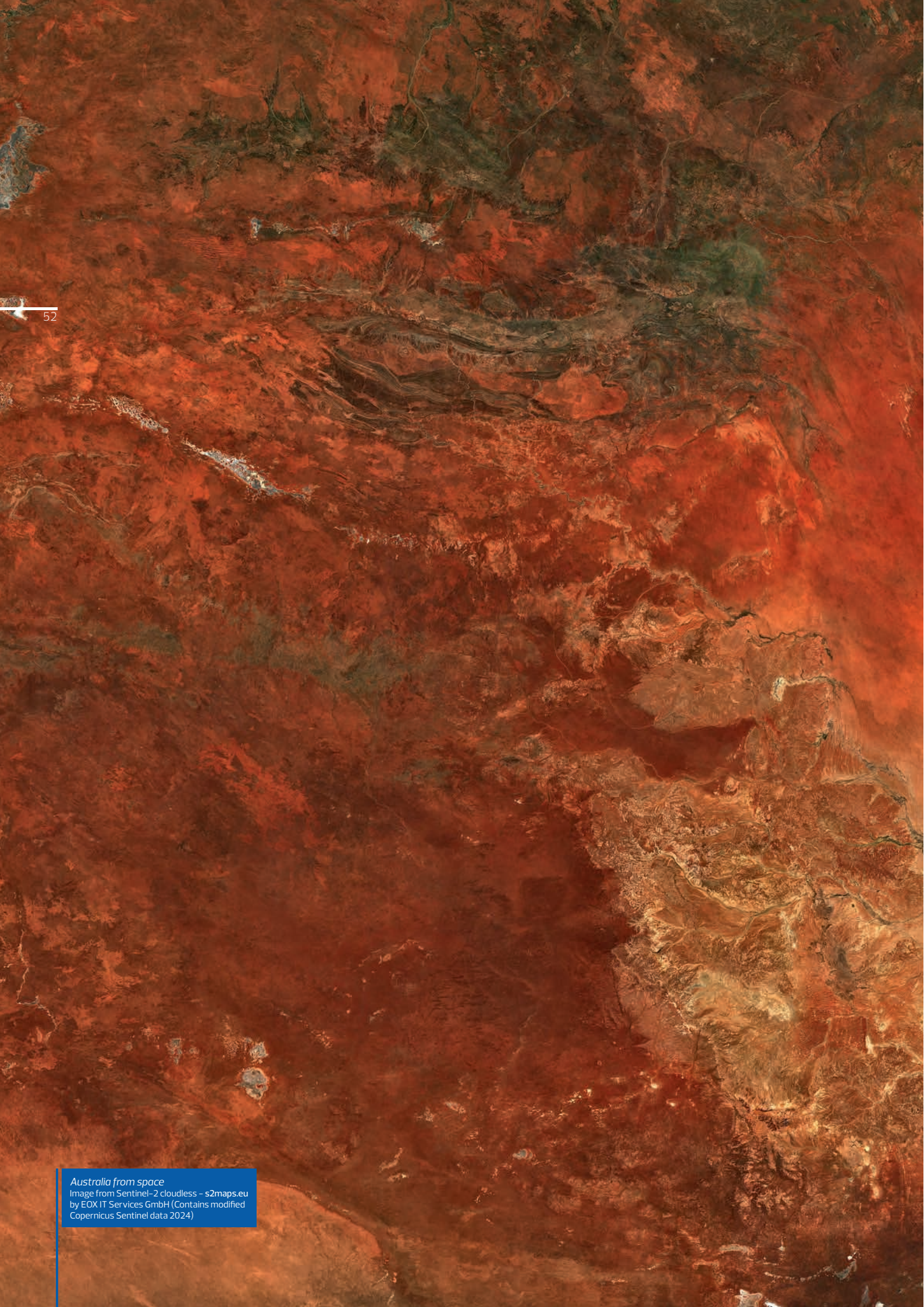
Lothringerstraße 4/1, 1040 Wien
www.eodc.eu

CONTACT
Dr. Christian Briese
office@eodc.eu
+43 699 1668 7511

FACTS

Sales:	5,0 M€
ESA Share:	514 K€

Sentinel-1C's advanced radar captures intricate details of this region, providing invaluable data for monitoring soil moisture and assessing crop health.



Australia from space
Image from Sentinel-2 cloudless – **s2maps.eu** by EOX IT Services GmbH (Contains modified Copernicus Sentinel data 2024)

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 enable people consuming 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 75 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.

EOX has a sixteen-years long record of space software projects building components of Earth Observation satellite payload ground segments. Most of them include ultra-modern 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 2024. 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 2024 presenting and demonstrating successful projects and activities at industry leading events and workshops like:

- Intergeo 2024, Stuttgart, Germany - presentation addressing challenges of handling satellite data and introducing cloud-based EOxHub platform allowing users to access, process and visualise data.
- IACS Community Exchange (ICE) 2024, Rome, Italy
- EO for Agriculture under Pressure 2024 Workshop, Frascati, Italy
- FOSS4G Europe 2024, Tallinn, Estonia – talk presenting large-scale geospatial data processing using Dask and Mapchete, highlighting their integration in EOX's infrastructure for creating cloudless satellite mosaics under the EOxCloudless product.
- FOSS4G Europe 2024, Tallinn, Estonia – presentation of the View Server software enabling cloud-native EO data access, transformation and visualisation through standardized APIs, and its deployment in systems like EOEPCA, CSCDA and AMS.

EOX at Intergeo in Stuttgard, Germany. © EOX IT Services GmbH

EOxHub Workspaces platform was re-designed and improved. It is an integrated cloud platform for ingestion, analysis and visualisation of satellite imagery and other geospatial and non-geospatial data. It is optimized for team work. EOxHub is being used in more than 15 ESA projects which proves the usefulness and capability of it. Learn more about the EOxHub workspaces on its website (hub.eox.at).

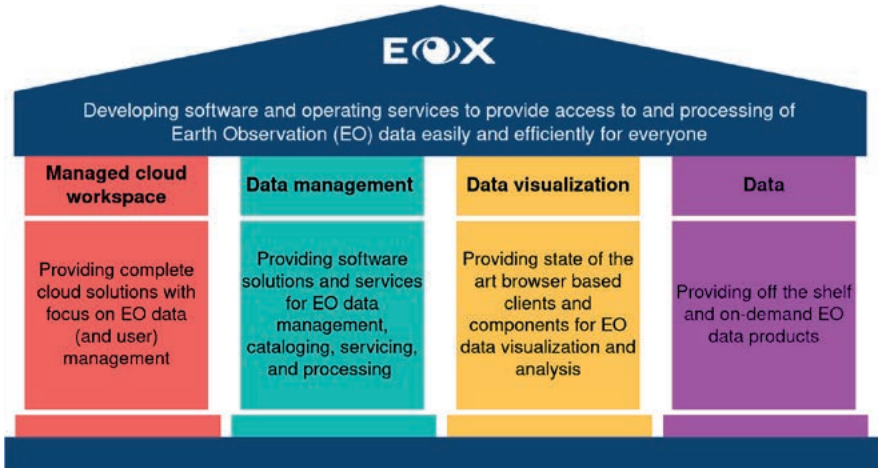
EOX creates a worldwide cloudless mosaic of satellite imagery called EOxCloudless. The source of the data are the Sentinel-2 satellites and the mosaic gets updated on an annual basis. The main improvement in the 2024 version was rewriting and fine-tuning the Bidirectional Reflectance Distribution Function (BRDF) correction. The BRDF correction adjusts satellite imagery for variations in surface reflectance caused by differences in viewing and illumination angles. This helped to substantially remove visible stripes caused by the path of the satellites.

In summary, 2024 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

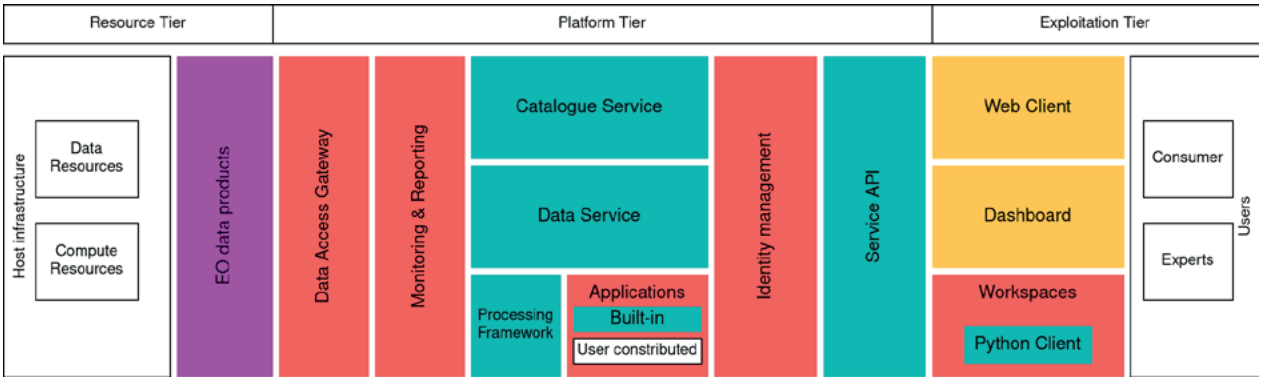
EOX is a full-stack technology provider for the handling of big data from Earth observation (EO) satellite missions. The following figure shows the 4 main technology pillars of EOX.

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.

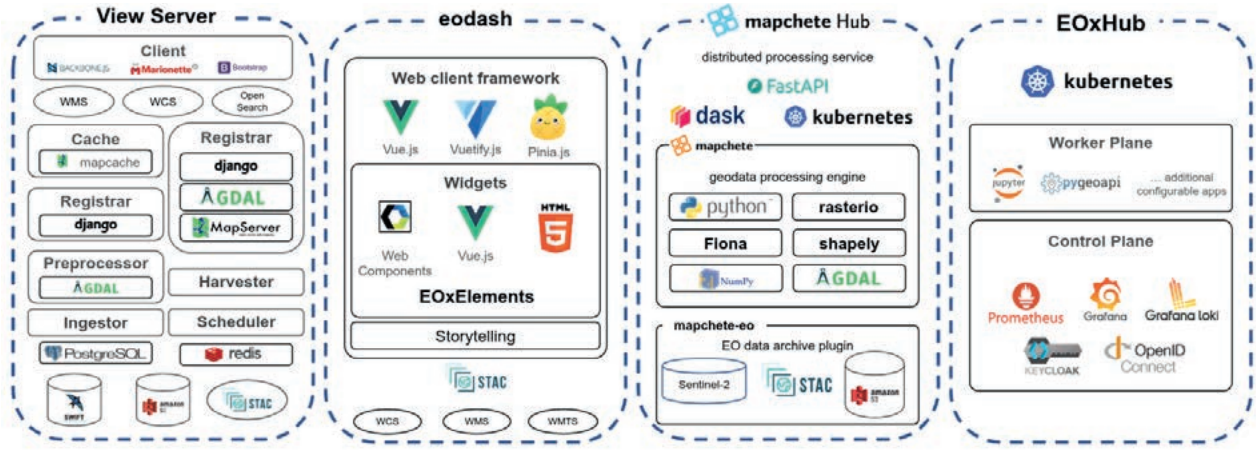


The figure shows what aspects of a complete system architecture can be covered by software modules developed and delivered by EOX.

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



Four core examples of the many software elements integrated in EOX-provided solutions © EOX IT Services GmbH

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.

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 2024.

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

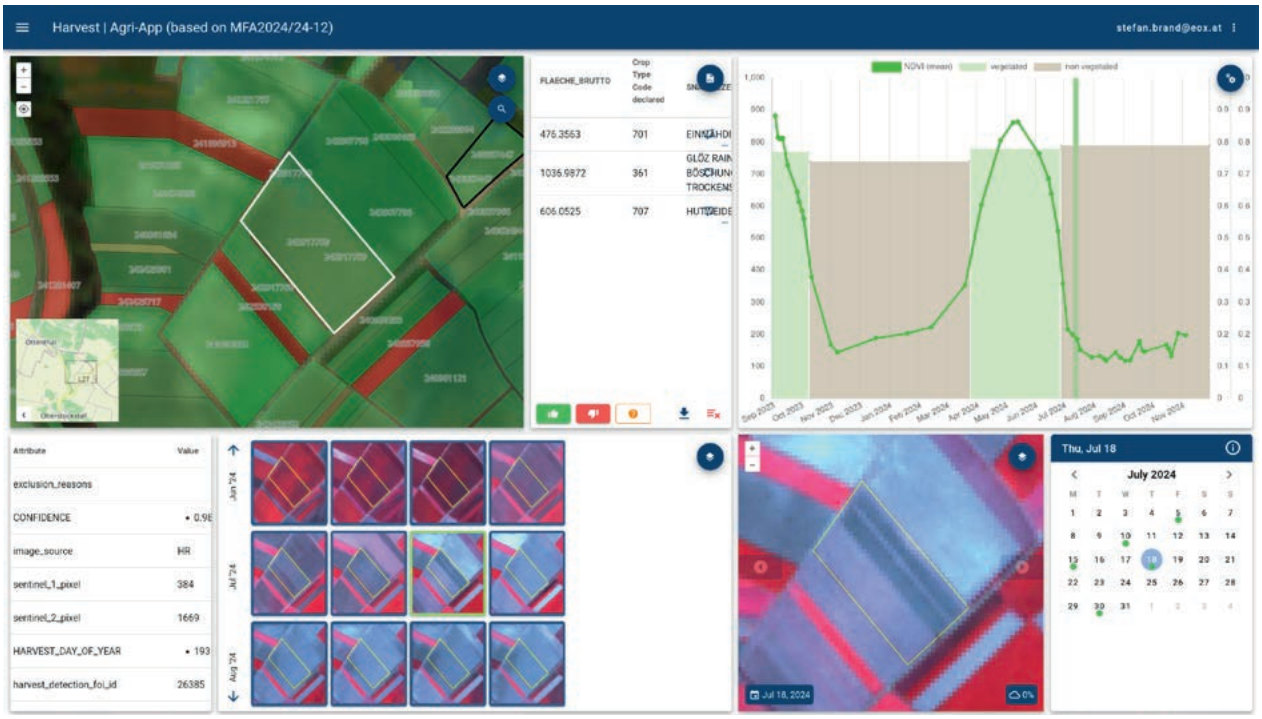
EOX offers Agricultural Area Monitoring solutions based on satellite EO data to support expert judgement and decision making compliant with the EU Common Agricultural Policy (CAP). The following figure shows the "Parcel Explorer" user interface for crop type validation which is an example from a number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

In 2024 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.



VirES – Virtual Research Environments

The family of VirES services has been operated by EOX for ESA for a decade, providing operational user services for the Earth Explorer missions Swarm and Aeolus. These services have been developed and continually improved in close contact with the scientific user community to cater for their needs. The data provided by the VirES servers are continuously synchronised with the Swarm and Aeolus mission archives. 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.

EOX IT Services GmbH

Thurngasse 8/4, 1090 Wien
eox.at

CONTACT

DI Stephan Meißl
+43 (0) 664 9688701
stephan.meissl@eox.at

FACTS

Sales: 3,49 M€
ESA Share: 1,93 M€

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

Eviden Austria GmbH

former Atos IT Solutions & Services GmbH

Eviden 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 April 2024 we were pleased to open our new Eviden Innovation Technology Center, in Prottes, Lower Austria. The Eviden Innovation Technology Center serves as a venue for collaborative projects, bringing together experts, researchers, and industry professionals. The facility will build upon SkyMon's proven track record in Satellite Tracking, Interception, Geolocation, Space Situational Awareness (SSA), Satellite Communication Situational Awareness (SCSA),

VSAT monitoring and geolocation, and various other initiatives.

The activities in 2024 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)

The satellite communications industry has evolved tremendously in the last 5 years, faster than in the 50 years beforehand. Along the rapid development of LEO constellations, the number of satellites in space has increased exponentially during the last few years. This coupled with the latest developments of next generation satellites has led to a major leap forward in the evolution of space technology, shaping the future of global connectivity and data-driven solutions. Designed for efficiency, adaptability, and high throughput, these satellites exemplify the innovative potential of digital signal processing, software-defined radios, and cloud integration. Next-generation satellites are equipped with advanced digital signal processing capabilities, often utilizing high-capacity processors that can adapt and reconfigure in real-time. They offer features like digital beamforming, interference management, and dynamic resource allocation, making them more efficient and responsive to variable demands.

Our next generation SkyMon system addresses these challenges by offering an advanced satellite monitoring solution based on a cloud-ready state-of-the-art microservice architecture on top of a high-performance generic core, allowing flexible adaptation on changing requirements with minimal risks. By incorporating artificial intelligence, big data and cloud features, Eviden makes the system more intelligent, with automated monitoring features. Seamlessly interacting with customer business applications, SkyMonNG can process data no matter where they are stored and enables to visualize and analyze metrics through a smart dashboard.

Benefits of SkyMonNG:

- **Comprehensive Carrier Monitoring and Interference Localization**
  SkyMon integrates advanced monitoring and geolocation tools into a single solution, accessible via an intuitive GUI. Operators can monitor satellite links in real-time, identify issues, and localize any type of interference without needing external applications.. With SkyMon ILS ONE, the industry's first single-satellite geolocation solution, operators can overcome traditional geolocation limitations, such as requiring two adjacent satellites or precise satellite ephemeris data.

- **Flexible Cloud-Ready Architecture Tailored to Your Needs**
  SkyMon's modular design adapts to various configurations, from single-site installations to multi-site deployments. SkyMon's microservice-based architecture allows for seamless integration with cloud environments, enabling scalable operations and reduced on-premises infrastructure requirements.

  This scalability minimizes additional hardware investments by optimizing the use of existing equipment like antennas and measurement devices. The system's multi-site capability connects ground stations worldwide, offering centralized monitoring from a single hub, accessible remotely.

- **Monitoring of next generation satellites using onboard processing**
  SkyMon supports the monitoring of the new dynamic behavior of VHTS satellites including onboard spectrum monitoring and beam hopping. The system is designed to keep operators at the forefront of modern satellite management.

- **High-Precision Technology**
  SkyMon ensures precise and reliable measurements, even for faint signals masked by noise or other signals. Automatic calibration guarantees accuracy up to ±0.2 dB, regardless of external factors like temperature fluctuations or atmospheric interference.

- **Intuitive User Experience**
  SkyMon's user interface is designed in collaboration with satellite operators, ensuring ease of use and efficiency. Operators can choose between automated background monitoring—with 24/7 operations and automatic alerts—or foreground modes for direct control and specific measurements. Customizable templates further streamline reporting tasks. A redesigned, modern frontend provides operators with fully customizable widgets and smart dashboards, making data visualization and analysis more intuitive and actionable, Built with Angular for responsive web performance, SkyMonNG adapts to any device—mobile, tablet, or desktop—ensuring a consistent user experience.

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

- **Enhanced API Integration**
  SkyMonNG offers robust APIs for seamless interaction with other business applications, enhancing operational efficiency.

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.

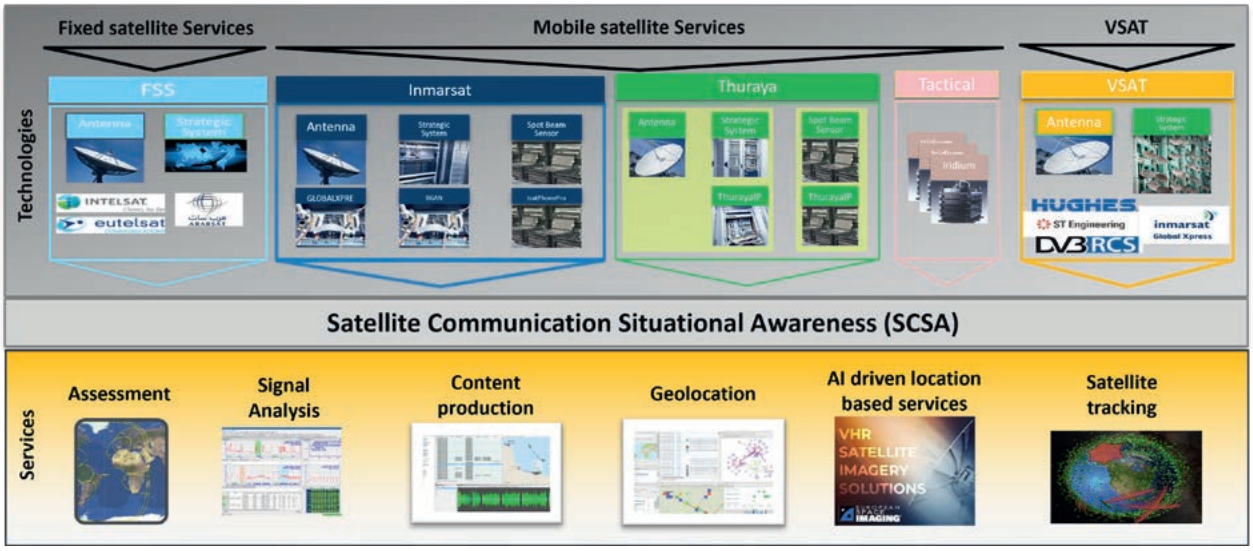
Eviden excels in mastering this critical signal intelligence environment. In Eviden we share the vision that Space will define the future of national security as any military operations rely more and more on the space domain for communication and observation.

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.

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



Overview about the SCSA portfolio.

In addition, this data can be used for

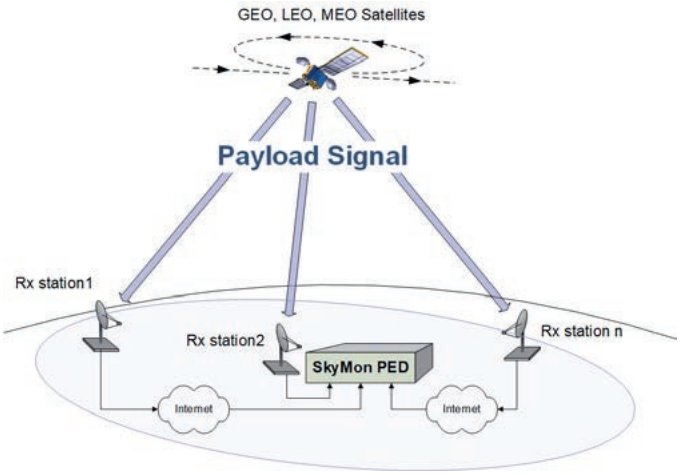
- Traditional satellite ranging activity (supporting flight dynamics operators to prepare satellite manoeuvres and calculate the state vector before/after the manoeuvre)
- Collision and interference avoidance (e.g., coordination of co-located satellites)
- Space situational awareness activity
- Remote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

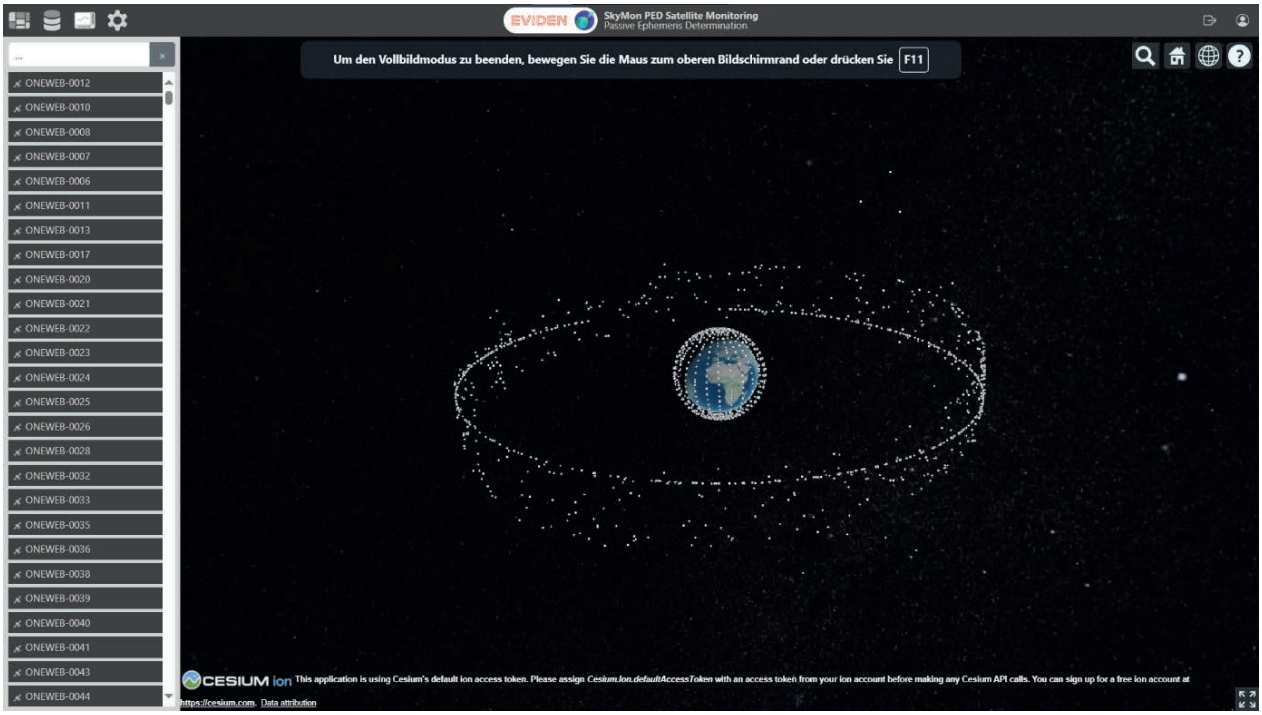
Therefore, the system will provide ephemeris data of active satellites in terms of simultaneously receiving a signal of a satellite at different places on earth (Rx-Stations) and measuring the Time Difference Of Arrival (TDOA) between each station pair (passive ranging).

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.



General architecture of STS

The result will show the calculated orbit of the satellite in a map. Below an example of the orbit visualization:



A first version of STS has been released mid of 2024.

Eviden Austria GmbH

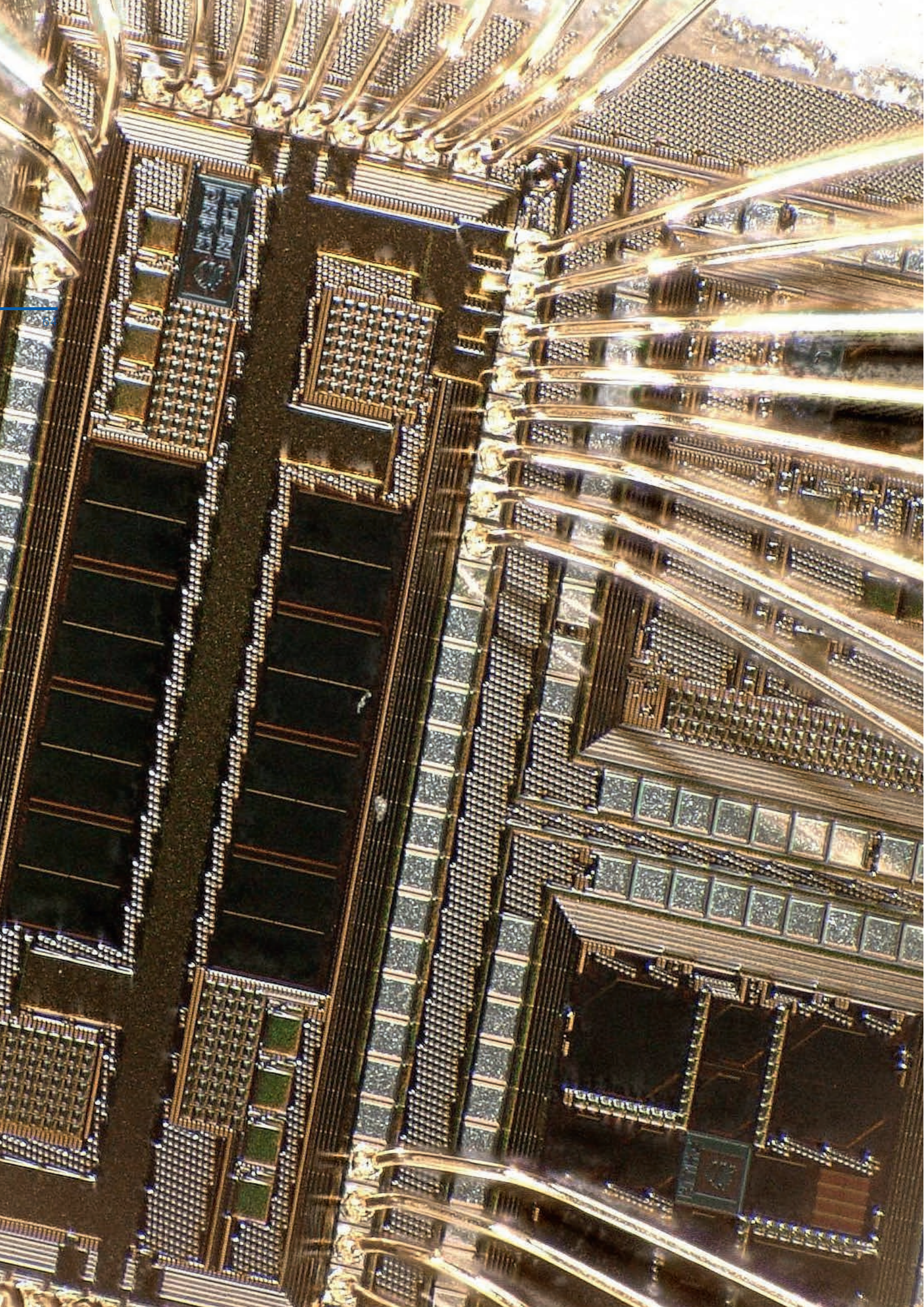
Wagramer Straße 19/Stock 16, 1220 Vienna
www.eviden.com

CONTACT

Ing. Erwin Greilinger
+43 664 88551479
erwin.greilinger@eviden.com

FACTS

Sales:	6,9 M€
ESA Share:	60 K€



Fachhochschule Wiener Neustadt GmbH

with its Forschungsgesellschaft FOTEC

Field Emission Electric Propulsion (FEEP) Technology: ECLIPSE thruster development

Building on FOTEC's FEEP heritage technology, the first prototype of the ECLIPSE thruster has been developed and tested in 2024. This thruster aims at meeting stringent requirements of long duration science and Earth observation missions, where a highly precise pointing accuracy is required for the mission success. This thruster can fit 500 grams of propellant and incorporates a focusing electrode, which is used to reducing the beam divergence, therefore reducing the losses, which eventually translate into higher thrust for lower power consumption. The thermal design is also optimized to reduce the losses.

The first thruster prototype was manufactured and tested in the large vacuum chamber in FOTEC's Aerospace Laboratory. First, a thermal characterization was done. Later, a performance test was carried out. Here, the generated thrust was precisely measured with FOTEC's thrust balance and the beam was analysed with the Faraday cup system mounted on the semi-circular arm. The results show that the thrust range of 5 to 500 µN can be achieved.

The ECLIPSE thruster firing in the large chamber during the performance test

Active Spacecraft Potential Control for CubeSats

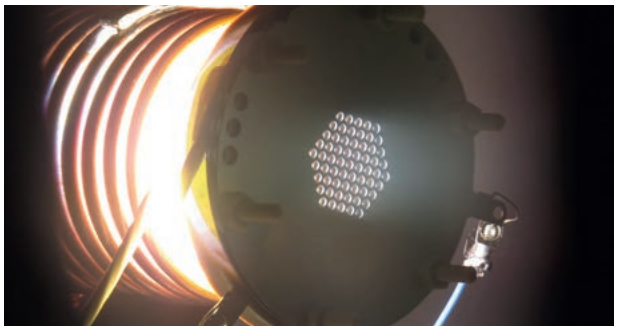
Since the 1960s, the Austrian Institute of Technology (AIT) and later together with the Space Research Institute (IWF), FOTEC has developed active spacecraft potential control (ASPOC) solutions by emitting positively charged ions. Previous missions successfully featuring FOTEC's ASPOC instruments range from GEOTAIL in 1992 up to NASA's MMS mission in 2015. Most recently, the ASPOC instrument was upgraded with respect to FOTEC's mN-FEEP (Field Emission Electric Propulsion) tech-

ASPOCube instrument mechanical design

nology, referring to the next generation of ASPOC, named ASPOC-NG, with a total mass of 1.2 kg and maximum power consumption of 2.2 W. To serve the demands of popular CubeSat and SmallSat missions, a miniaturized ASPOC instrument providing a low-mass and low-power potential control for small spacecraft is being developed within the ASPOCube project. In 2024, the focus was on design of the instrument with miniaturization of the power processing unit (PPU) and the integration and miniaturization of both an ion and electron emitter module. The PPU and emitter modules are integrated in compact design fitting in a 1U envelope. Part of the activities during the manufacturing and test preparation were already finished in 2024.

Atomic Oxygen compatibility testing

The new space industry is strongly focusing on very low earth orbits (LEO + VLEO) which are closer to the Earth surface to increase the quality of RF-communication and Earth observation. But in these orbits the high concentration of the very aggressive and corrosive atomic oxygen (ATOX) atoms can potentially damage and disintegrate oxygen sensitive materials like silver, other metals and many polymers, and strongly modify the properties of exposed surfaces. An extensive knowledge of ATOX influence on materials and surfaces is therefore necessary to determine what materials to use on satellites that fly in low orbits.



The new ATOX source shows the typical white diffuse oxygen beam during operation

FOTEC is now working on the development of a new ATOX test facility which allows not only the testing of smaller material samples, but also testing of whole satellites or mechanisms, optic systems, quantum payload and radar antennas in their 14 m^3 high vacuum chamber. This enables satellite operators to predetermine and increase the expected lifetime of their payloads and the satellite structure itself.

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 potential, 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 2024 the AM team of FOTEC focused on propulsion applications with design and manufacturing of mono- and bipropellant thruster components out of Nickel-based Hastelloy X and IN718, continued the work on shape-memory alloys for deployment mechanisms, additively manufactured porous Tungsten and Tantalum crown emitters for FEEP thrusters and in-situ resource utilization by processing Martian regolith simulant in relevant environmental conditions.

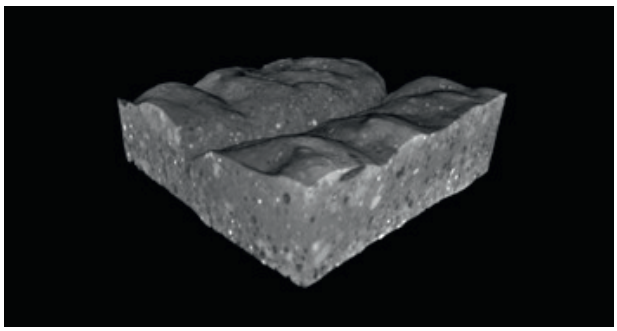
Within the additive manufacturing process and material developments, FOTEC continued with the FFG project STEPS (Stereolithographic printing of Tantalum for Electric Propulsion Systems). The main objective of this project is to investigate the use of Tantalum in combination with additive manufacturing 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 2024 the Tantalum feedstock development continued and different sintering additives and Tantalum grinding methods were investigated to achieve the required density after sintering. This task takes more time than expected, that is why the test campaign planned for 2024 was postponed to 2025. Within this campaign the performance of the additively manufactured Tantalum-based crown emitters will be determined.

Training setup for the flexible pivot and deployment mechanism made of shape-memory alloy NiTi

Within the second activity that deals with crown emitter manufacturing by using AM technologies, the ESA De-Risk study CROWN 2.0, in 2024 significant progress was made. The FOTEC team developed a Tungsten-based feedstock that fulfils the requirements in terms of mechanical integrity and density. Furthermore, the standard post-processing steps such as needle tip etching and wetting with the propellant Indium worked as planned. In 2024 single needle firing tests were performed successfully. For manufacturing a full crown emitter with 28 needles the formulation of the polymeric binder needs to be modified to ensure easier cleaning and sufficient green part strength (current polymer binder leads to insufficient cleaning and damaged samples). The team is working on this issue and plan to close this ESA De-Risk study successfully in 2025.

In 2024 FOTEC successfully closed the ESA project 4D-Printing ("Assessment of reliability of 4D printing materials due to ground/space environmental effects") together with RHP Technology GmbH and Aerospace & Advanced Composites GmbH. In total five different concepts were manufactured, trained and tested to investigate the shape-memory behavior for different applications (mainly deployment mechanisms).

In terms of space exploration, FOTEC has successfully closed the ESA OSIP activity RAMMEC (Recycling enhanced additive manufacturing processes under Martian environmental conditions). The objective of this project was the investigation of 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. Furthermore, also recycling aspects were addressed by using space-grade food packaging foil as base material for filament fabrication. A test campaign was conducted to assess the mechanical and thermal properties of Martian regolith/polymer foil mixtures and added to the material database. The main focus of the project was on the Sulfur concrete approach by mixing Martian regolith simulant with Sulfur. The gained results proof that this feedstock is a promising candidate for future exploration missions. FOTEC is preparing a follow-on activity to further develop the environmental test chamber by adding functionalities such as UV radiation and a wind tunnel.



Extrusion-based 3D-printing device processing Martian regolith simulant (left), computer tomography image of 3D-printed regolith sample (right)

FHWN

Within 2024, the university of applied sciences Wiener Neustadt (FHWN) founded the competence center for Custom Semiconductor Technology (CSCT) to host and organize funded R&D research projects with a focus on space applications. All projects focus on the development of semiconductor components, tailored to applications, which involve very specific requirements such as environmental conditions in space. In particular, research activities of 2024 are listed below.
www.fhwn.ac.at/hochschule/kompetenzzentren/custom-semiconductor-technologies

Scies4Free Phd doctoral program

Scies4Free is a cooperative doctoral program of the TU Wien the Austrian academy of sciences (OeAW) and the University of Applied Sciences Wiener Neustadt (FHWN). It complements scientific excellence in basic research with an application-oriented practical focus in the technology development. The FWF funded doctoral program started at 01.10.2025 and will last for four years.

Within the program, five PhD students are working on the development of new technologies for high precession measurements. The tailored development of an instrumentation became an integral part of research and requires a detailed knowledge of the physical theory as well as a precise understanding of the technology. In particular, two PhD projects are hosted at the FHWN and study topics in the field of space science.

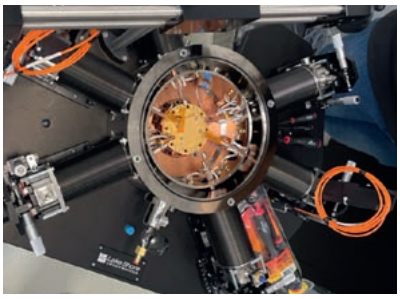
Within one PhD projects, DEPFET detectors with repetitive non-destructive readout (RNDR-DEPFET), provided by the semiconductor laboratory of the Max-Planck-society are studied for their application for direct dark matter experiments and for high precision measurements in space. Low noise DEPFET detectors without RNDR_were developed for space applications such as Bepi-Columbo or the ESA#S next large mission ATHENA. With RNDR, a deep sub-electron noise can be achieved, which enables electron number resolved measurements and thus the detection of single near infrared photons. Due to the appr. 500 µm thick depleted silicon bulk in combination with a low dark current rate, a high quantum efficiency is feasible to search for rare events. Within a second PhD project, CMOS integrated devices are designed, procured and operated to detect single photons based on avalanche processes. These elements will be coupled to a hexagonal boron nitride single photon sources, which shall be operable at room temperature. Such structures can be realized in a standard CMOS process and provide key aspects to realize quantum technology experiments in space, such as quantum key distribution (QKD). Both developments will be evaluated w.r.t. the radiation hardness.
www.tuwien.at/doc/scies4free

SEERad: Radiation damage studies

Within the FFG funded SEERad project, the capability of performing single event effects tests at MedAustron is studied and an irradiation procedure is developed. Due to the complex structure and fabrication technology of microelectronics, the characterization of SEE properties heavily relies on experimental irradiation studies. The progress in miniaturization of electronic structures, esp. fabrication processes below 100 nm results in a significantly increased sensitivity to SEE. Considering the extensive use of commercial off-the-shelf (COTS) components within the so-called "New Space" era – instead of space-grade radiation hard or -tolerant electronics – the need for those studies even increased.

Within 2024 FHWN established and leads a work package dedicated to space research in the upcoming research strategy of MedAustron. This enabled and triggered further projects and cooperation. For instant FHWN will receive samples of wide band gap materials such as SiC and GaN from a Fraunhofer institute to do a cooperative characterization and study w.r.t. radiation hardness and space application. As well in 2024, a common irradiation test together with the Max-Planck-Institute of extraterrestrial physics (MPE) was done at MedAustron in order to irradiate DEPFET detectors, representative for the ATHENA mission as well as for high precision measurements.

CryLab: A deep temperature laboratory at WN



Based on an infrastructure funding of the GFF, FHWN procured a 4K cryostat with a closed (dry) helium circulation. This device will enable the detailed study for radiation semiconductor devices as well as the development of deep temperature CMOS structures. After irradiation of semiconductors with massive particles, the lattice structure gets damage by displacing atoms from their regular lattice position. This finally results in additional energy levels within the band gap of the semiconductor. Temperatures in the range of some Kelvin will freeze out free charge carriers and are suited to activate energy levels in the band gap. Basically, the band-gap can be mapped by continuously increasing the temperature. The activated traps or defects will be characterized with correlated current (TSC) or capacity (DLTS) measurements. Although this method is well established, it needs to be further developed and studied for wide band gap materials, esp. of interest for future space applications. In addition, CMOS designs for deep-temperature applications shall be designed and evaluated. These structures are essential for future quantum technology devices, as they minimize the heat induction between conventional electronics and quantum devices, operated in the range of mK.

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.

Fachhochschule Wiener Neustadt GmbH
FOTEC Forschungs- und Technologietransfer GmbH

Johannes Gutenberg-Straße 3, 2700 Wiener Neustadt
www.fhwn.ac.at
www.fotec.at

CONTACT

Dr. Carsten Scharlemann
+43 5 04211235
carsten.scharlemann@fhwn.ac.at

FACTS

Sales:	3,8 M€
ESA Share:	2,2 M€

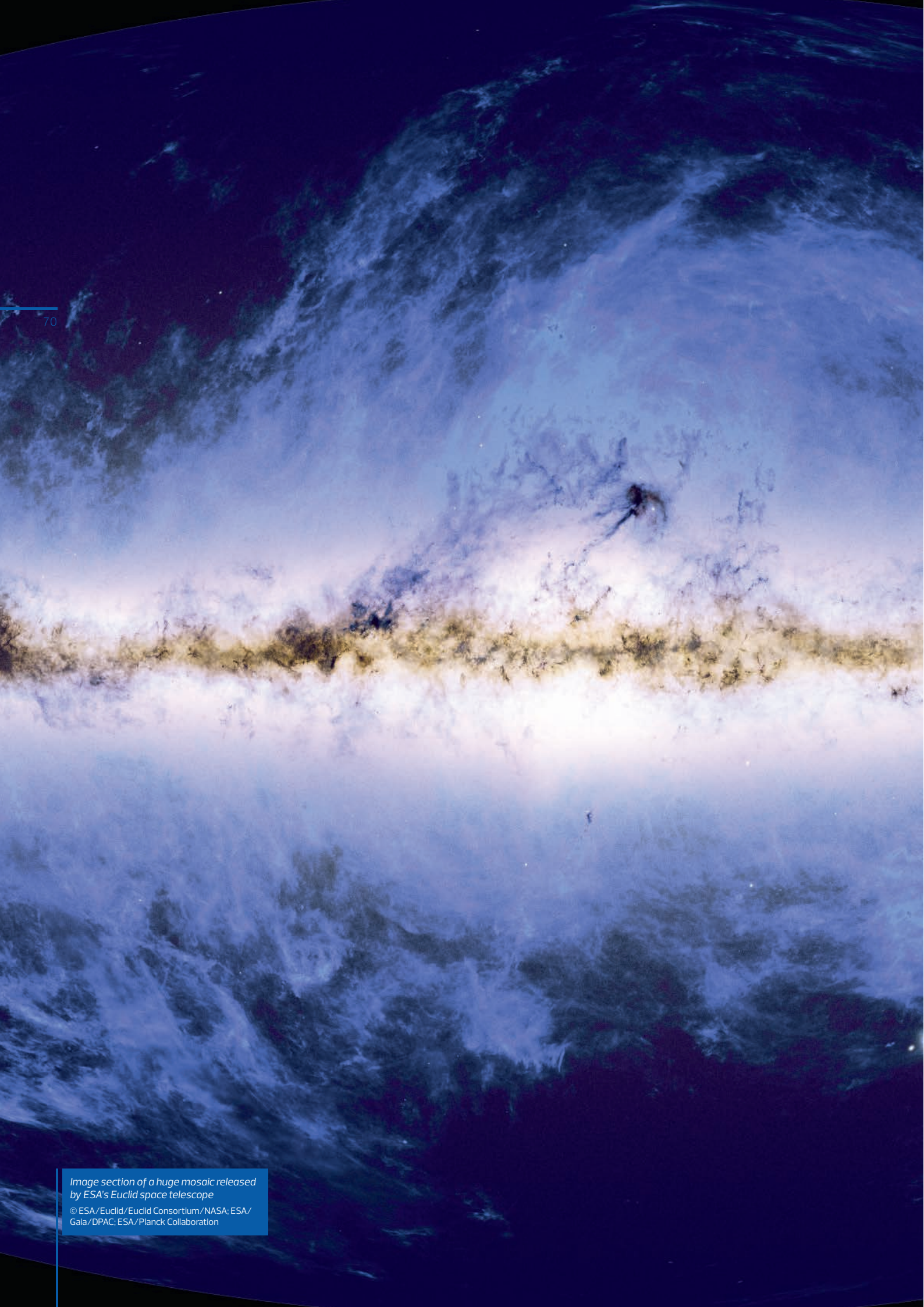


Image section of a huge mosaic released by ESA's Euclid space telescope

Fantana GmbH

High Performance Opto-Mechatronics for Space

Fantana GmbH is an Austrian company developing opto-mechatronic solutions for space and defense applications. In 2024, the company advanced its work on compact, high-performance payloads for Earth observation and remote sensing. Drawing on expertise in electronics, software, and optics, Fantana contributes to technologies that enhance performance, autonomy, and functionality in modern satellite platforms.

Optical Payloads for Earth Observation

Earth observation missions demand increasing imaging quality and onboard data handling. Fantana's systems combine optical and mechatronic design with embedded software to maintain performance under launch and in-orbit conditions. This enables reliable imaging for environmental monitoring, land-use analysis, and disaster response.

Integrated onboard software supports functions such as data filtering, compression, and analytics. By processing data directly on the satellite, Fantana's payloads reduce downlink volume and enable faster ground response.

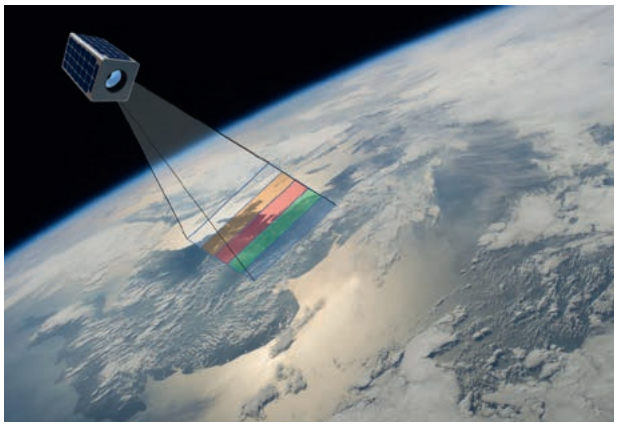


Illustration of an implemented concept for capturing multispectral satellite images. © Fantana GmbH

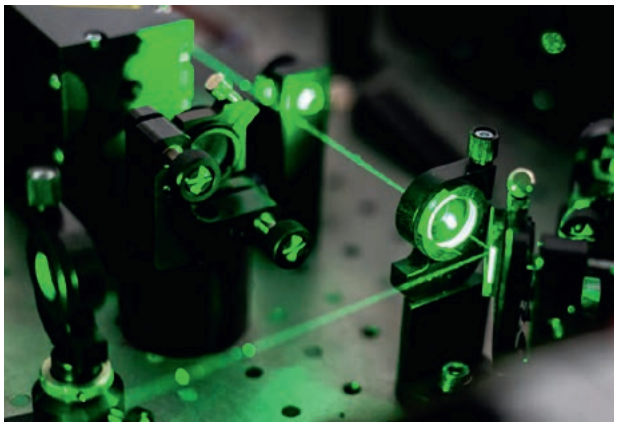
Evaluation results of a multispectral satellite image of the greater Vienna area. © Fantana GmbH

Beyond conventional imaging, Fantana is also active in developing optical sensing systems that employ laser-based techniques for atmospheric measurements—such as wind profiling from airborne or orbital platforms—broadening the company's EO capabilities.

Doppler Lidar Sensors for Velocity Measurement

Fantana's sensor portfolio now includes Doppler Lidar systems for remote velocity detection. These instruments determine motion through the frequency shift of scattered laser signals and are designed for atmospheric studies, weather monitoring, and related applications.

The systems combine laser optics, beam control, and signal processing to provide accurate, stable measurements even in demanding environments.



Optical breadboard setup for an advanced Doppler Lidar sensor system for remote velocity measurements. © Fantana GmbH

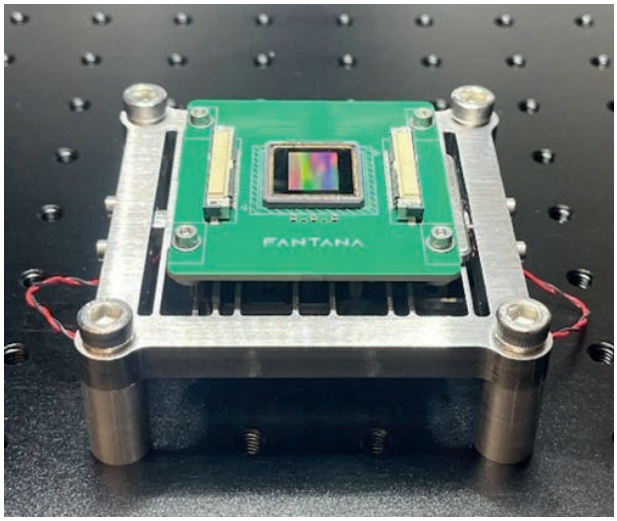
Precision Mechatronic Solutions

Fantana develops mechatronic subsystems that support optical instruments in space. These include fast steering mirrors for image stabilization, which compensate for motion and vibration, as well as piezoelectric actuators for fine positioning—offering sub-micron resolution for aligning optics or calibration targets. Such components are critical where precise, reliable movement is needed under space conditions.

On-Board Intelligence and Integrated Systems

Fantana combines mechanical, electronic, and software design to build compact, integrated systems for use on satellites. This includes custom embedded electronics that can operate under space constraints, along with software that supports autonomous functions. In some payloads, neural-network-based algorithms are used to perform basic image recognition or segmentation on board, allowing data to be pre-processed before downlink.

Recent developments have placed more focus on image processing and data reduction directly on the satellite. Advanced compression methods and classification routines help limit bandwidth usage while preserving key information content.



Opto-mechatronic motion system for high-fidelity image capture applications. © Fantana GmbH

The company's electronics have been used in several CubeSat-class missions, including power systems that remain operational in low-Earth orbit after several years. By keeping hardware and software development largely in-house, Fantana is able to ensure consistency and integration across system components. This approach supports the development of subsystems that can perform reliably and carry out mission tasks with limited ground intervention.

Key Capabilities and Strengths

- High-Resolution Optical Payloads: Design and assembly of optical instruments for remote sensing applications.
- Doppler Lidar Sensors: High-precision velocity measurement systems using frequency-shifted laser signals for wind profiling and dynamic motion analysis over long distances.
- On-Board Data Processing: Embedded systems capable of image analysis and basic decision-making functions.
- Precision Mechatronic Solutions: Custom-built mechanisms for pointing, tracking, and stabilization (e.g. fast steering mirrors, gimbals) to ensure accurate alignment of optical systems and antennas.
- Space-Proven Electronics: Power and control electronics used in small satellite platforms with demonstrated flight heritage.
- End-to-End Engineering: Development process covering design, prototyping, testing, and system integration.

Fantana GmbH

Meravigliagasse 4/1, 1060 Wien
www.fantana.at

CONTACT

Dr. Thomas Riel
riel@fantana.at
+43 650 9976443

FACTS

Sales:	0,61 M€
ESA Share:	0 M€

GATE Thruster

GATE Space Innovation GmbH

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 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.

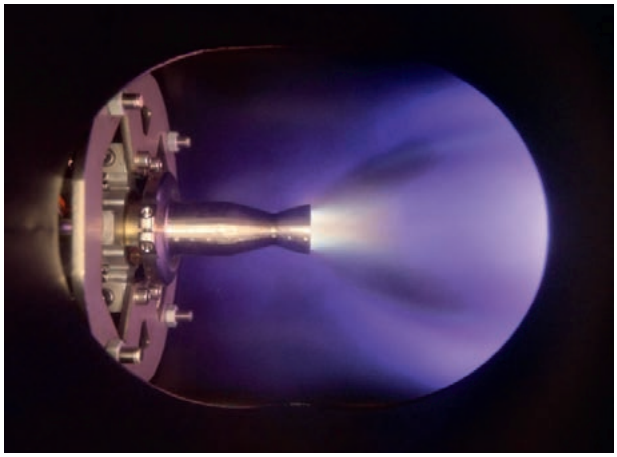
Fueled by their past successes and validation from the industry confirming the market need for innovative chemical propulsion, GATE Space was officially founded in 2022. This marked the beginning of their mission to transform the space industry with groundbreaking propulsion solutions, leveraging their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

The GATE Thruster

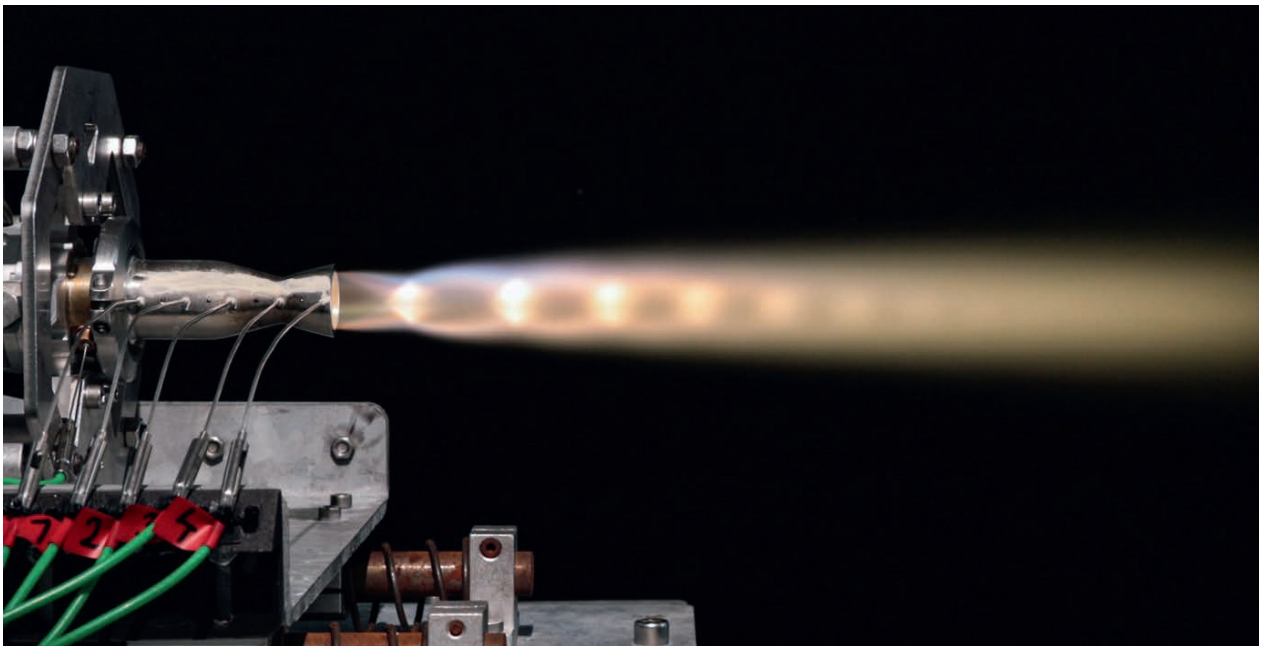
The GATE Thruster is a pioneering advancement in propulsion technology for NewSpace applications. Featuring a patented injection technology, it offers precise deep throttling capabilities at a ratio of 1:10 as the only spacecraft thruster available on the market today, granting a multitude of benefits.

A standout feature of the GATE Thruster is its ability to inherently compensate for feed system-induced pressure variations. 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 burns, the GATE Thruster enables orbit transfers, station keeping, collision avoidance



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



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

maneuvers, rendezvous and proximity operations and de-orbiting. This comes at a fraction of the price and complexity of comparable propulsion systems.

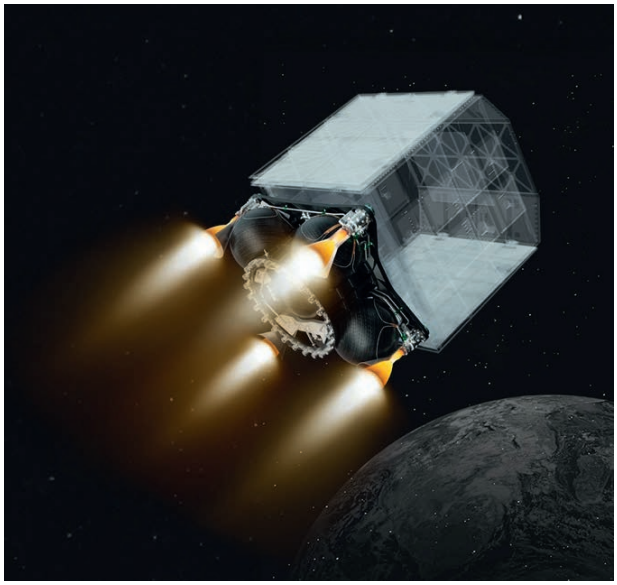
Additionally, the GATE Thruster's deep throttling capability serves as the enabling factor for differential thrust stabilization, allowing three-axis stabilized orbit transfers without additional reaction control thrusters. Apart from further reducing complexity in the propulsion system, this approach 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 oper-



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

ational 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.

Outlook

Looking ahead, GATE Space anticipates significant advancements in the coming years. Following a funding round with private investors, the award of multiple contracts by the European Space Agency (ESA) and the signing of multiple Letters of Intent (LOIs) from customers to deliver propulsion systems, GATE Space is now gearing up for 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 and make GATE Space one of a handful of European suppliers for chemical propulsion systems.

About GATE Space

GATE Space was founded in 2022 in Vienna, Austria, and is on a mission to revolutionize in-space mobility.

The company's user-friendly, plug-and-play mobility solution, the GATE Jetpack, can be implemented within less than a day and at a tenth of the cost of legacy products, allowing companies to maximize satellite revenue and prolong satellites' operational lifetimes.

Improvements to GATE Space's in-house testing infrastructure.
© GATE Space

GATE Space Innovation GmbH

Frauentorgasse 72-74, 3430 Tulln an der Donau

www.gate.space

CONTACT
Moritz Novak, MSc
CEO
+43 660 3420250
moritz.novak@gate.space

GATE Space Inc.

Two Embarcadero Center, 8th floor, 94111 San Francisco, California, USA

Landcover Dynamics 2016–2018
© Bing Satellite © Carto DB © GeoVille

GeoVille

Informationssysteme und Datenverarbeitung GmbH

GeoVille provides a wide range of value-added services derived from Earth observation data to enable GIS applications. With more than 26 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	Financial Institutions	Public Authorities	Private companies
European Environment Agency, European Space Agency, European Union, IFAD, United Nations Programmes	Asian Development Bank, European Investment Bank, EuropeAid, World Bank	Various ministries and agencies for environment, agriculture, forestry, research, water and energy commissions	Agriculture, Financial Sector, Consulting, Construction, Oil & Gas, Telecommunication, etc.

ESA Director General visits Geoville

High-Level visit led by Dr.Andreas Geisler, Head FFG-ALR (far left) and Dr.Marcus Hofer, Managing Director Standortagentur Tirol GmbH (far right).

In times of geopolitical change, space technologies are crucial not only for long-term climate and environmental protection but also for urgent security applications. The future role of the European Space Agency (ESA) and Austria's participation in it were the central topics of a meeting at the GeoVille headquarter in Innsbruck with a distinguished Tyrolean: Dr. Josef Aschbacher, ESA Director General, with representatives from the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation, and Technology (BMK), the Austrian Research Promotion Agency (FFG), Standortagentur Tirol and experts from GeoVille.
With advanced compression and streaming technologies provide by GeoVille's EarthStreamer, earth observation data will soon be as accessible as weather data, becoming a daily resource for a wide range of users—from climate researchers and corporate sustainability reporting teams to civil protection agencies and national defense authorities. The EarthStreamer technology in action was demonstrated through a live drone video data stream via Eutelsat. Users can effortlessly access and process such data streams in real time on both desktop and mobile devices in the field, without the need for complex software solutions.

Dr. Josef Aschbacher: "Here at GeoVille, satellite data is used to create digital maps and situational awareness data — for Tyrol, for Austria, for Europe, and even globally. These large volumes of satellite data can be easily compressed and accessed by anyone, everywhere on commodity devices using a so-called 'Earth Streamer.' I'm very pleased for ESA that we are involved in enabling this work."

NEW PROJECT HIGHLIGHTS

EUROPEAN SPACE AGENCY

SMART-CONNECT — Resilient connectivity during disasters

The European Space Agency's (ESA) Civil Security from Space (CSS) SMART-CONNECT project aims at the enhancement of disaster response by ensuring continuous communication during emergencies. SMART-CONNECT is closing the documented open gaps of the civil security sector through the provision of an easy-to-use solution allowing uninterrupted transmission and reception of critical situational awareness situation globally. A key component is the conneXstream middleware (connexstream) developed by GeoVille and its partners, which automatically switches between available terrestrial and satellite networks to ensure uninterrupted data flow. This system enables secure, end-to-end data exchange among citizens, first responders, disaster management centers, and situational awareness service providers, addressing bandwidth limitations that often hinder data transmission during crises.

Within the last year the competence and capabilities of SMART-CONNECT have been further expanded with the addition of **FREQUENTIS** (AT) to our core team. Together we are expanding beyond traditional narrowband Private Mobile Radio (PMR) systems like TETRA by integrating MCX (Mission Critical Communication Services) to enhance crisis communication with big-data dissemination. The goal is to ensure EO situational awareness data reaching all responders within the perimeter of action, enabling real-time video, Earth observation insights, and automatic failover for seamless connectivity. MCX Services, integrated into the SmartConnect portfolio, creates new possibilities to disseminate critical data in a secure way, making itself useful to all kinds of governmental and non-governmental actors.

Contract Value: 12.383K €

Destination Earth Streaming Service

Our DestinEStreamer service enhances the efficiency of accessing, managing, and streaming climate data on the DestinE Platform (DestinEStreamer – DestinE Platform). DestinEStreamer is using advanced technologies for compression, streaming, and data conversion to improve data handling processes. Key benefits for customers, such as the European Space Agency (ESA), include:

1. **Efficient Data Compression:** DestinEStreamer uses state-of-the-art video compression techniques, achieving compression **ratios of up to 97%** while maintaining an extremely low-**quality loss of less than 0.01%**. This leads to **significant storage savings** and more **efficient handling of large datasets**.
2. **Enhanced Data Access:** The service provides a **comprehensive API** for seamless data access and metadata retrieval, ensuring that users can easily explore and retrieve relevant datasets. This is crucial for and climate research needs.
3. **User-Friendly Interface:** The platform features an **intuitive user interface** that simplifies dataset exploration, making it accessible even for **non-technical users**, which improves overall usability and productivity. The web-application is responsive and operational for mobile and desktop on Windows, MacOS, Linux, iOS and Android.
4. **Integration with Python:** The dedicated **Python module** facilitates access to data streams and allows conversion into memory **arrays and data cubes at runtime**. This makes the service adaptable for various analysis tasks and well-suited for research environments like ESA's.
5. **Data Conversion**: The integrated data conversion module allows users to transform the compressed streams **into various target formats**, providing flexibility in handling data and ensuring compatibility with a range of systems.

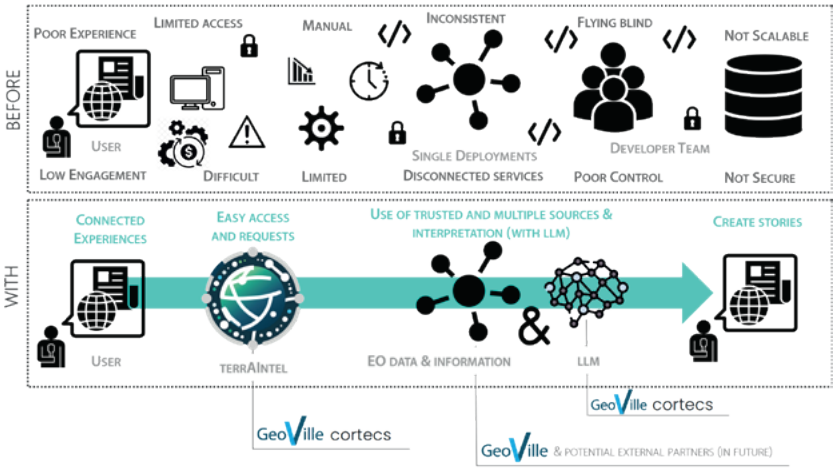
Overall, the DestinEStreamer service supports ESA by streamlining data management, reducing storage costs, and enabling fast, secure access to large and complex datasets, while providing tools for effective data exploration and analysis.

Register at: streamer.destine.eu
Contract Value: 130K € (to date)

terrAIntel: From geospatial questions to data-driven decisions

In today's rapidly evolving Earth Observation (EO) landscape, the main challenge is no longer data scarcity, but rather the complexity of transforming the hundreds of terabytes of diverse data captured daily into insights that are equally accessible and actionable for non-experts and experts alike. To meet this challenge, GeoVille, together with project partner

cortecs and supported by the European Space Agency's InCubed programme, introduces **terrAIntel**, an innovative end-to-end geospatial intelligence platform designed to democratize EO data access and interpretation, enabling users to seamlessly translate geospatial questions into data-driven decisions.



terrAIntel leverages advanced Artificial Intelligence (AI) and Natural Language Processing (NLP) technologies, empowering users to effortlessly pose geospatial queries in everyday language. This capability significantly enhances usability by converting complex EO data products into intuitive responses, complete with visualizations such as interactive maps and graphs.

Digital and investigative data journalists are the primary beneficiaries of overcoming longstanding technical barriers related to the accessibility and interpretability of EO data products. For media professionals, this translates into rapid access to ready-to-use EO-based insights, enabling richer, transparent, verified, and evidence-based storytelling on globally significant issues such as climate change, urban expansion, and sustainability – topics with broad relevance across numerous other sectors, including urban planning, disaster management, environmental monitoring, agriculture, and beyond.

terrAIntel's global early adopter community and international reach highlight GeoVille's commitment to making EO data more accessible to everyday users. By tackling the often-overlooked challenge of underutilization after initial creation, the platform enhances accessibility and user engagement, naturally promoting the reuse of existing EO data products and fostering long-term data sustainability. Building upon GeoVille's expertise, terrAIntel represents a strategic advancement that strengthens Austria's prominent position within global space innovation and further advances the global EO ecosystem.

Contract Value: 2.250K €

AUSTRIAN SPACE APPLICATION PROGRAMME

CarbComply: Towards multi-decade carbon cycle monitoring solutions supporting legal compliance with new EU regulations.

The European Commission has set ambitious climate targets to reach carbon neutrality by 2050 through the Green Deal Agenda and the European Climate Law. The policy framework which encompasses the EU Forest Strategy, EU Soil Strategy, the EU Regulation on Deforestation-Free Products (EUDR), the 2023 revision of EU LULUCF Regulation sets new requirements for public stakeholders and the private sector. A key component is the EUDR which aims to combat deforestation caused by imported goods. Starting from the end of 2024, EU companies cannot sell products originating from deforested areas, with significant penalties for violations.

CarbComply
Towards multi-decade carbon cycle monitoring solutions supporting legal compliance with new EU regulations

CarbComply seeks to develop innovative EO-based compliance evidence services, specifically focusing on above-ground biomass (AGB) and soil organic carbon (SOC) as the primary carbon storage pools, constituting over 90% of carbon content. The project aims to address the entire carbon cycle over a period exceeding 20 years, incorporating the latest advancements and datasets for a comprehensive carbon balance assessment. **CarbComply** will provide proof-of-concept for 2 prototypes:

1. a long-term, consistent, and harmonized AGB density (AGBD) time series using existing and new Copernicus mission data (i.e., BIOMASS, ROSE-L, CHIME). The methodology involves fusion methods for multiple satellite sensor data and calibration using field data.
2. CarbComply is to improve a satellite-based soil carbon modelling method, initially developed for arable land in Austria. The project will review the main drivers of soil organic carbon (SOC) changes and develop a service for continuously monitoring soil quality and SOC content in Europe. This includes the analysis of hyperspectral satellite data.

Starting December 30, 2025, the EUDR will ban products linked to deforestation in the EU. EO services provide businesses and regulators with satellite monitoring capabilities that:

- Reduce costs by limiting manual audits
- Provide precise compliance evidence
- Identify supply chain risks early
- Streamline reporting processes

Law firm **Cerha Hempel** is contributing legal expertise to ensure CarbComply's services meet regulatory standards. The EUDR itself recommends operators cross-check geolocation coordinates against satellite imagery to verify compliance.

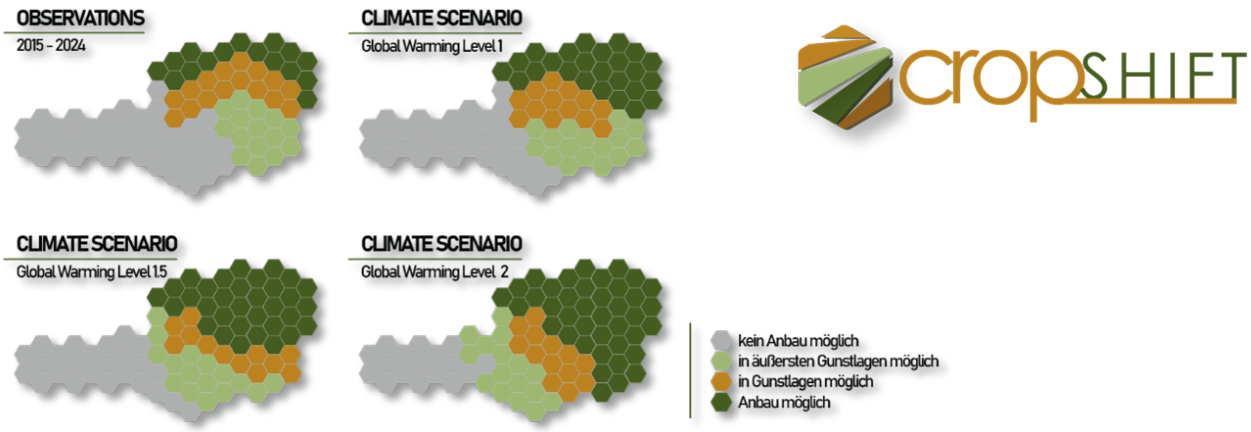
Contract Value: 682K €

FFG DIGITAL TWIN EARTH

CropShift: A service to identify climate change-induced geographical shifts of crop growing areas.

The effects of climate change—rising temperatures, altered precipitation patterns, and more frequent extreme weather events—pose significant challenges to agriculture by affecting crop phenology, suitability, and risks. As a result, some regions are becoming less viable for agriculture, while others may present new opportunities for crop production.

The CropShift project aims to deepen our understanding of how climate change impacts agricultural systems. By combining the latest climate scenarios with high-resolution data on crop-growing areas and weather-related



crop-growing parameters, CropShift identifies, quantifies, and visualizes the effects of heat and drought risks on crop growth to ultimately forecast yield reductions and changes in crop cultivation spatial patterns over the coming decades.

This service will be highly valuable to farmers as it will help raise awareness of the effects and impacts of climate change by providing up-to-date scenarios on climate-induced challenges in agriculture. It will help farmers better plan and proactively identify strategies for adapting to upcoming changes in crop growing conditions and mitigating risks. By supporting informed, strategic land-use decisions tailored to local contexts, CropShift will also promote sustainable and resilient management of agricultural resources.

Contract Value: 852K €

EUROPEAN ENVIRONMENT AGENCY

Unveiling the Hidden Landscapes: The CLMS Small Landscape Features (SLF)

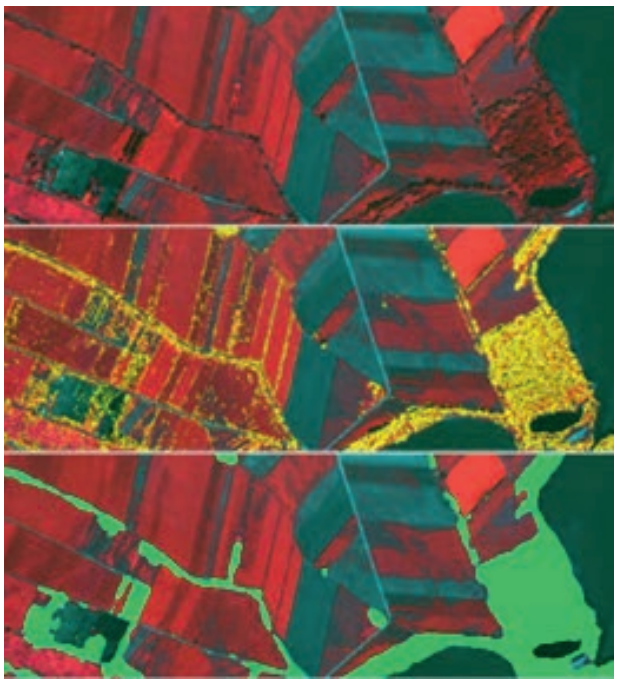
In the vast tapestry of Europe's landscapes, small woody features – hedgerows, isolated trees, and linear woodlands – often go unnoticed. Yet, these seemingly minor elements play a crucial role in biodiversity, carbon sequestration, and soil conservation. Recognising their importance, the European Environment Agency, as part of the Copernicus Land Monitoring Service (CLMS), commissioned the creation of the High-Resolution Small Landscape Features (SLF) product.

The SLF product is a triumph of advanced remote sensing and data analysis. It leverages VHR and Sentinel-2 satellite imagery, combined with sophisticated algorithms, to detect and map these subtle yet vital landscape elements. This intricate process requires meticulous calibration, verification, and validation. Datasets are currently available for 2015 and 2018, covering the EEA38 and the United Kingdom, with the next update for 2021 currently being produced.

The Small Woody Features product is well-suited to enhance our understanding of landscapes, support biodiversity and carbon sequestration assessments, inform sustainable land management practices, and aid in climate change mitigation strategies. Environmental managers and policymakers now have a powerful tool to assess the distribution and condition of these woody features, enabling targeted conservation efforts. Farmers can use it to optimise land management practices, promoting biodiversity and soil health. Researchers gain valuable insights into the ecological functions of small woody features, contributing to a deeper understanding of ecosystem dynamics.

The creation of the SLF represents a successful collaboration within the European space sector, bringing together scientific expertise and technical capabilities to develop a useful tool for environmental monitoring.

Contract Value: 4.800K €

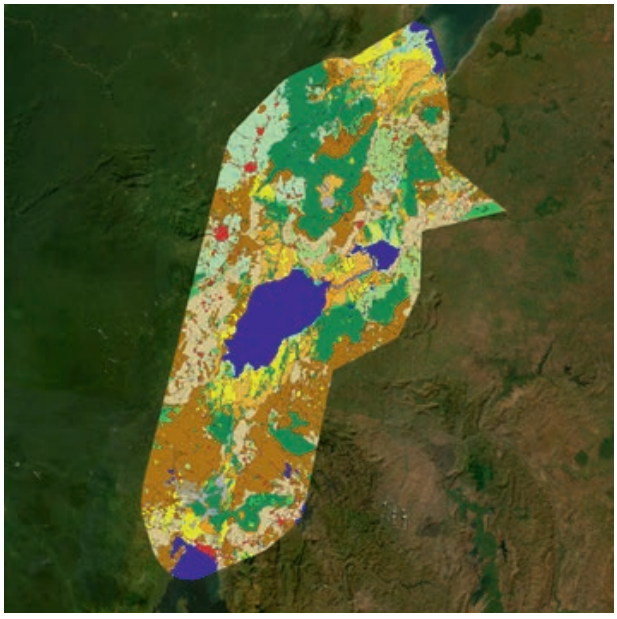


Interim classification comparison (up: VHR_IMAGE_2018, middle: SWF2018 interim classification output; down: UNet interim classification output)

JOINT RESEARCH CENTER (JRC)

High-Resolution Hot Spot Monitoring: Mapping Change, Protecting Nature

In a world where environmental changes are accelerating at an unprecedented rate, the ability to monitor and respond swiftly has never been more crucial. The High-Resolution Hot Spot Monitoring (HSM) initiative is at the forefront of this mission, harnessing cutting-edge satellite technology, to track and protect our planet's most vulnerable ecosystems.



Reference Landcover 2016 of Greater Virunga (Copernicus HotSpot Land Cover Change Explorer)

HSM focuses on delivering high-resolution land cover and land cover change products currently encompassing over 1.2 million square kilometres in different Area of Interest (AOI). These AOIs included Key Landscapes for Conservation (KLCs) and Protected Areas (PAs), primarily across the African continent. The initiative utilized very high to high-resolution satellite imagery from Sentinel-1, Sentinel 2 and ESA Third Pary Missions to produce accurate datasets, enabling stakeholders to monitor environmental changes effectively.

Building on success, the current project was launched in November 2024 with the aim of introducing near real-time land cover change alerts at a 10-meter resolution, significantly improving the timeliness and accuracy of environmental monitoring. The enhanced capabilities will allow for rapid detection of deforestation, urban expansion, and other land-use changes, facilitating prompt conservation actions.

The HSM initiative exemplifies how space-based technologies can drive innovation in environmental conservation. By providing high-quality, accessible data, HSM empowers countries worldwide to make informed decisions regarding land use and biodiversity protection. The anticipated advancements in monitoring capabilities are expected to further strengthen global efforts in preserving critical ecosystems.

In conclusion, the High-Resolution Hot Spot Monitoring initiative stands as a testament to the power of satellite technology in fostering sustainable development and strengthening its role in preserving the planet's natural heritage.

Contract Value: 7.000K €

CLMS Global Land Cover and Tropical Forest Mapping and Monitoring Service

The increasing pace of environmental change and the scale of global challenges demand reliable and timely information about Earth's surface. The new global land cover and tropical forest mapping and monitoring service (LCFM) is set to provide a significant advancement in our understanding, offering solutions to pressing needs in diverse areas.

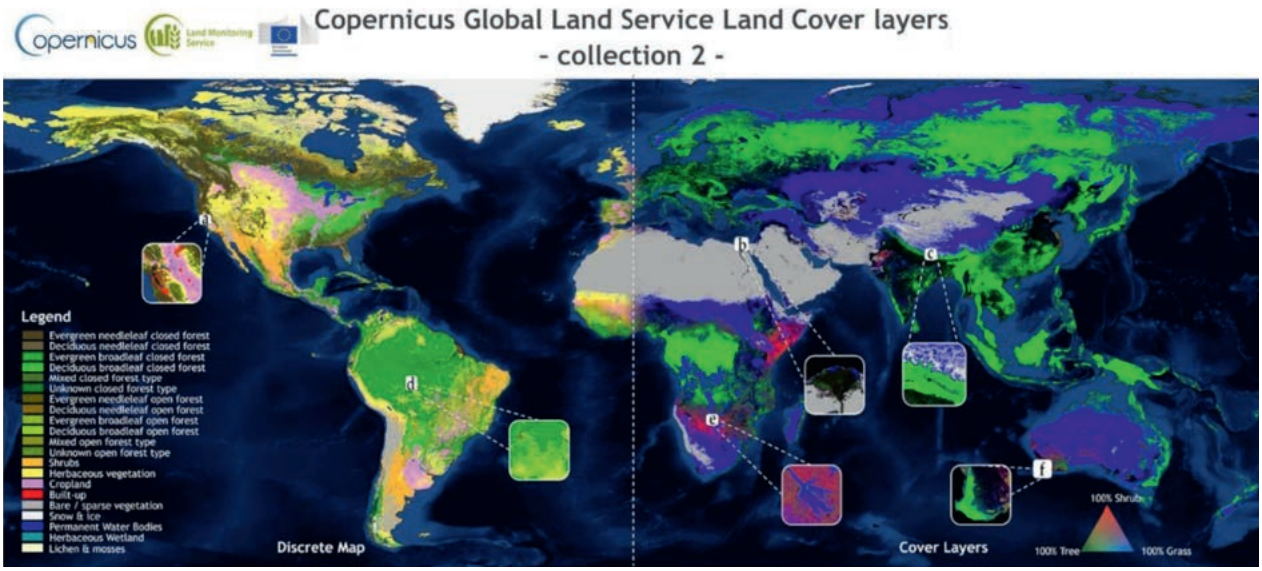
The LCFM service represents a significant advancement in global land cover monitoring. Building upon the established 100m Copernicus Global Land Cover layers, it incorporates valuable insights gained from ESA's WorldCover and the Horizon2020 REDD Copernicus projects. This integration aims to deliver a dynamic global land cover service at an enhanced 10m resolution, covering the period from 2020 to 2026.

Furthermore, the availability of reliable, timely, and consistent tree cover information is essential for supporting key policy initiatives, such as the EU Deforestation-Free Regulation (EUDR) and the REDD+ policy process. However, there are many other possible applications for this data, including:

- Tracking changes in forest cover, agricultural land use, and urban expansion to assess their impact on carbon emissions and climate patterns.
- Identifying critical habitats, monitoring habitat loss, and supporting conservation efforts.
- Providing data for informed land use planning, agricultural optimisation, and resource management.
- Mapping flood-prone areas, monitoring deforestation that can lead to landslides, and assessing the impact of natural disasters.

LCFM will generate frequent, sub-annual land surface categorisations and land cover characteristics in 110m resolution, which will then be consolidated into comprehensive global annual land cover maps and 10m resolution tropical forest monitoring products.

Contract Value: 11.300K €



Copernicus Global LCFM for 2015. Left: The discrete map with 23 classes, right: Colour composite of 3 cover fraction layers (R: Shrubland cover fraction, G: Tree cover fraction, B: Herbaceous cover fraction)

COMMERCIAL SERVICES

Area Monitoring System (AMS) for Austria and Wallonia

Since 2023, GeoVille, in collaboration with EOX, has successfully operated the Area Monitoring System (AMS) for Agrarmarkt Austria as part of the European Union's Common Agricultural Policy (CAP). This satellite-based monitoring system ensures compliance by regularly observing nearly three million agricultural parcels and detecting key land-use activities and farming practices.

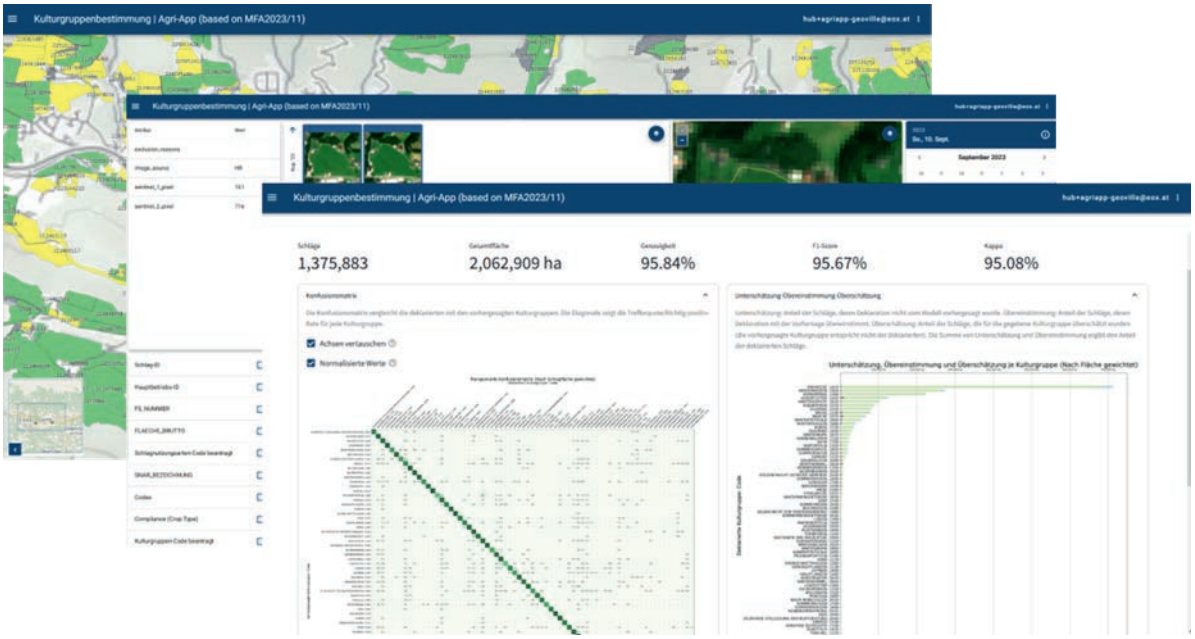
Using advanced Earth observation technology, AMS identifies main crop types, monitors mowing and harvest events, detects cover cropping, tracks soil sealing, and assesses other agricultural practices. This enables authorities to efficiently verify compliance with CAP regulations, reducing the need for time-consuming on-site in-

spections.

With two full seasons completed and the third year about to begin, GeoVille, with its partner EOX, has proven its effectiveness and scalability. For Agrarmarkt Austria, the Area Monitoring System reduces the need for manual field visits, and Austrian farmers benefit from longer application deadlines.

''With two full seasons completed and the third year about to begin, the AMS has proven its effectiveness and scalability. For AMA, the AMS reduces the need for manual field visits, and Austrian farmers benefit from longer application submission deadlines.'' (Bernhard Eder, Agrarmarkt Austria)

The success of our operation has led to its expansion beyond Austria. Implementation is now underway in Wallonia, Belgium, for the local Paying Agency Organisme Payeur de Wallonie OPW.

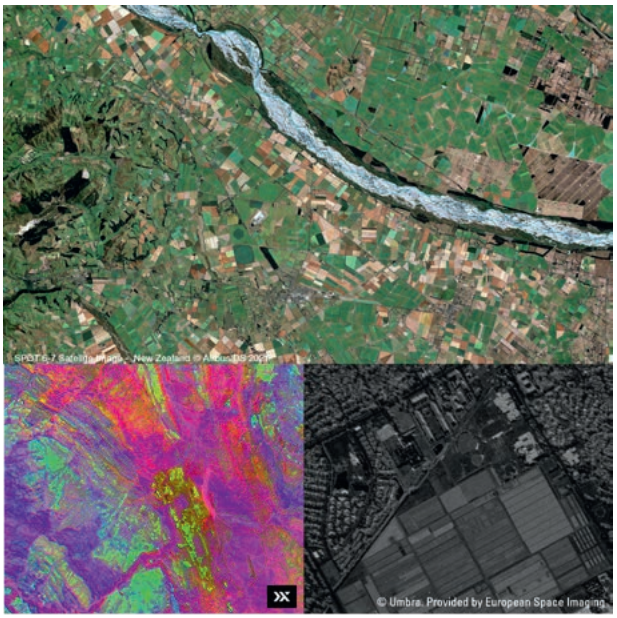


Contract Value: Commercial in confidence

Central access to commercial satellite data – Archive imagery and satellite tasking

GeoVille is in the unique position to offer access to almost all commercial Earth Observation satellites, enabling the freedom to provide truly fit-for-purpose data at highest quality or cost efficiencies. This includes access to internationally available archive data as well as regular and specialized tasking assignments with various customizable options such as maximum cloud cover, low incident angle etc. The satellites offer a high revisit rate and allow frequent monitoring of land cover, environmental phenomena and emergency situations. Thereby, GeoVille provides a single access point to global satellite operators and supports and guides customers to find a truly fit-for-purpose and cost-efficient solution to their enquiries.

Our portfolio covers optical, hyperspectral, radar as well as elevation data, offering geometric resolutions starting from 15cm. The data is suitable for various applications, from a thematic point of view (environmental monitoring, urban planning, emergency management etc.) as well as regarding the level of information, from precise image analysis and feature extraction towards regional and national scale applications. GeoVille has successfully provided data for several environmental applications such as forest management, impact analysis after windthrow events, snow height measurements, and radar data for detecting mowing events.



Martin Ulz, palos GmbH „GeoVille's experience in acquiring and analysing satellite data has helped us in recent years to provide our forestry customers with an additional basis for decision-making. This enables them to make well-founded decisions in the face of climate change, increasing calamities and changing utilisation requirements. Our partner's decades of expertise, combined with the knowledge and technological capabilities of our software solutions, will significantly advance digitalisation in the forest and ensure a sustainable forest for our customers."

Contract Value: Commercial in confidence

GeoVille Information Systems and Data Processing GmbH

Sparkassenplatz 2, 6020 Innsbruck
www.geoville.com

CONTACT

Dr. Christian Hoffmann
+43(0)512 562021-0
info@geoville.com

FACTS

Sales:	12,5 M€
ESA Share:	5,1 M€

MORE INFO

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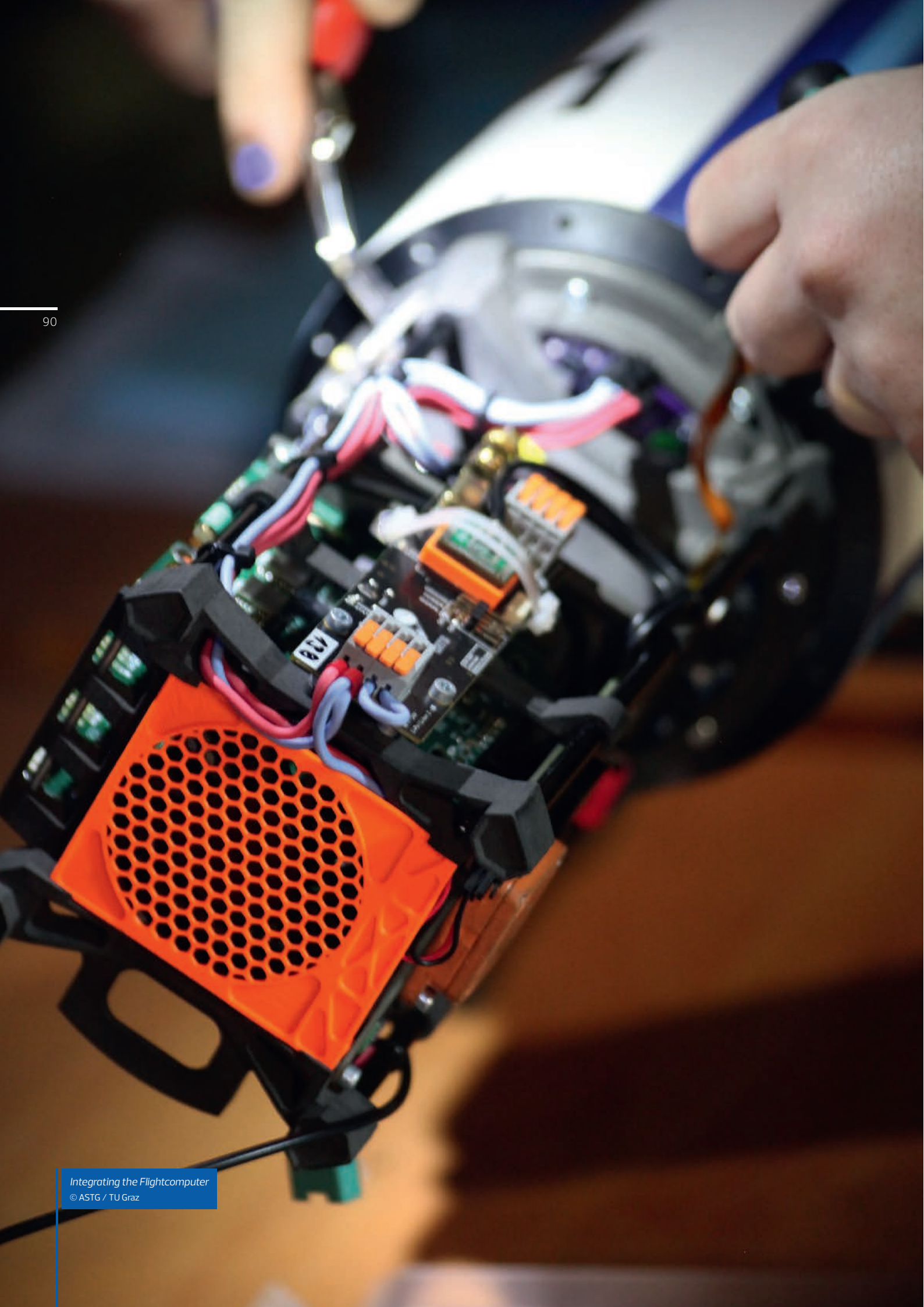


Integrating the Flightcomputer

Graz University of Technology

Technische Universität Graz

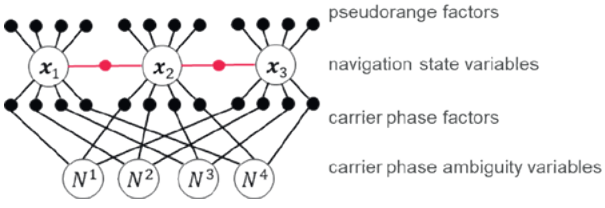
Institute of Geodesy / Working Group Navigation

Factor Graph Optimization for GNSS-based PNT determination

The Working Group Navigation at the Institute of Geodesy of the Graz University of Technology is contributing to the ESA NAVISP Element 1 project FaGO, which explores the use of Factor Graph Optimization (FGO) for GNSS-based navigation. FGO is a modern estimation technique that has demonstrated superior performance over conventional methods like the Extended Kalman Filter, particularly in challenging GNSS environments. While well-established in robotics applications such as SLAM, its use in GNSS positioning is still emerging and FaGO aims to shed light on the recent success.

Unlike traditional approaches that estimate positions recursively, FGO models the entire trajectory as a graph of variable nodes and factor nodes, allowing it to consider all available information at once. This big picture approach improves accuracy and robustness, even when GNSS measurements are deteriorated due to the environment. The graph-based model also enables efficient solutions to the resulting large-scale optimization problems and supports incremental smoothing, which makes FGO suitable for real-time applications.

In FaGO, this technique is applied to Single Point Positioning, Precise Point Positioning, and Real-Time Kinematics. For each method, tailored graph models are developed to strike a balance between trajectory quality and computational performance. The models are further strengthened with additional constraints from inertial measurements. A key innovation in the project is the integration of Galileo High Accuracy Service (HAS) data into the Precise Point Positioning implementation, allowing for high-precision positioning based on emerging European infrastructure.



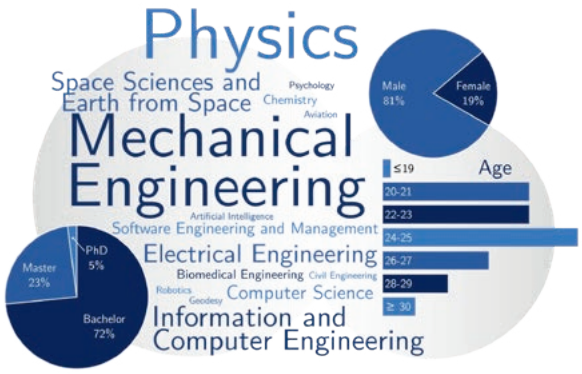
Example: Precise Point Positioning modelled as a Factor Graph. Variable nodes correspond to the unknowns and factor nodes correspond to the observations. Edges show the dependencies between variables and nodes. © TU Graz

To validate the performance of FGO in real-world conditions, FaGO includes a thorough benchmarking campaign. Results will be compared against both commercial-off-the-shelf GNSS receivers and reference Extended Kalman Filter implementation, using data from dedicated field campaigns and public datasets. This will offer a clear assessment of FGO's practical benefits in terms of positioning quality and computational efficiency.

The FaGO project is led by OHB Austria, with the Working Group Navigation contributing with their expertise in Factor Graph Optimization, geodetic estimation theory, sensor fusion and GNSS data processing.

Aerospace Team Graz

The Aerospace Team Graz (ASTG), founded in 2019, is an interdisciplinary association in Graz, made up of and lead entirely by students. Our overall aim is to provide students with the opportunity to gain practical experience in the aerospace sector. We achieve this by designing, manufacturing and operating rockets on an annual basis as part of the European Rocketry Challenge (EuRoC). We were able to score overall victory at EuRoC in 2023. In the meantime, we have also started to develop scientific experiments as payloads for sounding rockets.



Project Alcedo

The project started in late 2023. Alcedo was the first ASTG rocket with the aim to compete in the highest altitude category at EuRoC; 9000 meters above ground. To reach this altitude, we developed a new hybrid rocket engine based on HTPB as solid fuel and nitrous oxide (N2O) as oxidizer. The Engine provides a maximum thrust of 4.4 kN over a burn duration of 9 s. For higher precision in reaching the target apogee accurately, an airbrake can be deployed automatically mid-flight. To ensure a safe landing, we designed a fully redundant dual-deployment recovery system with a two-parachute design. For communication, Alcedo uses Bidirectional wireless link with a transmitting power of 1 W in combination with a self-developed antenna system. The latter consists of three patch-antenna rings on the rocket shell, one GNSS ring for location tracking and two 2.4 GHz rings for data and command transmission.

Alcedo's launch at EuRoC 2024 © ASTG / TU Graz

With our performance at EuRoC 2024, we earned:

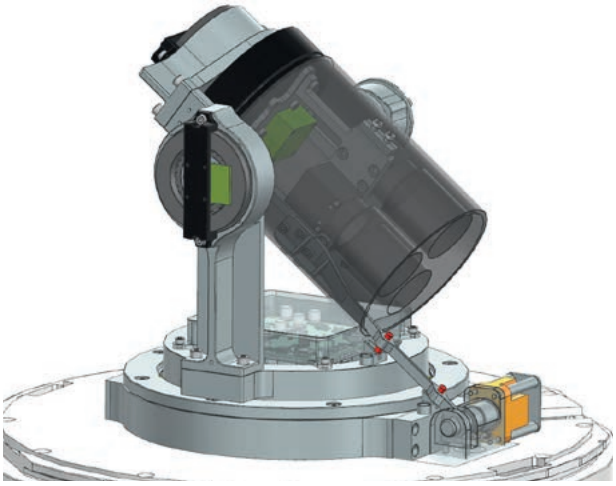
- The H9 Flight Award, granted to the best performing hybrid engine rocket with a target apogee of 9km.
- Design Award for the most coherent technical concept of the overall system and flight vehicle.
- The Technical Award, honoring the technical documentation effort of the team.

Consistency across all categories resulted in 2nd place for us in the overall ranking.

Project APEX

APEX (Auroral Polarization Explorer) has been under development since 2023. Its goal is to observe the aurora borealis from an altitude of about 80km, minimizing atmospheric interference. From there, measurements of the auroras' polarization state will be made.

This measurement has not been performed from near space by any experiment to date. With APEX, we hope to finally shed some light on the discrepancy between theoretical models and previous measurements.



The APEX CAD Model © ASTG / TU Graz

We are developing a 3-axis gimbal mount to stabilize our imaging instruments with. The imaging itself will be done by industrial machine vision cameras with on-chip polarization filters. The individual cameras will be tuned towards the expected emission lines, 557 nm and 630 nm respectively.

For this, we participate in the REXUS/BEXUS program by the Swedish Space Agency (SNSA), the German Space Agency (DLR) and the European Space Agency (ESA) Education Office. In late 2024, a delegation of the APEX team presented the project in front of the program panel at the selection workshop at ESA ESTEC in Noordwijk, Netherlands. Following the event, APEX got accepted into the program and listed for flight RX35 of REXUS cycle 16 in March 2026.

Graz University of Technology

Inffeldgasse 12, 8010 Graz
www.tugraz.at

CONTACT
Prof. Dr. Franz Teschl
Dean of Studies for Space Sciences
and Earth from Space
+43 316 873 7447
franz.teschl@tugraz.at

Institute of Geodesy

Steyrergasse 30, 8010 Graz
www.ifg.tugraz.at

CONTACT
Univ.-Prof. Dr. Philipp Berglez
Institute of Geodesy / Working Group Navigation
+43 316 873 6830
pberglez@tugraz.at

Aerospace Team Graz

Inffeldgasse 16b, 8010 Graz
www.astg.at

CONTACT
Manuel Mathias Maurer
President of ASTG
info@astg.at

Mars Rover Perseverance / Mastcam-Z

JOANNEUM RESEARCH Forschungsgesellschaft mbH

DIGITAL – Institute for Digital Technologies

JOANNEUM RESEARCH has been committed to space science, research, and technology development since 1978. The Institute for Digital Technologies (DIGITAL) specializes in the following key 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 renowned technology development partner, actively contributing to projects funded by the European Space Agency (ESA), the European Union, the space industry, research institutions, and international space agencies such as NASA, ASI, and DLR. Its expertise spans cooperative technology development, from prototype creation to commercial products. Notable achievements include a forest damage monitoring service, a satellite channel emulator, a satellite signal monitor, and vision-based navigation with 3D reconstruction for planetary surface exploration. Developed systems undergo rigorous validation and optimization in field trials, ensuring a strong scientific or commercial potential.

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 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 used worldwide. 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. The following two sample activities highlight innovative applications of satellite technologies. The AI-ACM Experiments on Alphasat demonstrate how satellite communication links in the high-frequency Q/V-band can be optimized.

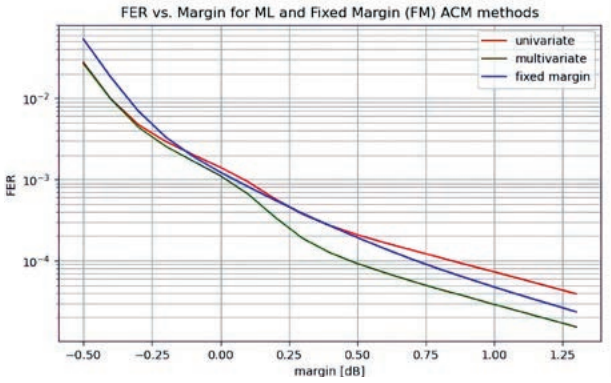
Meanwhile, ESERCOM-D explores how satellite navigation can contribute to more sustainable road usage, offering new possibilities for eco-friendly transportation solutions.

AI-ACM Experiments on Alphasat

The project focuses on optimizing Adaptive Coding and Modulation (ACM) for satellite communication in the Q/V band using machine learning methods. The goal is to improve the efficiency of ACM by better predicting signal-to-noise ratio (SNR) fluctuations and optimizing adaptive adjustments. To achieve this, classical ACM algorithms with fixed modulation and coding thresholds are compared with two machine-learning (ML)-based approaches: a univariate and a multivariate model.

For the development and validation of these methods, an extensive dataset was used, collected over a period of two years at the ground station in Graz, Austria. These measurements are based on the Alphasat TDP5 Aldo Paraboni Q/V-band transponder system. Compared to lower frequency bands, the Q/V band experiences stronger signal attenuation due to atmospheric effects such as rain, making precise predictions crucial for optimal data transmission.

A key component of the project is the implementation of an ML-based prediction model using the XGBoost architecture. While the univariate model only uses the SNR time series as input, the multivariate model integrates additional parameters such as LDPC iterations, symbol error rate (SER), and ModCod, which can be directly measured from the modem. This allows for a more accurate estimation of channel conditions without relying on direct SNR measurements. The results show that the multivariate model reduces the frame error rate (FER) while increasing spectral efficiency. Particularly during phases of strong signal attenuation caused by atmospheric disturbances, the model minimizes data loss by making early adjustments to modulation and coding. Figure 1 illustrates the relationship between the frame error rate (FER) and the chosen modulation margin, demonstrating that the ML-based multivariate model achieves a lower error rate with a smaller safety margin compared to conventional methods. This leads to more efficient use of available bandwidth and a 3.6% increase in spectral efficiency compared to fixed ACM thresholds.



Relationship between frame error rate (FER) and margin for the classical fixed-margin ACM, the univariate, and the multivariate ML-based prediction model.

Another advantage of the developed system is that it is trained on pre-collected data and can then be used for real-time predictions. This significantly reduces computational effort in practical applications, facilitating integration into existing satellite modems. This method offers a promising alternative to classical ACM strategies and represents an important step towards intelligent, ML-supported satellite communication.

ESERCOM-D – EGNSS enabled Standardized European Road Condition Monitoring and Distribution

Road infrastructure management is a growing challenge, with increasing demands for sustainability, efficiency, and cost-effectiveness. ESERCOM-D sees itself in the pioneering role of addressing these challenges through innovative technological advancements and a strong focus on standardization. ESERCOM-D is designed to enhance road wear monitoring and decision-making, ensuring smarter and more sustainable road usage. The project integrates advanced sensor systems and European GNSS (EGNSS)-based localization technologies to improve road maintenance strategies and secure road usage while aligning with international standards, enabling better long-term infrastructure planning and cost savings.

The focus of this project is the usage of the Galileo services HAS (High Accuracy Service) and OSNMA (Open Service Navigation Message Authentication) for two different use cases. Use Case 1 deals with the wear-map con-

Symbol photo with JR recording platform

tent provision. Therefore, road sensing service providers survey the road surface using EGNSS/INS for geo-referencing. The data is provided to a road wear data management platform where AI-based algorithms automatically detect, classify, and geo-reference road wear. The result is a road wear map, which will be integrated into the road operator's digital twin. The road damages in the map include information about the type of road damage, the severity, and the time of detection. In addition, the road wear information will be provided to drivers via standardized messages and RSUs (road-side units, C-ITS communication) to increase road safety. Use Case 2 handles the GNSS-correction data provision to road users and road vehicles. The idea of this use case is that automated vehicles have cm-level position accuracy by receiving GNSS correction data (Galileo HAS, RTK, and OSNMA data) via RSUs on motorways and an AMQP broker using cellular communication in rural areas. This approach significantly reduces the number of users for RTK or HAS data providers, which could not handle millions of direct connections via cellular communication like it is state-of-the-art. Knowing the exact location of road damage and its position, the vehicle can drive safer by applying a road damage avoidance maneuver. In addition to the technical challenges, the project focuses on finding and applying appropriate standards for the interfaces between the system's components. If gaps in standardization are detected, standardization bodies are approached to discuss the findings and possible solutions.

The project ESERCOM-D (https://esercomd.eu) was started in October 2024 and will last for three years. The consortium consists of JOANNEUM RESEARCH (prime), Finnish Geospatial Research Institute, Politecnico di Milano, Virtual Vehicle, University of Applied Sciences Upper Austria, ASFINAG, Enide, MoTeRe and Evolit. ESERCOM-D has received funding from the European Union Agency for the Space Programme under the European Union's Horizon Europe Framework Programme, grant agreement No 101180176.

Space Robotics Vision / Space Science & Exploration

The DIGITAL Space Robotics & Instruments Team (SRI), 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, conduction and publication of planetary science, field trials' involvement and data handling, AI, and visualization.

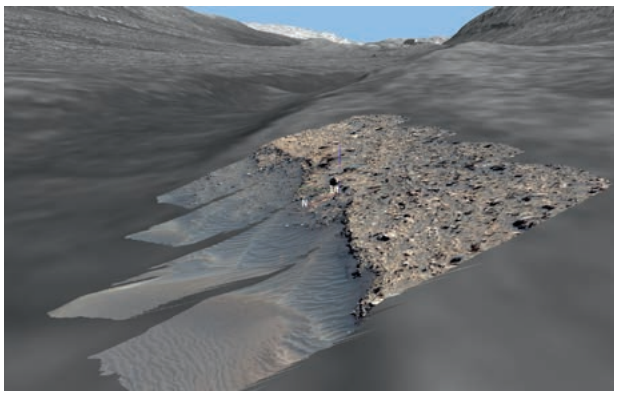
Mars 2020 Mastcam-Z 3D Vision

The NASA Mars 2020 Perseverance Rover mission landed on Mars on 18th February 2021 and carries Mastcam-Z, a stereoscopic zoomable multispectral camera coordinated by Arizona State University. Gerhard Paar from JOANNEUM RESEARCH (JR) is one of about a dozen international Mastcam-Z Co-Investigators (Co-Is), with Austrian collaborators from JR, and VRVis (Dr. Christoph Traxler and Team), and three collaborators from Imperial College London.

Mastcam-Z 3D Vision, (ASAP funded activity Mars-3D & Mars-4D) continued to cover 3D vision building blocks (3D vision processing PRoViP and visualization – PRo3D, see Figure), 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. The Austrian team (JR, VRVis and ÖAW), embedded in daily operations, 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 youtube.com/@pro3dspace120/videos. As an example, the 10 sample tubes as dropped by Perseverance in the so-called "Three Forks" region were documented in position and pose in a publication for the 10th international conference of Mars, see www.hou.usra.edu/meetings/tenthmars2024/eposter/3188.pdf.

MSL-3D

The Mars Science Laboratory (MSL) rover Curiosity landed in Gale crater, Mars, in 2012, with the overall goal of characterising its habitability. MSL in 2023 began its fourth extended mission ("EM4"), and the proposal for the forthcoming "EM5" is presently under review. MSL-3D is enabling researchers to accurately reconstruct and study in 3D rock outcrops essential to understanding ancient surface conditions within Gale crater, providing insight to ancient Martian climate and potential habitability.

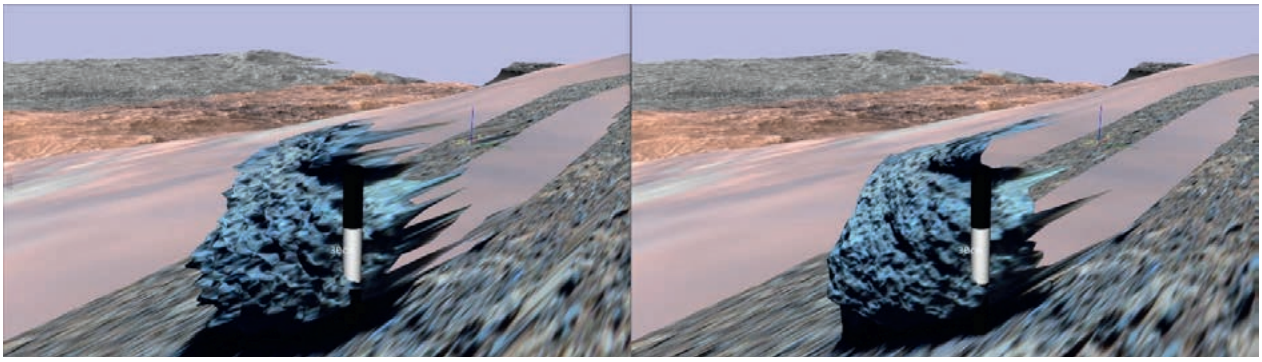


PRo3D superimposition of JR's PRoViP 3D stereo processing product of MSL Mastcam Scene 105383 of MSL Sol (Martian Day) 4102, looking towards the southern end of Gediz Vallis Ridge, onto the HiRISE (Mars Reconnaissance Satellite camera) Digital Terrain Model to verify a Mastcam calibration refinement result. © NASA/JPL-CalTech/MSSS/JR/VRVis

The ASAP Project "MSL-3D" is supporting the main scientific agenda of two UK scientists (Dr. Davis and Dr. Banham from Imperial College London) utilizing JR's and VRVis' assets for 3D vision processing and visualization for the purpose of geology on Mars. The Mars Rover Curiosity's Mastcam stereo imagery is processed to analyse late-stage surface flow events and reconstruct paleo-environments along Curiosity's traverse. This work is fully integrated into the mission, with occasional presentations and observation requests for the Mastcam instrument dedicated to Dr. Davis's and Dr. Banham's research, in collaboration with Gerhard Paar from JOANNEUM RESEARCH, a member of the MSL Science Team.

Further unique strengths of the Austrian JR/VRVis processing & visualization expertise are enhancing the geometric Mastcam calibration, and assemble mission history in a geologic and outreach sense by means of annotated video documentation in a fidelity never seen before, making use of multi-scale 3D models from Planetary Data System (PDS)-released MSL data products, long baseline stereo configurations, and data fusion with satellite terrain models. Novel added-value aspects that can be easily established with the gained MSL infrastructure access and new 3D vision & visualization assets fostered already collaboration with other teams from the UK and USA.

AI-Mars-3D



Comparison between regular stereo 3D vision product (left) and its AI-enhanced version (right), using the AI-Mars-3D-stemming prototype of JR's PRoViP planetary vision processing pipeline, displayed within VRVis' PRo3D viewer. The strength of the AI enhancement algorithm in particular sets in at medium-to-larger distances (for microstructures from about 20m, as in the displayed case). © NASA/JPL-CalTech/MSSS/ASU/USGS/JR/VRVis

The ASAP-funded AI-Mars-3D project, in collaboration between JOANNEUM RESEARCH, VRVis, the two Austrian industry partners SLR Engineering and Dibit Messtechnik GmbH, as well as UK partner SAIIL leverages advanced Artificial Intelligence (AI) 3D vision processing methods to enhance 3D models from satellite and rover imaging. The project aims to:

1. develop and validate high-resolution 3D models that outperform existing methods, and
2. ensure these AI-enhanced techniques are reliable for scientific research.

By using close-range rover images as a ground truth database, the project seeks to boost AI acceptance in planetary exploration and extend these methods to terrestrial applications like tunnelling and traffic monitoring, in collaboration with industrial partners to assess commercial viability.

In 2024, use cases and requirements from all consortium members were consolidated and summarized regarding space and terrestrial scenarios as well as 3D-vision use cases and necessary functional updates to processing (PRoViP) and visualization (PRo3D). Large portions of satellite data sets in the Mars 2020 and MSL landing sites Jezero and Gale Crater, respectively, were converted into much higher resolution both in 2D and 3D, and a prototype for substantial quality and resolution enhancement of Rover-based stereo image products was implemented. This component is presently under test in the frame of JR / VRVis' contribution to the Mars 2020 and MSL rover missions with highly promising results (See Figure) which are also in investigation for their use in industrial environment (tunnel construction and traffic monitoring domains).

DIGITAL-IVA-SRI Outlook for 2025-2027

The participation in the Mars 2020 mission with 3D vision data processing and visualization for the Mastcam-Z instrument will go on with JR and VRVis at least until mid 2025 in the frame of the joint ASAP contract "Mars-4D", emphasizing on integrating ground penetrating radar Rimfax data, fostering scientific papers jointly with the Mars 2020 science team, and enhancing camera calibration and therewith 3D vision processing products. The inclusion of AI-enhanced stereo processing is planned as well.

Light bridging and testing for ExoMars PanCam 3D vision and visualization will continue until 2027 in the ASAP "Rosalind-3D" activity, with clear emphasis on supporting the forthcoming Mini Simulations early in 2026 and the preparations thereto. Further activities in industrial frame are planned in the support of Rover Operations Control tactical 3D vision processing software and camera calibration.

Regular processing for the Mastcam instrument on board the MSL Rover Curiosity with envisaged high-level pub-

lications will continue in ASAP MSL-3D until mid 2025 with an intention to propose a continuation until mid 2027, in collaboration with scientists from the UK and USA, respectively.

The scientific processing and visualization / 3D-GIS contributions for the Hera 3D vision framework will be deployed and tested in verification of nominal 3D GIS operations using data from the successful Hera Mars fly-by in March 2025. AI-Mars-3D will undergo its main validation phase such that the elaborated mechanisms are available in JR / VRVis' mission contributions to Mars 2020, MSL, ExoMars and also Hera.

Remote Sensing & Geoinformation

The research group "Remote Sensing and Geoinformation" develops solutions and products for environmental monitoring, safety-related monitoring and mobile, multi-sensor data collection and analysis. A R&D focus in 2024 was on developing Earth Observation based monitoring systems for national and Copernicus services by exploiting AI-based solutions and time series analysis for image segmentation and analysis. We carried out related research activities under national FFG contracts, ESA contracts, EEA contracts or as Horizon Europe projects. In the following, we exemplarily present developments and results from Horizon Europe project EvoLand.

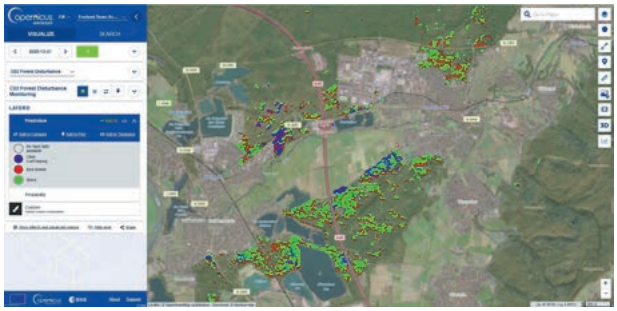
Evolution of the Copernicus Land Monitoring Service

Horizon Europe project EvoLand develops and tests new and innovative methods and rolls out 11 candidate prototypes in support of the evolution of the Copernicus Land Monitoring Service. It integrates novel Earth Observation, in-situ data and the latest Machine Learning techniques to continuously monitor the status, dynamics and biomass of the land surface. The project focuses on five key thematic domains: agriculture, forest, water, urban, and general land cover.

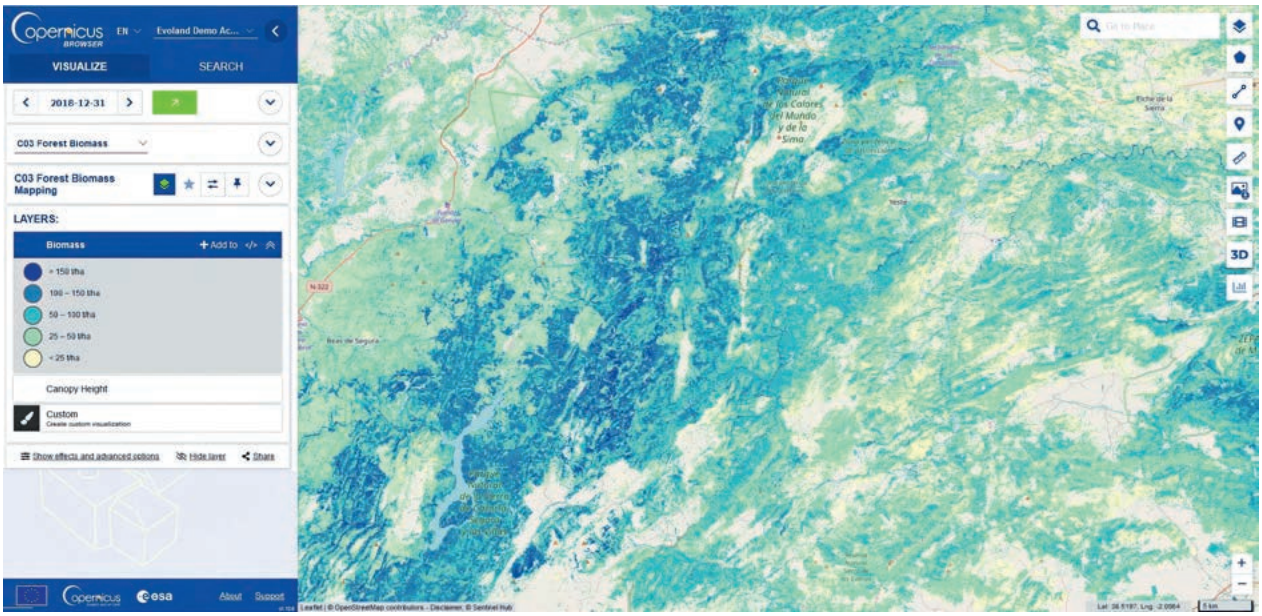
JOANNEUM RESEARCH leads the algorithm developments on continuous forest monitoring, improved forest disturbance mapping and forest biomass mapping. The goal of the forest disturbance mapping is to identify main disturbance agents at sites of identified forest change – e.g. biotic agents such as bark beetles and abiotic agents, such as forest fires and storm damage. For this goal, innovative AI/ML methods are combined with in-situ reference datasets on forest disturbance for model training. At selected test sites, we generate candidate prototypes together with partner GAF AG that map forest disturbances and analyse patterns and trends in disturbance size, frequency and change severity. The forest biomass candidate service aims to complement the HRL VLCC portfolio with spatiotemporally consistent estimates of above-ground woody biomass (AGB) and forest canopy height (FCH). The project's first phase demonstrated the potential of using satellite time series and reference data from national forest inventories and from space-borne LiDAR to map AGB and FCH. The next phase will focus on multi-annual consistent estimates to assess forest ecosystem dynamics. Radar data, like L-band ALOS PALSAR, improves mapping quality due to better canopy penetration.

Learn more at: www.evo-land.eu

Continuous Forest Monitoring Candidate (www.evo-land.eu)



Forest Disturbance Monitoring Candidate (www.evo-land.eu)



Forest Biomass Candidate (www.evo-land.eu)

JOANNEUM RESEARCH Forschungsgesellschaft mbH

DIGITAL – Institute for Digital Technologies
Steyrergasse 17, 8010 Graz
www.joanneum.at

FACTS

Sales: 3,5 M€
ESA Share: 1,6 M€

CONTACT

DI Michael Schmidt
Coordination of the Space Business Area
+43 316 876 1311
michael.schmidt@joanneum.at

Communications & Navigation Technologies:
DI Dr. Michael Schönhuber
Head of Research Group
+43 316 876 2511
michael.schoenhuber@joanneum.at

Space Robotics & Instruments:
DI Gerhard Paar
Intelligent Vision Applications
+43 316 876 1716
gerhard.paar@joanneum.at

Remote Sensing & Geoinformation:
Mag. Janik Deutscher
Head of Research Group
+43 316 876 1776
janik.deutscher@joanneum.at

NASA's Space Launch System (SLS) rocket at Kennedy Space Center in Florida.

Magna Steyr Fahrzeugtechnik GmbH & Co KG

Division Aerospace

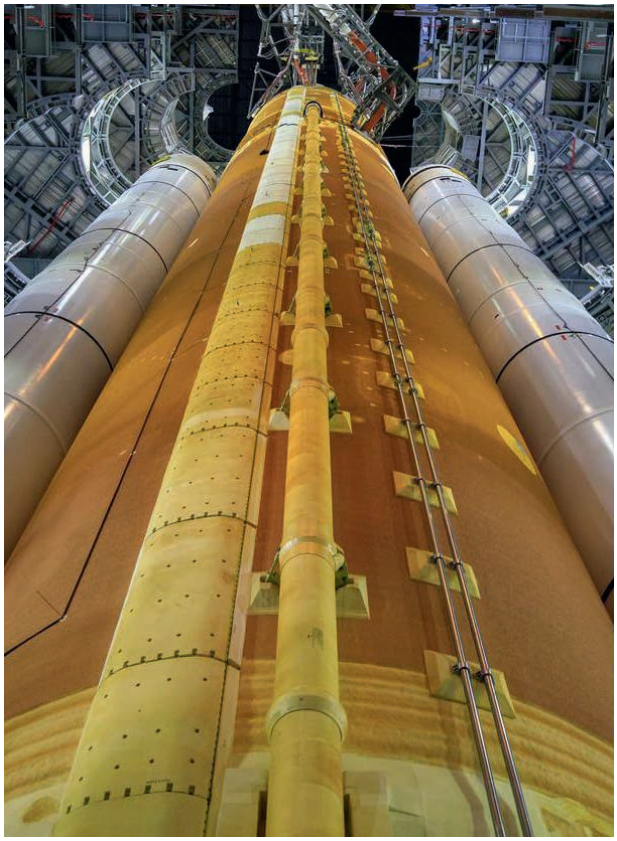
SLS (Space Launch System) Propulsion Systems Lines and Flexible Joints

The Space Launch System and the evolving configuration of this unique super heavy-lift rocket is NASA's backbone for the return of human to the Moon and deep space exploration.

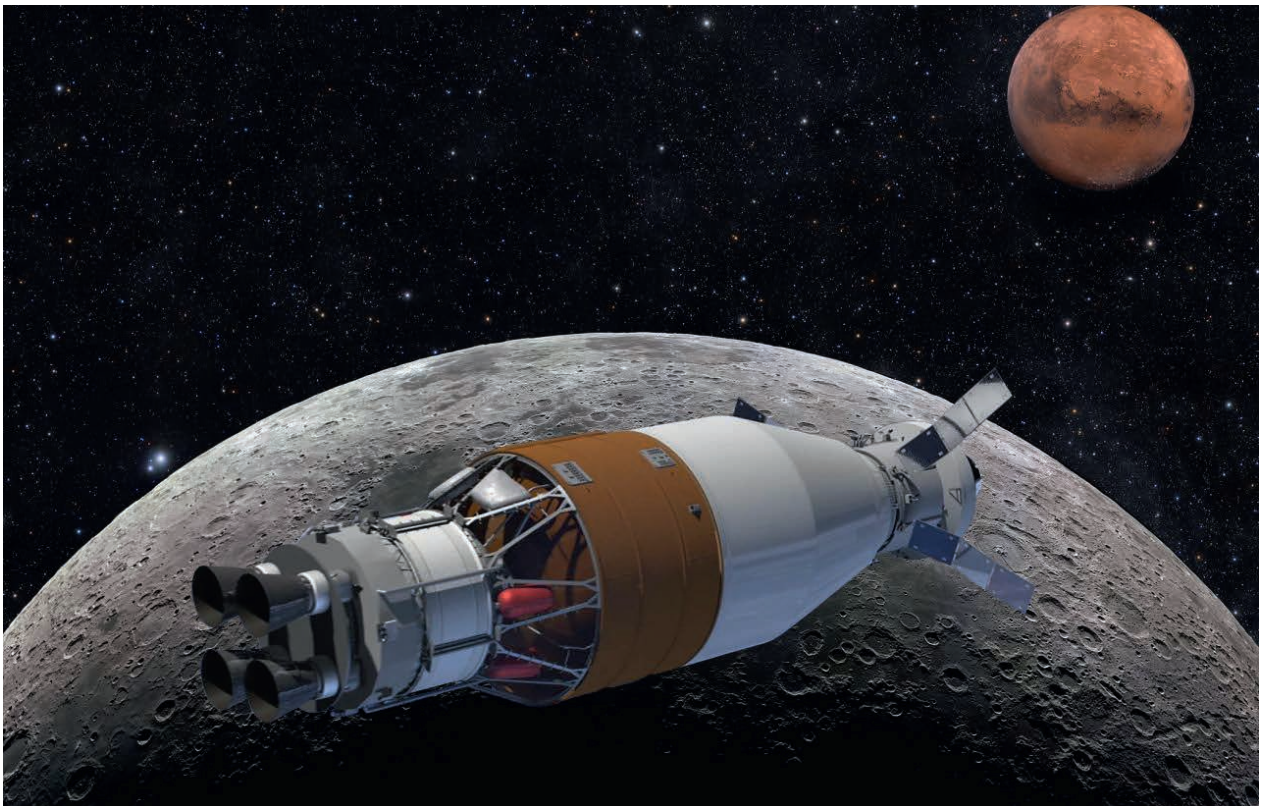
Working on the SLS fills us with pride! MAGNA's association with this U.S. program is almost a decade old and the journey has proven to be varied, eventful, and very rewarding. Limited to build-to-print contracts in 2015, we have since then been entrusted by our customer with additional work packages, this time however as Build-to-Spec ones. This is a testament and endorsement by the market of our design capabilities and execution discipline.

MAGNAs contribution to the SLS

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 lines delivered by MAGNA are used for LOX and LH2 transfer. They are semi-rigid types, i.e., they include compensators for angular and axial displacements.



NASA's Space Launch System © NASA



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

In addition to the Core Stage activities, MAGNA manufactures Feedlines for the Exploration Upper Stage (EUS). Those lines comprise unique compensators designed and manufactured by MAGNA in Graz.

In 2024, MAGNA produced hardware for the CS program and maintained ongoing activities for the design and testing of EUS feedline compensators.

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

Vega-Evolution, also known as Vega-E, is part of the broader efforts by the European Space Agency and its partners to maintain and advance Europe's capabilities in space launch technology.

This program aims to develop an enhanced version of the Vega launch vehicle, primarily for small to medium-sized payloads. It focuses on improving the performance, cost-efficiency, and environmental impact of the Vega rocket.

Vega-E features a cryogenic stage (LOX & LCH4) 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 through engine re-ignition.

MAGNA has been entrusted by the Italian company AVIO with the responsibility for two work packages on this launch vehicle:

- the MR10 engine lines and
- the propellant lines equipped with corresponding compensators

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

The activity for the Engine Lines has a hybrid character and combines a Build-to-Print content with a contribution by MAGNA for Development and Production Engineering. In 2024, MAGNA delivered the line set for the third engine line development model and design iteration (DM3) in view of the newest engine hot firing test campaign. This will then be followed by the start of the next development phase for engine lines qualification from 2025 on.

In contrast to the VUS MR10 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 the integrity of the fluid conveyance pipework. Highlights of 2024 include the successful completion of the lifecycle test for the compensator breadboard model and setting the course that will lead to a Critical Design Review at line level.

Vega-E © ESA-J. Huart

Magna Steyr Fahrzeugtechnik GmbH & Co KG

Division Aerospace
Puchstraße 85, 8020 Graz
www.magna.com/aerospace

CONTACT
DI (FH) Armin Scheinost
+43(0)316 404-7122
armin.scheinost@magna.com

Planet earth from the space at night

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 was originally 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

OHB Austria is a leading European aerospace company specializing in satellite-based navigation technologies, space systems, and scientific research. As part of the OHB Group, the company contributes to cutting-edge space projects, including satellite development, GNSS technology, and scientific development for space exploration. With the know-how of our team members, we develop solutions, services, and applications according to customer and market needs.

Development of the company

In 2024, the company was renamed from OHB Digital Solutions to OHB Austria to make its change in mission and strategy from 2025 onwards visible to the outside world. In parallel, the company was transferred from the business-segment Digital into the business-segment Space Systems within the OHB group to reflect the new direction of the company. OHB Austria will not only focus on GNSS signals, but also extend its RF interference detection capabilities into other areas. Additionally, OHB Austria will expand its software offering to spaceborne GNSS Receivers and other transceivers, mainly for OHB System AG. To underline that OHB Austria is the representative of OHB group in Austria, the capabilities will be expanded to include satellite mission planning and other space services, including but not limited to military capabilities.

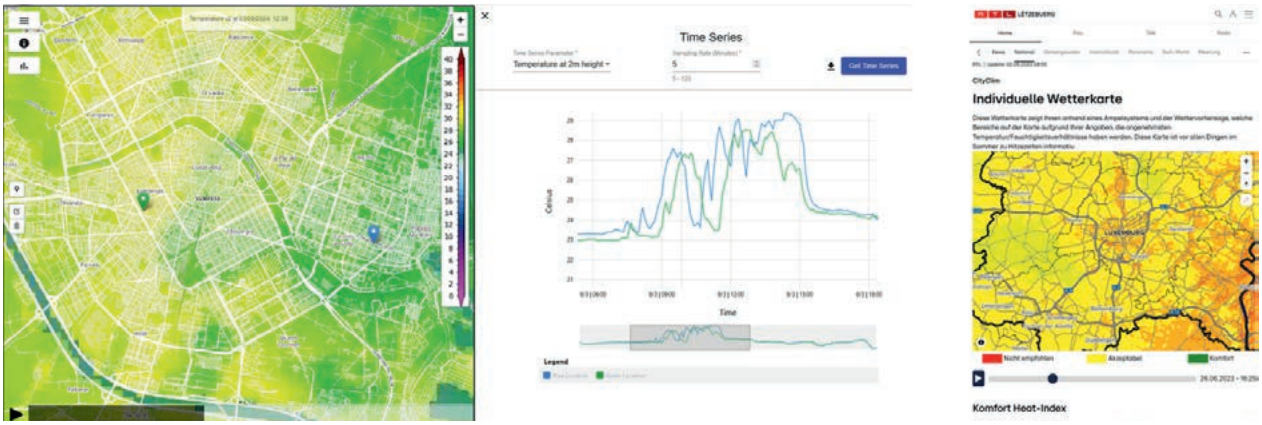
Project Highlights in 2024

CityCLIM: Next Generation City Climate Services Using Advanced Weather Models and Emerging Data

From 2021 to 2024, OHB Austria was part of the environmental science project CityCLIM under the leadership of OHB System AG. CityCLIM is a European Union-funded project designed to develop an open platform for climate information and mitigation services. It integrates data from Earth observation sources, ground measurements, and urban weather prediction models to provide detailed weather forecasts for various European cities. The project acknowledges the significant impact of climate change on urban life, particularly the Urban Heat Island effect, and addresses these challenges through mitigation and adaptation strategies.

Generic City Climate Platform (GCCP)

The Generic City Climate Platform (GCCP) is a Software-as-a-Service (SaaS) solution developed as part of the CityCLIM project to provide climate adaptation and mitigation services for cities. It integrates diverse climate data



Two of the services (left: Heat Wave information Service for Valencia, right: Citizen Weather Sensation in Luxembourg)

sources, including ground measurements, airborne and satellite data, to offer an advanced urban weather model. The platform serves as a one-stop shop for City Climate Services, helping both city administrations and citizens understand, predict, and respond to climate-related challenges.

Types of Services

- Citizen Climate Knowledge Services (CCKS): A public service that informs, warns, and engages citizens on climate change and extreme weather events, encouraging awareness and adaptation.
- City Administration Services: A decision-support tool for city planners and policymakers to analyze, simulate, and implement sustainable urban climate strategies.

Our Work

Apart from work done as the lead of various deliverables during the span of the project, as part of the of the consortium, OHB Austria was the lead beneficiary of a Work Package which not only oversaw the analysis of each of the four (Thessaloniki, Luxembourg, Karlsruhe and Valencia) Pilot cities' infrastructure, but also the customization, field-testing and demonstration of the CityCLIM services and prototypes.

In-Situ Data Processor

In addition to the management tasks, OHB Austria was responsible for developing the In-Situ Data Processor (ISDP) which acts as communication bridge between in-situ sensors and the GCCP, as well for implementing the Data Provider which made the data from the sensors available to the Pilot Cities. To accomplish that the Processor accesses the data from the sensors through REST API requests, processes the data in a unified format and stores the resulting information in the Data Warehouse of the Generic City Climate Platform. From there the data is made available for building the weather model but also made freely accessible for the Pilot Cities.

There are three sources from which the In-Situ Data Processor gathers the sensor data:

- MeteoTrackers, a portable weather sensor which can be mounted on bicycles. It has been used throughout the project in various citizen recording campaigns organized in the pilot cities.
- Barani Stationary Sensors, which were also distributed to the pilot cities to be mounted e.g. on schools and public buildings
- Valencia's FIWARE network of sensors, which was already functioning prior to the development of CityCLIM. The In-Situ Data Processor has managed to integrate sensor data coming from all types of sensors installed, which include Pollution Sensors, Bus-mounted Sensors, and traditional Weather Stations.

For more information on the project please visit https://www.cityclim.eu/.

Barani weather sensors

Meteotrackers on bicycles

FaGO: Factor Graph Optimization for GNSS-based PNT determination

In 2024, we started a new ESA NAVISP project: FaGO. The main objective of this project is to assess the utilization of Factor Graph Optimization (FGO) for

GNSS-based PNT determination. This picks up on recent research suggesting that the results from FGO are superior to those of conventional Bayes filters. As the basis for the evaluation, an FGO-based navigation engine and a corresponding testbed are to be implemented. The benchmark for the novel technique will then be obtained by analysing the results from a test campaign and from public data sets. Of special interest is the comparison of results to those from the EKF and output from COTS receivers.

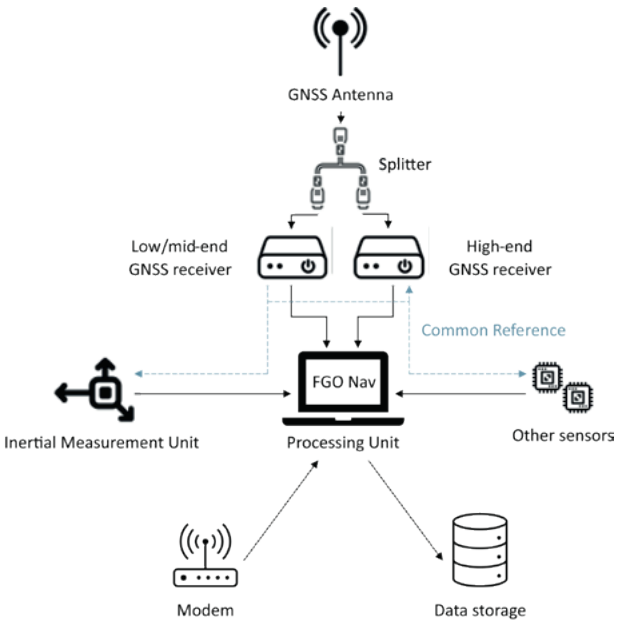
Implementation of an FGO-based navigation engine

A flexible navigation software engine shall be implemented (FGO-Nav) which uses FGO to estimate PNT solutions based on single-/dual-frequency GNSS data and in combination with inertial measurements. The engine shall have a Real Time Kinematic (RTK) and a Precise Point Positioning (PPP) mode.

While not explicitly stated in the requirements, we assume that the engine shall be able to process raw GNSS measurements (pseudorange, carrier phase, Doppler) as well as PPP/RTK PNT output from receivers. All processing shall be causal, which means that only past and present inputs are processed. FGO-Nav shall accept standard file formats (RINEX etc.) as input. Other specific capabilities such as the interpolation of data/outliers, the configurability with respect to the batch size ("history") used for optimization shall also be implemented.

Setting up a test bed for data acquisition, processing and analysis

The FGO-Nav shall be integrated in a testbed that shall allow to collect input data using sensors, process the data with the FGO-Nav and analyse the results. The testbed shall be composed of two COTS GNSS receivers (dual frequency/multi constellation), an IMU, a dual-frequency GNSS antenna as well as a recording and processing unit. One receiver shall be a low-/mid-end device, the other a high-end device. To guarantee synchronized measurements, all sensors shall be synchronized/disciplined by a common reference. The testbed configuration shall be controllable using a GUI.



Hardware setup

Measurement campaign

During a measurement campaign, at least 24h of synchronized data with ground truth shall be recorded with the testbed. The data shall be collected during drives through different environments (suburban, light urban, deep urban). It shall be possible to configure the testbed to record at least GNSS raw measurements (pseudorange, carrier phase, C/N0), IMU data, different DOP values, and statistics about the visible, tracked, and processed satellites/signals. The configurability shall also include the sensor parameters.

Analysis of the results and benchmarking

The results from the FGO-based PNT estimation shall be analysed at least in terms of accuracy and computational burden. The analysis results shall be visualized in the GUI. The performance of the FGO-Nav shall be compared with that of the COTS receivers. In addition, public data sets shall be processed and analysed for comparison with public benchmarks (Google Smartphone Decimeter Challenge, Hong Kong UrbanNav).

Project Approach

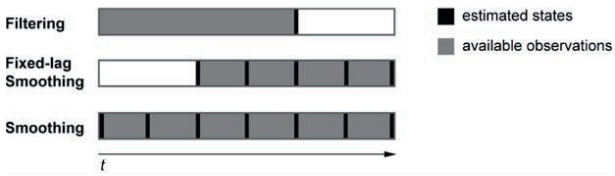
To reach these activity objectives we structure our approach as follows:

- Understanding the potential of Factor Graphs to solve GNSS-specific challenges
- Modelling the PNT estimation problem as a Factor Graph
- Solving the formulated problem in an efficient and robust way
- Using recent GNSS models and correction data
- Implementation based on established FGO libraries
- Methodological sound benchmarking against COTS receivers and a state-of-the-art EKF implementation

Understanding the potential of Factor Graphs to solve GNSS-specific challenges

The first step of FaGo is to analyse the potential of Factor Graph Optimization to tackle the challenges that are inherent to GNSS data processing. Our focus will be on overcoming limitations of the filtering-based estimators in the presence of measurement errors and low measurement quality in challenging GNSS environments.

As a first step, a literature review is carried out. The resulting understanding will be the necessary foundation for the next steps.



Comparison of filtering and smoothing: Filters use only past (condensed into the current best estimate) and current information (measurements) to estimate states, smoothers use all available information. The figure is based on Teunissen & Montenbruck (2017).

Outlook for the years 2025 and 2026

Thanks to the smooth execution of the major Romatsa project, the expansion of our product portfolio, and strong order intake over the past six months, we are confident that OHB Austria will continue its trajectory of profitable growth in the coming years, just as it did in 2024. Regardless of the current economic situation of Austrian industry, OHB Austria is convinced that the Austrian aerospace and space sectors will continue to expand in the years ahead, and we are committed to playing an increasingly significant role in this growth. We.Create.Space.!

OHB Austria GmbH

Kärntnerstraße 7b/1, 8020 Graz
www.ohb-austria.at

CONTACT

Dipl.-Ing. Bernhard Czar
CEO
+43-316-890971-30
office@ohb-austria.at

FACTS

Sales:	1,4 M€
ESA Share:	0,1 M€

ESA Athena Fixed Metering Structure Demonstrator

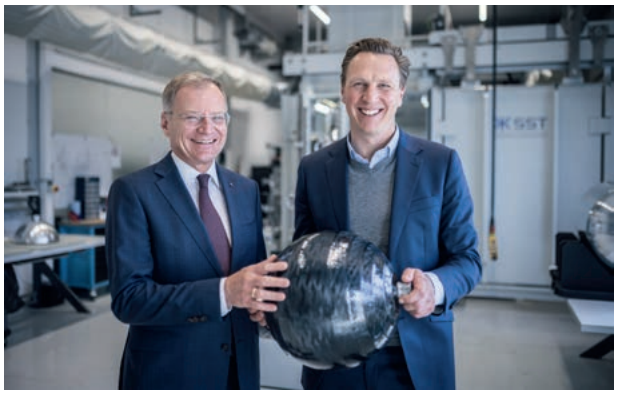
Peak Technology GmbH

Through close collaboration with leading system-level primes and the European Space Agency (ESA), Peak Technology GmbH has strategically advanced its expansion, establishing itself as a key supplier of Composite Overwrapped Pressure Vessels (COPVs) and structural components for the European space industry. Parallel to the conventional, multi-year development activities for diverse classical space programs, high-paced, spin-off products for new space have proven to be a lucrative business branch.

Recent highlights featured high-profile visits to Peak Technology's facilities in Holzhausen, Upper Austria by Thomas Stelzer, Governor of Upper Austria, and Josef Aschbacher, Director General of the European Space Agency (ESA).

ATHENA

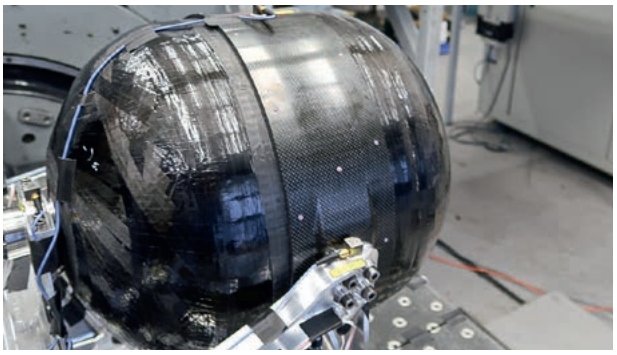
Culminating the multi-year development with performance of the Static Load Test, completion of the Static Load Test highlighted the success development of the demonstration composite telescope structure for the Advanced Telescope of the ESA ATHENA FMS (Fixed Metering Structure) program. Manufacturing and testing of the subscale demonstrator served as a concept validation prior proceeding to the full-scale program phase.



Governor of Upper Austria Thomas Stelzer with Peak Technology CEO Dieter Grebner in front of the new Electronic Beam Welding Machine © Max Mayerhofer

ESA Director General Josef Aschbacher and CEO Dieter Grebner looking at the Athena FMS Demonstrator © Polina Huard/ESA

ELSA-M



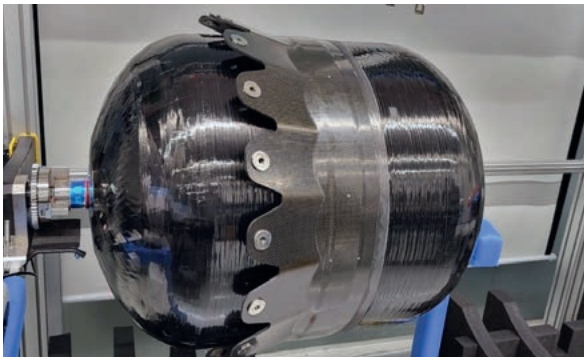
ELSA-M 40L Krypton COPV © Peak Technology

Under contract to Thales Alena Space, UK and their customer ASTROSCALE, development and qualification activities initiated end of 2022 for the electric propulsion 40L Krypton COPV were successful completed in 2024. This was followed by the fabrication, acceptance testing and delivery of the two flight models for the ELSA-mission. The revolutionary ELSA-M servicer is equipped with the capability to undertake multiple sequential on-orbit debris removals expanding the reusability and reducing the cost of the service. Its reliable, high-performance Kr tank is accordingly an essential element.

The ELSA-M In-orbit Demonstration (IOD) is planned for 2026 and serves as the first commercial "Active Debris Removal" satellite mission to complete the innovative end-to-end operations of a removal service with a full sized and fully representative client.

Galileo Second Generation (G2G)

After successful conclusion of the four-year development and qualification phase, series production of the Xenon Storage Tank (XST) including delivery of the first two flight models for Airbus Defence and Space, France marked a key programmatic milestone.



Galileo Second Generation © Peak Technology

The 175L XST serves as the propellant tank to store Xenon gas for the Electric Propulsion System (EPS) within the Galileo Second Generation (G2G) G2SB1-B and is accordingly an integral component of the satellite. The second generation of Galileo satellites is equipped with digital navigation payloads, electric propulsion, enhanced atomic clocks, and more powerful antennas to enable greater accuracy, high-throughput inter-satellite communications, and superior flexibility and reliability. After manufacturing and successful completion of acceptance testing, the first two Flight Models (FM) were delivered to AD&S for subsequent integration into the system-level satellite platform. Manufacturing and acceptance testing of the next four flight models is currently in production.

HummingSat

The development of the electric propulsion Xe Tank for the HummingSat GEO telecommunications satellite product line for SWISSto12 continued in 2024. Due to the evolution of the platform and increased propulsion needs, the tank volume was enlarged from originally 115L to 175L. Peak Technology demonstrated its reliability as a development partner to enable rapid implementation of this change, leveraging the established knowhow and heritage within parallel in-house programs.

Scheduled for launch in 2026, the innovative HummingSat design was selected to produce the Intelsat 45 (IS-45) satellite using its for its small Ku-band satellite. In addition, Viasat/Inmarsat has chosen the HummingSat technology to build three I-8 satellites to strengthen its global L-band network. Production of a dedicated qualification model as well as the first six flight models is currently in progress.

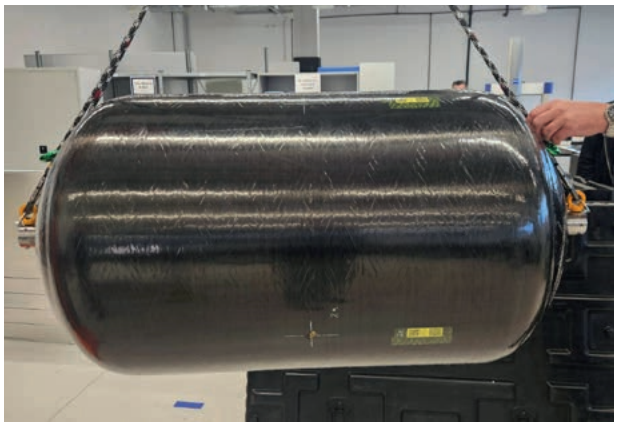
MaiaSpace

As a key element of the MaiaSpace small launch vehicle, Peak Technology provides 165L and 260L He tanks for the pressurization of the launch vehicle structure. The rapid-development tanks were adapted from proven pressure vessel designs to ensure alignment with the program's fast-track approach. The upcoming hot-firing test of the main stage will serve as a milestone in the launcher development.

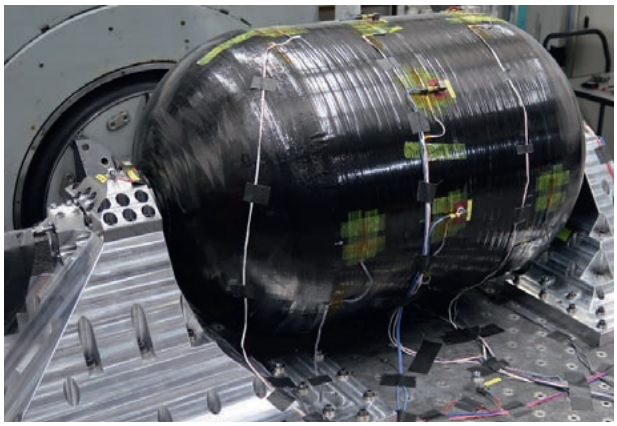
VEGA-E

Under contract to AVIO S.p.A., and with direct participation from ESA, Peak Technology is developing a lightweight 155L helium tank for the upper stage of the next-generation 'VEGA Evolution' launch vehicle. The tank efficiently stores helium for the pressurization of the new M10 liquid methane engine. Furthermore, its design represents the first use of advanced forging in the fabrication of the thin-walled liner, enabling both reduced tank mass and improved reliability.

In 2024, the first two flight-representative engineering models were successfully tested as a key verification of predicted performance. Testing included high-pressure cycling, vibration and burst testing.



COPVs mounted inside of MaiaSpace structure. © Peak Technology



155L VEGA-E tank is being tested. © Peak Technology

Peak Technology GmbH

Technologieparkstraße 6, 4615 Holzhausen
www.peaktechnology.at

CONTACT

DI Dieter Grebner
CEO
dieter.grebner@peaktechnology.at

FACTS

Sales:	18,8 M€
ESA Share:	2,5 M€

Quantum Technology Laboratories GmbH

Founded in 2017 by leading scientists in the field of quantum physics, qtlabs GmbH is an Austrian SME headquartered in Vienna and specialized in optical and quantum communication technologies for space-based applications. The company emerged from over two decades of scientific excellence, with its co-founders among the most highly cited quantum physicists worldwide and closely linked to Nobel Prize-winning research.

qtlabs is one of the few European companies that cover the entire value chain of quantum key distribution (QKD) systems: Consulting services including security proof, tempering and certification efforts, from high-performance entangled photon sources and receiver modules to fully integrated optical ground stations (OGS) and simulation software. The company also operates a dedicated Online Academy Education program, providing customer education and executive training to C-level and technical audiences across Europe.

Scientific Legacy and Technological Milestones

Optical ground station for satellite communication.
© J. Handsteiner, qtlabs.at

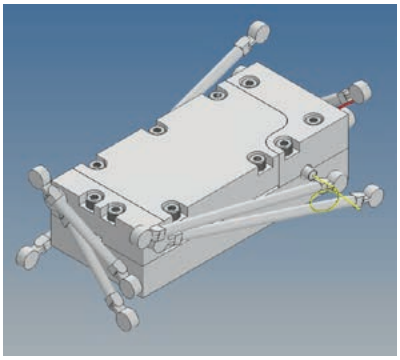
The scientific achievements of qtlabs are deeply rooted in cutting-edge research. The founders, Dr. Rupert Ursin and Dr. Thomas Scheidl, were key contributors to the first successful satellite-based QKD experiment outside China. Their work includes record-setting free-space quantum links between La Palma and Tenerife (144 km) and several space-based experiments under extreme conditions.

Many of the technologies used in these experiments now form the basis for qtlabs' commercial offerings.

Commercial Success and Project Landscape

With over 40 employees, qtlabs has transitioned from a research-driven start-up to a high-impact technology provider. The company is/was involved in numerous flagship projects funded by ESA, the European Commission, and national agencies:

- QKDSat and SAGA (ESA): Development of quantum-ready optical ground stations and QKD receiver modules.
- EURO-QCI: Infrastructure development for secure European quantum communication.
- UN:IO and LaiQa (EU): Contributions to future quantum-secure satellite constellations.
- TeQuantS (ESA): Developing quantum internet building blocks including satellite-based entanglement distribution.
- Commercial Deliveries: qtlabs' OGS systems and components are actively deployed by private customers across the EU27.



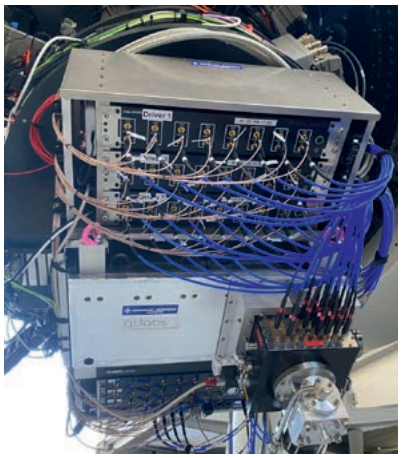
Compact entangled photon source (EPS) for quantum communication.
© M. Fink, qtlabs.at

Highlights: Optical Ground Stations & Deep-Space Optical Communication

qtlabs has successfully completed the Factory Acceptance Test (FAT) for two high-precision optical ground stations featuring 80 cm aperture telescopes, marking a key milestone in the ESA QKDSat project. These stations are critical enablers for secure quantum communication links between space and Earth. Notably, the stations support quantum communication signal reception as well as optical communication up- and downlinks. The successful FAT underscores qtlabs' capability to deliver cutting-edge quantum ground infrastructure compliant with ESA's rigorous standards. Currently, three additional ground stations are in production, further expanding the market share including also other satellite missions.

In a historic milestone for European spaceflight, a successful optical communication link was established on July 7, 2025, between Europe and NASA's Psyche spacecraft, over a distance of 265 million kilometers. Austrian company qtlabs played a central role in this breakthrough, having developed key components for the European ground receiver and co-led the demonstration. The test, conducted in collaboration with ESA and NASA, confirms the viability of optical communication for deep-space missions, enabling significantly higher data rates than traditional radio systems. qtlabs led the international consortium and was responsible for the optical design, component de-

Picture of on of the optical ground stations during factory acceptance test.
© P. Dieterich, qtlabs



Ground laser receiver for deep space optical communication.
© qtlabs

The Aristarchos telescope with 2.3m aperture.
© qtlabs

livery, integration, and commissioning of the optical ground laser receiver (GLR), installed on a 2.3-meter telescope in Greece. This achievement highlights Austria's advanced capabilities in photonic signal processing and precision optomechanics, positioning qtlabs as a leader in the emerging era of deep-space and quantum communication.

Integrated Products and Services

qtlabs offers a full technology stack for optical quantum communication:

- Optical Ground Stations: From compact rooftop systems to mobile lab-grade OGS containers.
- Photon Sources: BB84 faint pulse and BBM92 entangled photon sources (810/1550nm).
- Quantum Receiver Units: Polarization/phase decoding including SNSPDs & APDs.
- Adaptive Optics: Tip-tilt and deformable mirror systems for free-space optimization.
- Classical Communication & Safety: SDA-compliant modem integration and certified laser safety systems.
- Software: Digital mission simulation, time synchronization, error correction, privacy amplification.
- Consulting: Customer-tailored workshops, system architecture design, QKD education.
- Comprehensive quantum learning ecosystem with an interactive online platform (https://qurios.academy) tailored for engineers, as well as a stakeholder-focused version for strategic understanding. Complemented by offline workshops and hands-on sessions, it bridges the gap between deep tech and real-world application across all levels of expertise.

Financial Highlights and Market Outlook

Between 2020 and 2024, qtlabs grew its balance sheet from about €1 million to €4,5 million, of which approximately €1.8 million originated from ESA projects. The company's order books for optical ground stations are fully booked, with deliveries ongoing across several EU27 states – mostly in optical ground stations as well as training and consultancy.

qtlabs is part of a holding structure with several sister companies in Vienna (AT) and Munich (DE) dedicated to component level QKD systems as well as terrestrial fiber-based quantum communication.

Quantum Technology Laboratories GmbH

Clemens-Holzmeister-Straße 6/6, 1100 Vienna, Austria
www.qtlabs.at

CONTACT

Dr. Martin Bohmann
Head of Business Development
Martin.Bohmann@qtlabs.at
Dr. Rupert Ursin, CEO

FACTS

Sales:	4.5 M€
ESA Share:	1.8 M€

ESA BIC Austria has successfully incubated more than 80 space technology start-ups in Austria.

Science Park Graz GmbH

The ESA Business Incubation Centre (BIC) Austria was established in 2016 as part of Science Park Graz, expanding the portfolio of one of the oldest and largest start-up incubators in Austria. Since its inception, ESA BIC Austria has successfully incubated more than 80 space technology start-ups in the federal states of Styria, Lower Austria, and Salzburg. More than half of those start-ups were founded directly through the ESA BIC Austria program.
Science Park Graz (SPG) is the reference Business Incubator of the Austrian public high-tech start-up incubator network (AplusB) and the manager of ESA Space Solutions Austria. Since 2002, SPG is the driving force of the development of successful start-ups from the academic world.

© fotoCRafie | Chrissi Rechling

SPG is furthermore a key partner for 300 start-ups and entrepreneurial projects in Graz, Styria and beyond, providing coaching, access to business and technical networks, funding, and office accommodation. SPG also nurtures strong connections to various national organizations and agencies within the start-up ecosystem in Austria that are beneficial to the development and establishment of the supported start-ups.

The European Space Agency's Business Incubation Centre (ESA BIC) in Austria is the place for entrepreneurs, start-ups, SMEs, researchers and students to improve life on Earth through the commercialization of innovative space-enabled products and services in promising areas of the economy.

Supporting Entrepreneurship and Innovation

ESA BIC Austria serves as a vital hub for entrepreneurs, start-ups, small and medium-sized enterprises (SMEs), researchers, and students. The primary goal is to translate advanced space technologies into viable commercial

© fotoCRafie | Chrissi Rechling

products and services that enhance various sectors on Earth. This transformation is supported by tailored mentorship, industry expertise, and an extensive professional network, creating an ideal environment for disruptive innovations.

Through the ESA Business Incubation Programme (ESA BIC) in Austria, aspiring entrepreneurs receive structured support up to 24-month incubation period. The program provides guidance in business development, technology validation, and market integration, ensuring that innovative ideas transition effectively from concept to reality.

Start-ups participating in the ESA BIC Austria program gain access to an exclusive network of more than 1,700 space start-ups from 22 European countries. This network is one of the strongest start-up networks in Europe and attracted €556 million in investments in 2023 alone. Incubated startups benefit from €50,000 in non-repayable funding, access to technical and business expertise, office space with local incubation partners, exclusive offers, a global network of space-related investors, and high brand awareness and legitimacy from ESA.

The program also helps businesses build strong partnerships with established companies and research organizations, paving the way for long-term growth and international market expansion. Beyond financial support, ESA BIC Austria also provides strategic networking opportunities, allowing start-ups to showcase their innovations at international trade fairs, conferences, and investor events. This exposure not only strengthens their market presence but also attracts potential customers and investors, further fuelling their growth.

Key Offerings and Funding Opportunities

ESA BIC Austria plays a pivotal role in expanding space-based business opportunities. Its mission revolves around empowering European entrepreneurs by offering funding, incubation programs, and strategic partnerships.
Some of its key initiatives include:

1. **ESA Spark Funding Austria:** This program is designed to accelerate product development and commercialization efforts for Austrian companies incorporating space technologies. By encouraging the integration of satellite-based services and other space innovations, the initiative helps businesses enhance their existing product lines or develop entirely new offerings for non-space markets.
2. **ESA Business Applications Ambassador in Austria:** This initiative functions as a bridge between ESA, its Member States, and the broader industry ecosystem. By engaging with non-space sectors, the program supports the discovery of funding opportunities, facilitates industry partnerships, and drives collaboration between traditional and space-tech industries.

Success Stories

The impact of ESA BIC Austria and Science Park Graz can be seen in the tangible success of their supported start-ups. Companies that have emerged from these programs have made notable contributions to various industries and received international recognition.

One such example is the recent development of Austria's first state-run hydrogen facility, a milestone in sustainable energy solutions. The initiative, led by **HydroSolid**, aims to revolutionize hydrogen storage technology and promote the widespread adoption of green hydrogen as an alternative energy source. This project highlights the synergy between space technology and sustainable solutions, underscoring the potential for cross-industry applications.

Additionally, **BirdShades**, a Graz-based start-up, has created an invisible bird protection film for glass surfaces. This transparent coating is visible to birds but remains undetectable to humans, preventing bird collisions without compromising architectural aesthetics. The company, supported by ESA BIC Austria and ESA Spark Funding, is currently expanding its product testing in large-scale projects in the U.S., collaborating with leading universities and research institutions.

Another success story is **WEME Earth**, which utilizes satellite data to support the planning and construction of hydropower plants, particularly in developing countries. By accessing data from over 600 satellites, WEME Earth provides real-time insights on road conditions, geology, project progress, and weather patterns. This reduces uncertainties in project planning and enables more precise cost estimations, contributing to the sustainable expansion of hydropower worldwide.

With structured incubation, targeted funding, and strategic partnerships, incubated and alumni start-ups are well positioned to succeed in competitive markets. Through continuous support of innovation and collaboration, Science Park Graz and ESA BIC Austria are paving the way for the growth of technology-driven businesses in Austria and beyond.

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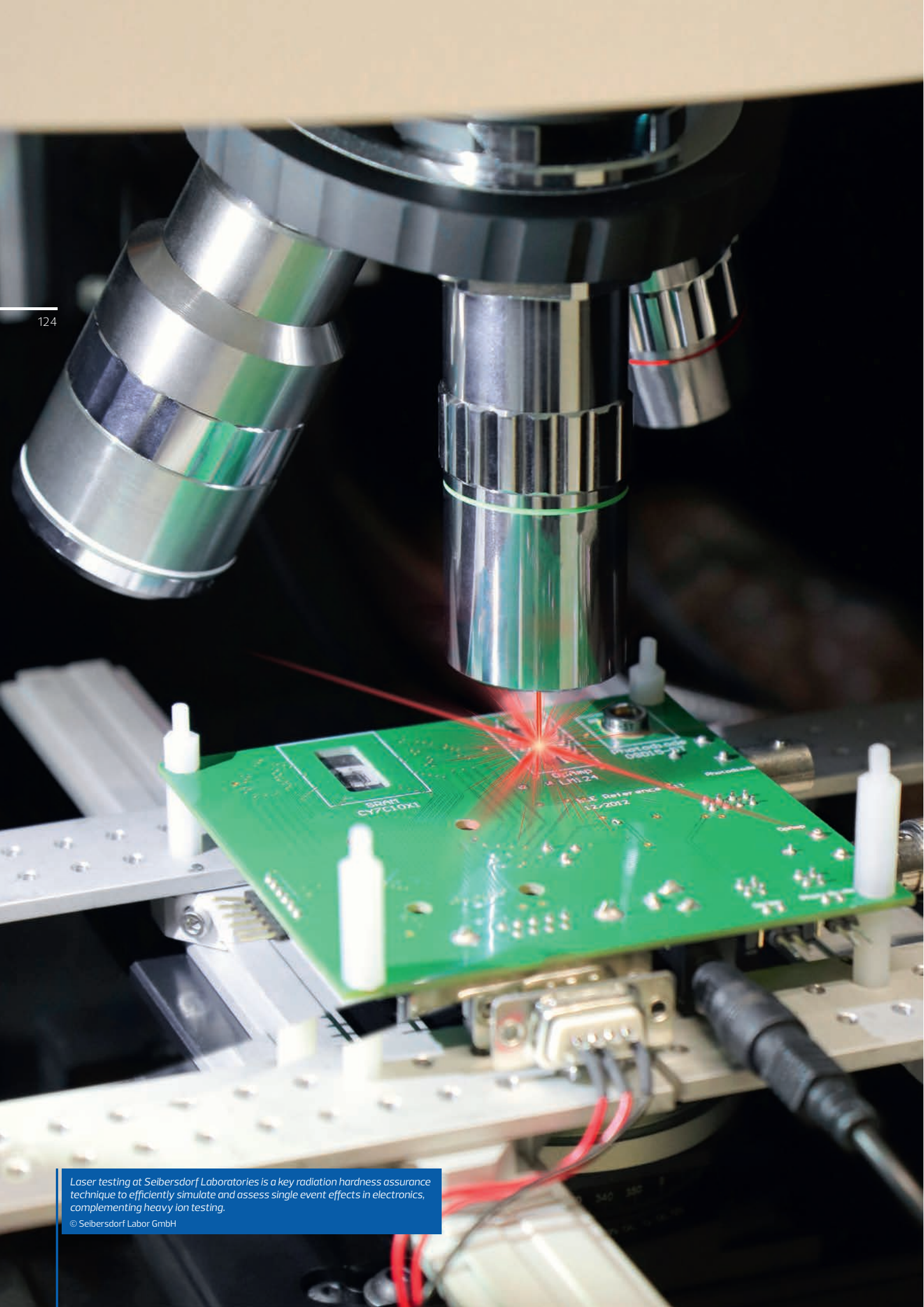
Science Park Graz GmbH

Sandgasse 36/4th floor, 8010 Graz
www.sciencepark.at

CONTACT
+43 316 873 9101
info@sciencepark.at



Laser testing at Seibersdorf Laboratories is a key radiation hardness assurance technique to efficiently simulate and assess single event effects in electronics, complementing heavy ion testing.

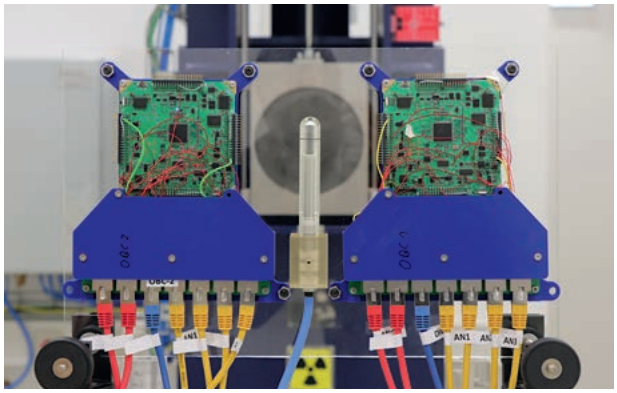
Seibersdorf Labor GmbH

Seibersdorf Labor GmbH, operating under the brand name Seibersdorf Laboratories, is known for its commitment to providing high quality laboratory analyses and cutting-edge measurement technologies. Strategically located at the Tech Campus Seibersdorf, just 30 kilometers south of Vienna, Austria, Seibersdorf Laboratories employs a dedicated team of over 190 qualified professionals and trainees to ensure excellence.

Our space activities focus on the study of space radiation and its effects on humans, electronic components, systems, and materials. As a recognized leader in the field, we provide specialized services in space weather analysis, radiation testing, and expert consulting. Our team of experts is highly experienced in areas such as aircraft crew dosimetry, total ionizing dose (TID), displacement damage (DD), and single event effects (SEE) testing. We consistently meet the stringent requirements of public authorities, space agencies, and the aerospace industry.

In the following, we present our space-related public projects and studies conducted in 2024:

- **SATDOS** – Successful in-orbit demonstration of a novel dosimeter payload for nanosatellites
- **CORHA-2** – Kick-off of a new ESA project on radiation hardness of commercial components
- **SEERad** – An FFG project on single event effect studies for aerospace applications
- **AVIDOS** - Human exposure to cosmic radiation onboard aircraft due to space weather



Our projects benefit from the extensive infrastructure and test facilities on our campus, such as our EN ISO IEC 17025 accredited TID testing facility, the TEC-Laboratory, or our novel SEE laser test facility Seibersdorf for single event effect testing of electronic components.

In 2024, Seibersdorf Laboratories held the 9th edition of its annual RADHARD Symposium, demonstrating our commitment to advancing knowledge and collaboration in the field.

SATDOS launched and operated onboard the Austrian CubeSat PRETTY © ESA, Arianespace, CNES

SATDOS – Reference Dosimeter Onboard PRETTY

In 2023, SATDOS, Seibersdorf Laboratories' compact reference dosimeter for nanosatellites, launched aboard the Austrian CubeSat PRETTY. Over one year, it reliably measured total ionizing dose (TID) and single event effects (SEE) in orbit. The mission, concluded in 2024, demonstrated SATDOS's ability to qualify commercial components in space. Now ready for integration, SATDOS supports in-orbit qualification and satellite lifetime analysis in future space missions.

seibersdorf-laboratories.at/satdos

Seibersdorf Laboratories kicked-off the ESA CORHA-2 project on radiation hardness assurance of commercial components for use in space.

CORHA-2 – Investigating the Applicability of Commercial Components for Space Use

Seibersdorf Laboratories started the ESA CORHA-2 initiative, a three-year project aimed at enhancing radiation hardness methodologies for commercial off-the-shelf (COTS) components in space applications. Building upon the achievements of its predecessor, CORHA-2 focuses on advanced radiation testing, the development of an open-access database, and the integration of artificial intelligence for performance prediction.

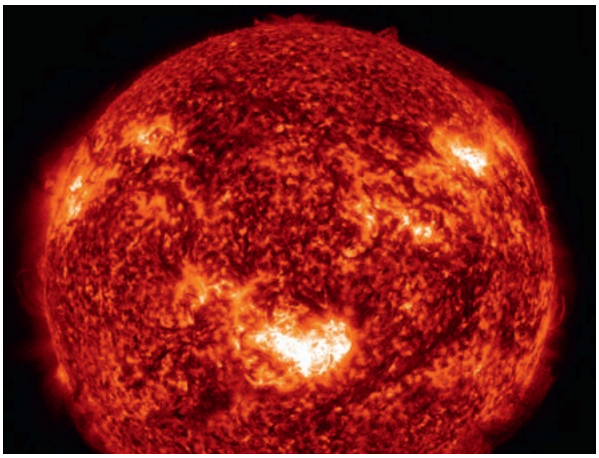
seibersdorf-laboratories.at/corha2
linkedin.com/showcase/corha-seibersdorf-laboratories

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

SEERad – Single Event Effect Studies for Aerospace Applications

Within the FFG initiative SEERad, Seibersdorf Laboratories and the University of Applied Sciences Wiener Neustadt jointly investigated irradiation techniques for the aerospace industry at MedAustron, Austria's leading particle accelerator facility, 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.

projekte.ffg.at/projekt/4373981



NASA/SDO image of the Sun on the 7th of May with active region that caused Mother's Day storm. © ESA/NASA Helioviewer Project

AVIDOS – Human Exposure to Cosmic Radiation onboard Aircraft

Seibersdorf Laboratories continued providing real-time AVIDOS-based services to ESA's Space Weather Network and to ICAO via the European PECASUS consortium. During the intense Mother's Day solar storm (May 10–13, 2024), the strongest since 2003, media reported widespread effects. AVIDOS real-time services showed no significant radiation dose increases at flight altitudes, later confirmed by detailed analysis, demonstrating the reliability of Seibersdorf Laboratories' monitoring capabilities during extreme space weather events.

swe.ssa.esa.int/avidos-federated

Book of Abstracts of 9th RADHARD Symposium

9th RADHARD SYMPOSIUM 2024, May 7th–8th

The mission of the RADHARD Symposium is to foster the exchange of hands-on experience in radiation hardness assurance. The 9th of Seibersdorf Laboratories' symposium highlighted automotive, space, and COTS components, supported by keynote speakers. The annual symposium targets a broad audience including space system integrators, electrical and electronic equipment manufacturers, industry experts, researchers, and students seeking insight into radiation effects on components and systems.

radhard.eu

Seibersdorf Labor GmbH

TECH Campus Seibersdorf, 2444 Seibersdorf
www.seibersdorf-laboratories.at

CONTACT
DI Dr. Peter Beck
Head of the Business Unit Radiation Protection Dosimetry
+43 50550 4305
peter.beck@seibersdorf-laboratories.at

The Atmosphere–Space Interactions Monitor or ASIM, mounted outside the European laboratory of the International Space Station

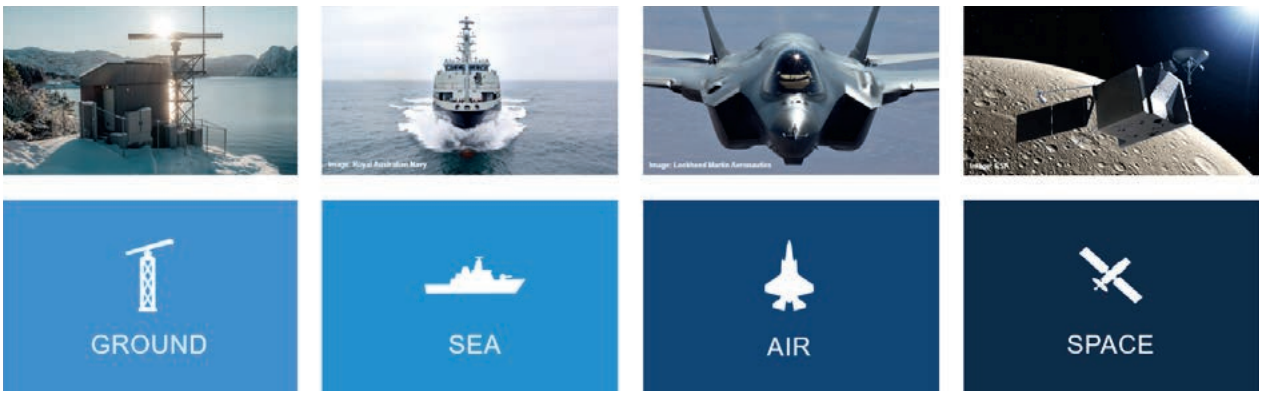
Terma Technologies GmbH

Terma is a global company partially owned by a commercial foundation and a Pension Fund, with roots in Denmark, about 1.800 employees and total annual revenue in 2024 of € 387 million. 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 100 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 specializes in the space sector, operating exclusively within the Terma Space Business Area. Located in Vienna, Austria, it serves as the headquarters of Terma Space and focuses on **Satellite Testing, Satellite Control**, and **Automotive Battery Cell Testing**.

As the home of the **Ground Systems Business Unit**, Terma Technologies acts as both the in-house R&D hub for Terma's Ground Systems products—such as ProUST FrontEnd, ProUST univerSAS®, ProUST SLP, the Battery Cell



Tester suite, Terma SPECTRA (Terma's SDR TT&C Modem) as well as the main design center for advanced **Electrical Ground Support Equipment (EGSE)** solutions.

These tailored solutions provide customers with reliable, cutting-edge technologies essential for successful space missions, particularly during the **Manufacturing, Assembly, and Integration** phases of satellites and launchers.

Terma Technologies delivers products, solutions, and services for:

- **Satellite and Launcher Manufacturers**
  - Electrical Ground Support Equipment (EGSE)
    - Instrument & Payload EGSEs
    - Spacecraft Platform Simulators
  - Special Check-Out Equipment (SCOE)
    - RF SCOEs
    - Power SCOEs
    - Solar Array, Battery, and Load Simulators
    - Launch Power Supplies (COTEs)
    - Data Handling SCOEs
    - AOCS SCOEs
    - RF Suitcases
- **Satellite Controllers**
  - Ground Segment Solutions and Integration
  - Mission Control System Maintenance & Evolution
- **E-Mobility Battery Cell Manufacturers**
  - Battery Cell Cyclers (leveraging space-grade technology)
- **Ground Stations**
  - SDR TT&C modem

In financial year 2024 the Business Unit achieved a revenue of € 15.9 million, based on commercial space markets, ESA, and Galileo activities. The share of Austrian ESA sales therein accounted for € 5.4 million. Following a successful integration into the Terma Group, the newly established **Terma Technologies GmbH** has commenced regular operations and is currently preparing for **AS9100 certification**, expected to be completed in 2025.

Satellite Testing

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

Continuing to deliver high-value solutions to our customers' Assembly, Integration, and Testing (AIT) processes, Terma Technologies has provided Electrical Ground Support Equipment (EGSE) and Special Check-Out Equipment (SCOE) for numerous institutional, commercial, and international space missions. Beyond Terma's well-established Radio Frequency (RF) and Power Subsystem testing solutions, an increasing number of projects now feature our RF Suitcases, as well as Instrument and Payload EGSE systems.

At the core of many of these solutions is the ProUST product family ("Protection Unit for Satellite Testing"), developed over recent years with support from ESA's GSTP and ARTES programs, along with the national ASAP program and own investments. Designed for seamless integration with third-party equipment, ProUST provides the hardware and firmware backbone of our testing solutions.

We continue to expand our EGSE offerings into the global commercial and military satellite manufacturing sectors. These efforts have led to further deliveries and upgrades of RF communication, payload, and power testing equipment for the Galileo program.

Copernicus Rose-L RF-SCOE © Terma

Galileo G2G S-Band SCOE © Terma

Galileo Payload Testsystem © Terma

Radio Frequency, Telemetry/Telecommand and RF Suitcase Test Systems

In 2024, the Terma RF department advanced its 'go digital' strategy, aiming to replace costly commercial off-the-shelf (COTS) equipment with in-house solutions and software-based technologies.

In close collaboration with FFG and ESA, Terma continued work on a funded project to develop a Software Defined Radio (SDR) modem, comprising a Universal Software Radio Peripheral (USRP) frontend and a PC-based backend. This approach offers several key advantages:

- Native support for L- and S-band frequencies (up to 6 GHz)
- Flexibility to support various coding and modulation schemes without additional external hardware
- Multi-link support for handling multiple communication channels simultaneously
- Easy reprogramming and feature upgrades via software while using the same hardware platform

This strategy enables more cost-effective, scalable, and adaptable RF test solutions aligned with evolving mission needs.

Terma's RF mission related work in 2024 was for: a UK Constellation, a German Bundeswehr mission, SpaceRider, BIOMASS, FLEX, Mass Change, Platino/Iride, Copernicus CO2M, Copernicus CRISTAL, Copernicus LSTM, Copernicus ROSE-L, Copernicus CIMR, Metop SG, Galileo G2G, LEO-PNT, Mars Sample Return, Ariel and Plato.

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, SpaceRider, Copernicus CO2M and Copernicus CIMR. HummingSat, SpaceRider and Copernicus CO2M & CIMR are based on our product UniverSAS® 2.1.

In the Instrument EGSE domain, we have 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 strongly committed to entering the Electric Mobility market with an innovative, integrated solution: the ProUST univerSAS®—our digital power supply, derived from space-grade technology. This product marks a major advancement in integration, cost-efficiency, and environmental sustainability. By leveraging cutting-edge technologies such as GaN MOSFETs, digital control, and high-efficiency power conversion, ProUST univerSAS® is ideally suited to meet the stringent environmental and performance requirements of electric vehicle manufacturers.
In 2024, we reached key milestones with the first deliveries of initial battery cell testing systems to our customers.

Terma Battery Cell Tester. front & rear view © Terma

Innovation: Terma SPECTRA – Software Defined Radio Modem

Terma SPECTRA — SDR TT&C modem © Terma

Under a contract that began with ESA's GSTP program and is now continuing under ARTES, Terma is developing Terma SPECTRA, a Software Defined Radio (SDR) modem designed primarily for TT&C Special Check-Out Equipment (SCOEs) and satellite ground stations.

The project began at the end of 2019, with the prototype phase completed in 2021. By 2024, the technology phase concluded, and development transitioned into the final product phase.

Key upgrades during this phase include:

- Replacement of the backend PC with a 1U 19'' rack-mounted system featuring improved CPU, faster storage, new RS422 serial interface, and SFP+ NIC, enabling optical fiber connectivity between the frontend and backend and leveraging DPDK for reduced latency.
- Implementation of ESA Code/Tone ranging.
- Full support for the most relevant CCSDS coding and modulation schemes.
- A modern, intuitive user interface for streamlined operation.

The product launch of Terma SPECTRA is scheduled for 2025, with the first deliveries expected to accompany Terma EGSE systems, including missions such as LEO PNT.

Planned developments following the initial release:

- Extended virtualization, enabling distributed deployments and synergies with related digital RF applications in edge clusters or the cloud
- Integration with Terma's TGSS Mission Control System
- Enhanced security features, eventually aligned with Zero Trust principles
- Support for additional coding and modulation schemes, such as LDPC and spread spectrum

Terma SPECTRA — UI © Terma

Satellite Control

Ground Segment Systems and Mission Control Software

Also, in the year 2024, 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
- Improvements and close-down of the ESA Common Core developments

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.

ESA Main Control Room © ESA

Terma Technologies GmbH

Autokaderstraße 29, 1210 Wien
www.terma.com/products/space/

CONTACT
DI Hans Martin Steiner
+43 664 88551471
E-Mail: hmst@terma.com

FACTS
Sales: 15.9 M€
ESA Share: 5.4 M€

Aerospace Key Visual – Orion Spacecraft

TTTech Computertechnik AG

TTTech is a leading global supplier of dependable avionic platform solutions, simplifying and reducing development cycles while enhancing the reliability of networked electronic systems in transportation and industrial automation markets. Established in 1998, TTTech Group employs over 2,300 employees worldwide, with a majority focused on engineering and software development. Headquartered in Vienna, Austria, TTTech Auto AG, its largest subsidiary, specializes in software platforms for advanced driver assistance systems and future autonomous driving cars.

TTTech Aerospace offers avionics platform solutions for aviation and space applications, consisting of complex silicon chips, hardware, software, and tools. Their products are used in major international space programs, including NASA Artemis and ESA Ariane 6.

TTTech Aerospace delivers high-performance, safety-critical networked computing platforms that ensure reliable and safe operation of spacecraft and launchers, integrating various systems such as guidance navigation and control, telecommunication, telecommand, life support, and environmental control.

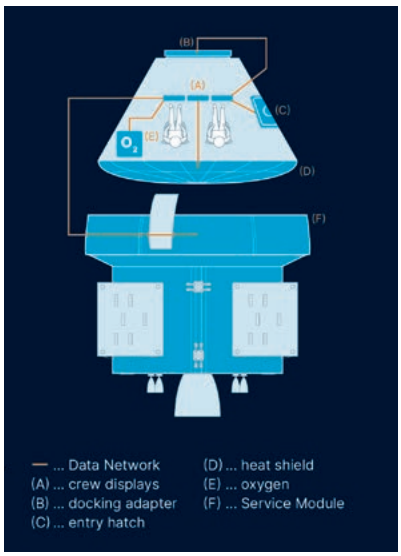


Illustration showing a simplified picture of how the TTEthernet® data network connects Orion and the European Service Module, reliably transferring all data needed for communication within the spacecraft as well as between the spacecraft and space stations, launch vehicles and ground stations.

Artemis I — First Mission Successfully Completed

In November 2022, NASA launched the Artemis I mission, an uncrewed test flight of the Orion spacecraft and ESA's European Service Module (ESM) around the Moon. TTTech's TTEthernet® products are part of the avionics system of NASA Orion and the European Service Module, working with Honeywell, Lockheed Martin, and NASA since 2006. The first successful NASA Orion Exploration Test Flight (EFT-1) was completed in 2014, with subsequent tests and adaptations leading to the Artemis I launch. Based on the products deployed in Orion, TTTech developes the TTEthernet data network which constitutes the data backbone of the Artemis Gateway.

Artemis – Gateway

The Artemis program consists of multiple key building blocks designed to bring humanity back to the Moon with a sustainable, permanent presence. It also aims to prove all necessary technologies for future missions that will safely transport humans to Mars and back. A cornerstone of this program is the Gateway, a human-rated station in lunar orbit capable of hosting astronauts on their journey to the Moon and back. Currently in development, TTTech is providing network and compute equipment for the various modules of the Gateway.

Drawing lessons from the international space stations, where hundreds of low-performance communication buses were cascaded to deliver the required quality of service for station control and operation, the Gateway employs a solution that integrates multiple modules in a modular way without losing the quality of service. The integration of these modules is complex and requires advanced technologies and products to master it, ensuring the capability to add and upgrade the overall station seamlessly.

European Space Activities 2024

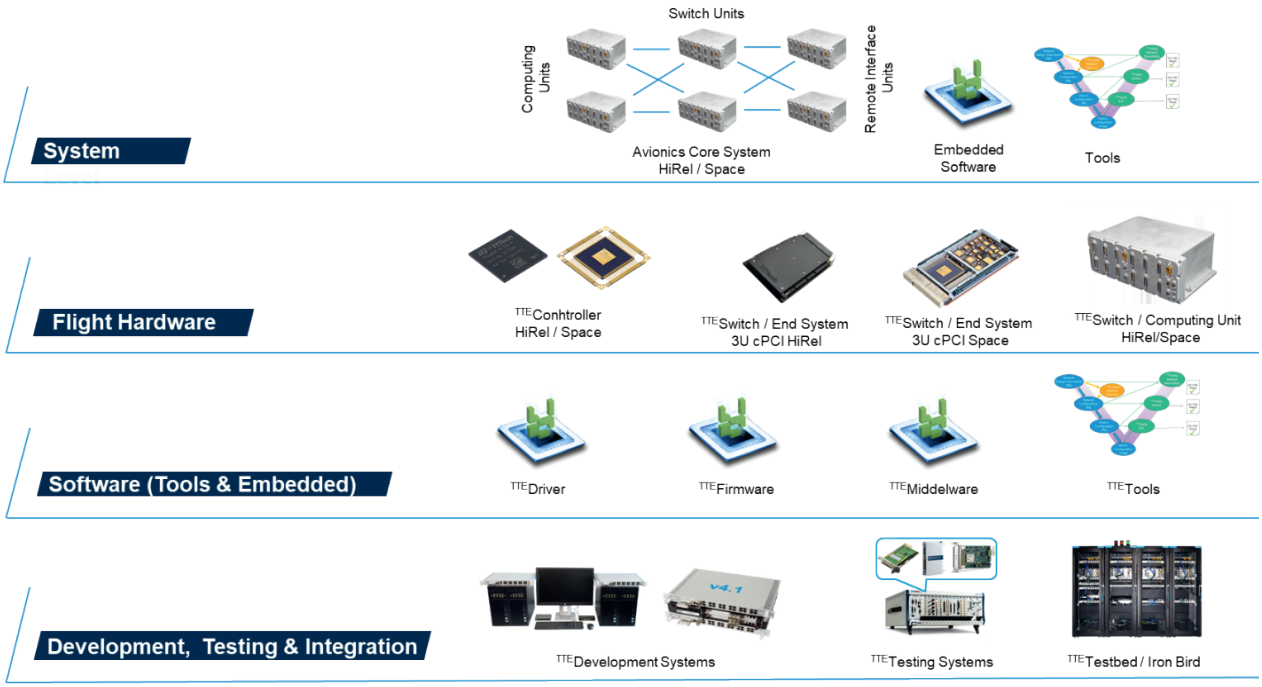
Europe's new flagship launcher, Ariane 6, will ensure independent access to space for the European space sector. TTTech has made substantial contributions to the creation of the avionics backbone system in Ariane 6. Its chips and related software are integrated into more than 50 avionic units, handling functions such as guidance navigation and control, telemetry and telecommand, power management, video streaming, and thrust-vector actuation. All these units connect to a single, redundant TTEthernet network, which serves as the launcher's nervous system. TTTech also contributed to Ariane 6 with firmware development, qualification, and integration support. Ariane 6 successfully completed its first launch in 2024 and deployed a commercial payload in early 2025. The launcher will now increase its cadence to the planned 10 launches per year, becoming a crucial pillar of Europe's dependable independent access to space.

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

Onboard Data Network – Human Space Flight / Space Station

ESA partnered early with NASA, the Canadian Space Agency, and the Japanese Space Agency on the international Artemis program. To ensure the availability of technology readiness level (TRL) in Europe, ESA and the Austrian Space Agency ALR (as part of FFG), together with TTTech and Beyond Gravity, initiated a development and qualification activity to de-risk ESA's Gateway modules and ensure compliance with ESA's ECSS standards. This ESA GSTP activity for the qualification of key TTEthernet® avionics elements—space-grade TTEthernet switches and network interface cards—reached 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 has enabled multiple programs outside of ESA, showcasing the impact of Austrian technology.

In 2024, TTTech made significant progress on contracts for ESA's Gateway modules "International Habitat" and other modules on the Gateway. TTTech is working with various primes for the different modules, most prominently in Europe Thales Alenia Space (TAS). This collaboration also offers the opportunity to work with TAS on the use of the same building blocks in other space applications, such as Earth observation.



Product Portfolio

TTTech Aerospace provides network and avionics core systems for use in safety-critical applications. These products encompass development and testing, embedded software, configuration and verification tools, flight hardware, and integrated system solutions. They are certified to the highest quality and safety standards, having passed rigorous safety reviews for various applications such as human space flight, launchers, and satellites. Consequently, they have been certified to the relevant standards by multiple authorities.

TTTech Computertechnik AG

Schönbrunner Straße 7, 1040 Wien
www.tttech.com

In 2024, TTTech's total space revenue grew to €22 million, while more than half the space revenues are made in North America, traction on the European market increases as the need for European space solutions becomes more urgent.

CONTACT

DI (FH) Christian Fidi
Business Unit Aerospace
+43 676 849372880
christian.fidi@tttech.com

FACTS

Sales:	22 M€
ESA Share:	1,4 M€

Notes

Photo: ESA/Webb, NASA & CSA, M. Meixner