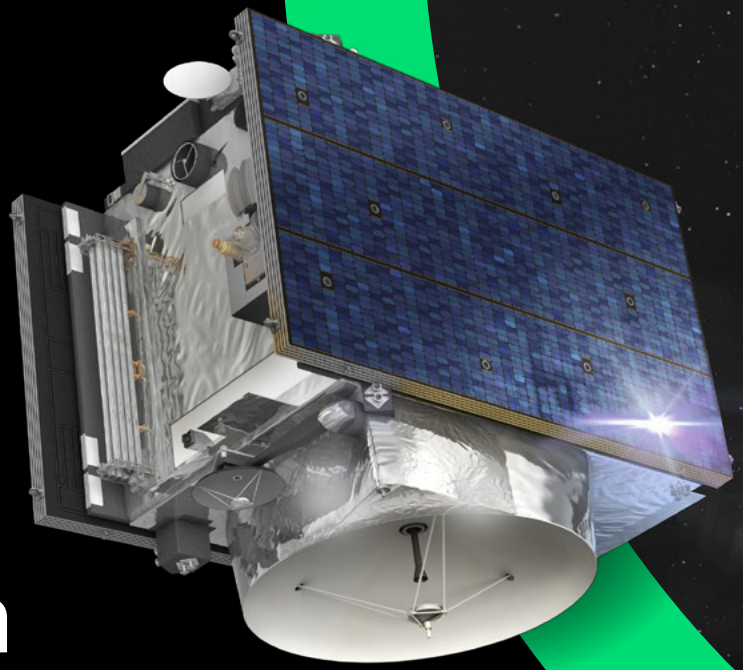
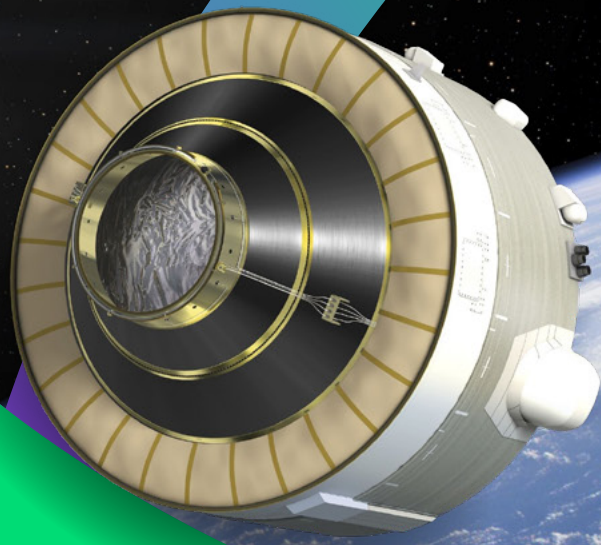
Enterprise Ireland



ESA and **European** supported Space Activities in Ireland **2022**



Space-related developments in Ireland supported by the **European Space Agency (ESA)** and **European Union**

esa

Rialtas na hÉireann
Government of Ireland

Foreword

Since Ireland joined the European Space Agency in 1975, Irish industry and research groups have been at the heart of Europe's space missions, building a reputation as providers of innovative technologies for use in the European space programme. In line with the National Space Strategy for Enterprise, Irish companies are also increasingly utilising space technology to provide solutions in a range of non-space sectors such as energy, medical devices and agriculture.

In November 2022, Ireland was fully represented at the ESA Council of Ministers meeting in Paris where Ministers from ESA's Member States, Associate States and Cooperating States convened to make critical decisions to strengthen Europe's space sector and ensure it continues to serve European citizens.

Ireland's annual investment in ESA is directly aligned with the strategy and objectives of Enterprise Ireland to develop the R&D capability of Irish industry and support the creation of high potential start-up companies.

Enterprise Ireland client companies continue to make ground-breaking progress through the innovation of key technology housed on board space craft. For instance, Cork based Varadis supplied ionising radiation sensors that were installed on the uncrewed Artemis 1 that launched in 2022 to the moon. Furthermore, in 2022, Ubotica Technologies, announced CogniSat-6, the first AI-centric CubeSat mission to include autonomous features which will optimise image gathering on specific areas identified in orbit.

As this annual report demonstrates, the involvement of dynamic Irish companies and research organisations with the European Space Agency has continued to flourish.

The Earth Observation sector in Ireland, which uses data derived from satellites, is contributing to our understanding of the impacts of climate change and is developing climate adaptation and mitigation measures to address same. Irish companies are developing solutions that incorporate advanced satellite systems to address some of these challenges and their impacts on specific sectors, including agriculture, water quality & biodiversity as well as offshore and renewable energy. For instance, in 2022 Irish company Treemetrics signed a €1.2m contract with ESA to use satellite imaging to provide accurate forest carbon credit estimates.

Heading into next year the future for the sector here in Ireland looks extremely bright – of particular interest to Irish space enthusiasts is the Exchange of Letters with ESA to facilitate the launch of Ireland's first satellite, Educational Irish Research Satellite (EIRSAT1). The satellite was designed and built by academic staff and students at University College Dublin (UCD). This is a superb example of cross collaboration across industry, research and public and private bodies to include Science Foundation Ireland, the Irish Research Council, Openet and the Department of Enterprise, Trade and Employment.

The number of Irish companies actively engaged with the European Space Agency (ESA) is at its highest ever - 96 organisations in total, with 4 coming on stream in the last year alone. I look forward to following the continued and impressive contributions of the industry in Ireland to European and Global space activities.

Leo Clancy

CEO, Enterprise Ireland

Front cover image is an artist's view of JUICE: ESA - D. Ducros

Introduction

In 2022, significant progress was made by the global space sector with commercial markets growing to a value of €360bn, accounting for 78% of global space activity. Upstream accounted for 3% of the commercial activity, with downstream services – focusing primarily on satellite communications, global satellite navigation and positioning system (GNSS) and Earth Observation – accounting for the majority (97%). The European share of the global upstream market was 19% of manufacturing value and 24% of global downstream services sector. Importantly, European private investment in space start-ups increased by 66% year-on-year, to a total of more than €1bn[1].

Ireland has an increasing number of space-active companies, realising economic benefit from participation in the world's second-largest space market and establishing supply opportunities overseas. The value of European Space Agency (ESA) placed contracts in Ireland in 2022 was €12.7m, with industrial activities accounting for the bulk of this figure. In 2022, 26 companies, including three new companies, were supported to develop high-tech products in Ireland, with additional industrial co-funding of €3.4m. Contracts totalling €587k were also placed with five Research-Performing Organisations (RPOs) in Ireland in the same period.

In line with the National Space Strategy for Enterprise, Irish companies continued to bring technology innovation to the space sector in 2022, many through 'spinning in' innovative technologies from terrestrial industrial sectors. For example, when NASA launched Artemis 1 in 2022 in a return to the Moon, Varadis radiation sensors were on board the Orion crew module to monitor the levels of ionising radiation throughout the mission. It is important to note that Irish companies are also increasingly exploiting space technologies in non-space markets, including the automotive, energy and medical device markets.

An ESA Ministerial Council meeting also took place in 2022 in Paris, at which Ireland announced an increased budget commitment to ESA recognising the economic return – both through export growth and the significant number of high value-added jobs – derived through our membership of the Agency. Industry in Ireland continues to integrate well into global space supply chains and an ever-increasing number of companies are providing high-tech, mission-critical solutions to the international space market.

The European Space Regulation highlights the need to foster the integration of new entrants to space supply chains. It is encouraging to see an increasing number of companies (at least eight to date) based in Ireland actively pursuing collaborative research, development and innovation (RD&I) opportunities with European space sector supply chains – partnering with Prime Contractors and Large System Integrators (LSIs) to deliver high-tech solutions to this competitive market. The level of spin-out activity and their capacity to attract investment from private funds gives confidence that industry in Ireland – both supplying hardware and developing solutions based on the use of space assets – is on the right path to both playing a key role in and realising an economic return through active participation across global supply chains.

Finally, 2022 was a year of change for the Irish Delegation to ESA. We would like to thank Ciara Bartley, Tony McDonald and Bryan Rodgers for their commitment to the Irish space industry during their time with the Delegation and impressive results realised. We wish them all the very best for the future.

1 All figures quoted provided by the European Space Policy Institute (ESPI) and the European Space Agency (ESA).

Content

01 Tackling industry applications using Earth Observation satellite data

Ubotica to launch AI-Centric satellite

In November 2022, Ubotica Technologies announced CogniSat-6, the first AI-centric CubeSat mission to include autonomous features.

CogniSat-6 will carry the CogniSat edge computing platform into low-Earth orbit. It will provide reactive retargeting to optimise image gathering on specific areas identified in orbit – without intervention from the ground. This allows faster response times for satellite tip and cue operations, resulting in higher value data gathering. This significantly accelerates the mission return on investment.

Additionally, the mission will execute a wide selection of CogniSat applications. These enhance the value of imagery available for analysis through smart, AI-enabled compression techniques. This yields a six-fold increase in the usable data received by the ground station compared to the transmission of uncompressed images – and a two-fold increase compared to standard compression.

Figure 1. Ubotica EdgeAI in Space: Near real-time insights © Ubotica Technologies

DAVRA wins €2m contract with ESA for End-to End Application Enablement Solution for Mine Monitoring

Davra won a €2m InCubed (ESA's Earth Observation Innovation Programme) contract to provide a management tool for the ongoing compliance assessment and monitoring of mine sites. The platform will be used during each mine's lifecycle – from early-stage prospecting, through production and to end-of-life operation. The solution will provide a wealth of data derived from industrial IoT sensors, satellite and earth observation, drone and LiDAR (laser imaging, detection and ranging), weather and climate data. The solution analyses combined data sets to provide actionable insights and predictive modelling. As water management is key in mine management, the products and services provided focus on its management.

Treemetrics signs €1.2m contract with ESA

Treemetrics, a developer of forestry management software, signed a contract with ESA in 2022 valued at €1.2m. Under the two-year term, Treemetrics will use satellite imaging, data analytics and advanced forest measurement technology to provide accurate forest carbon credit estimates.

The global demand for forest carbon credits is growing every year – having nearly quadrupled in 2021 – driven by an increasing desire across society to reduce carbon footprints. Many organisations across the globe are voluntarily committing to this and investors are demanding high-quality carbon projects. Planting trees and restoring forests are an important part of the global fight against climate change – and accurate forest measurement is key in this.

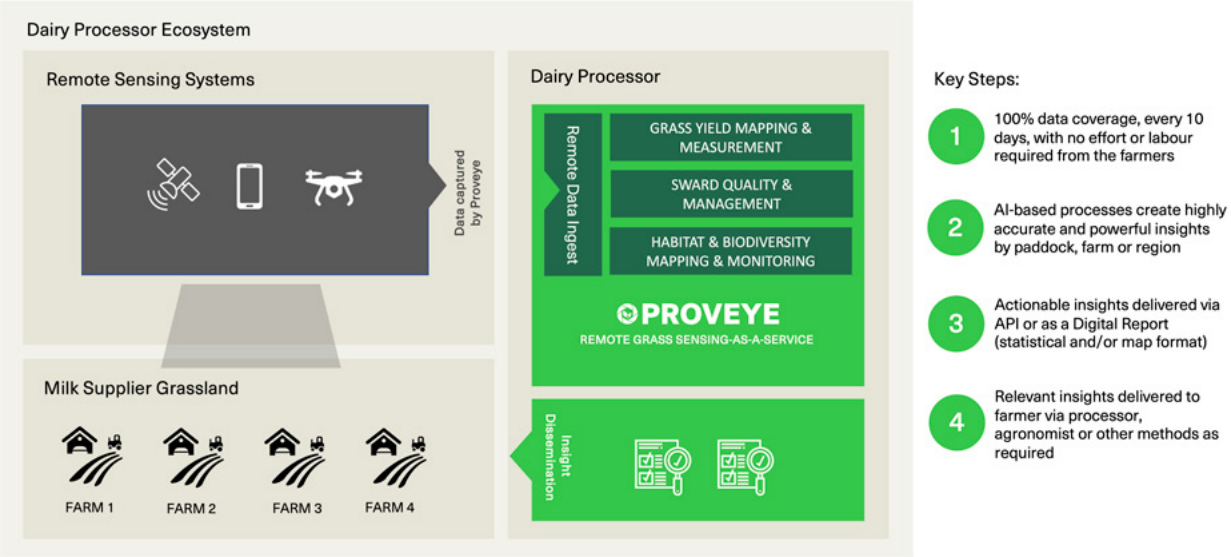


Figure 2. Proveye's automated remote sensing as a service for grassland monitoring. © Proveye

Proveye launches beta grass and habitat measurement solution for the dairy industry

Proveye launched its remote sensing-as-a-service solution for grassland with support from ESA, helping the dairy and beef industries make a leap forward in productivity and sustainability through automated measurement at scale of key grassland and habitat indicators.

The Proveye Grassland solution automates the generation of powerful new insights that can only be unlocked by measuring grassland accurately at scale. It uses satellite processing and drone-based remote-sensing imagery using cloud-based technologies. The quality of this data drives precision AI models to solve business challenges in sustainable milk and beef production.

The platform delivers insights at paddock, farm and regional level for grass yield and grass quality, alongside habitat and biodiversity monitoring.

Icon Geo already seeing the commercial gains from ESA Support

Icon Geo, a sister company of Compass Informatics and part of Tracsis Plc, is one of Ireland's leading satellite image analysers. The company is currently developing an automatic processing platform called HubCAP, designed to draw more information from the EU's Copernicus satellite images, and is supported by Ireland's membership of ESA both financially and technically via the InCubed programme.

Icon Geo has already been awarded a multi-million Euro commercial contract to provide a regular land use analysis in support of the Common Agricultural Policy (CAP). The system examines and analyses every available image to provide CAP paying agencies with vital information to help ensure an accurate and speedy payment process.

The images are captured from satellites that orbit the Earth from a distance of nearly 700 km, but with the help of analysis methods can still tell the difference between a field of barley and a field of wheat.

Figure 3. The right hand side of the image shows the Infra-Red data sensed by the satellite that is invisible to the human eye

02 Space and the green agenda

GeoAerospace Geospatial Data Stack for Greenhouse Gas emission monitoring

GeoAerospace – specialist providers of air and space-borne data – has been deploying multi-sensor Remote Sensing technologies over Ireland for the large-scale capture and processing of Optical (RGB, Multispectral, Thermal) and LiDAR data. This supports the SFI-Microsoft-funded Greenhouse Gas (GHG) Emission Modelling project, co-ordinated by Maynooth University.

Data was captured over agricultural, forest, peat and urban environments across Ireland on an ongoing basis throughout 2022. Fused with Copernicus Sentinel-2 data and ground-based sensor datasets (CO_2, weather), models were built for biomass, growth prediction and GHG emissions.

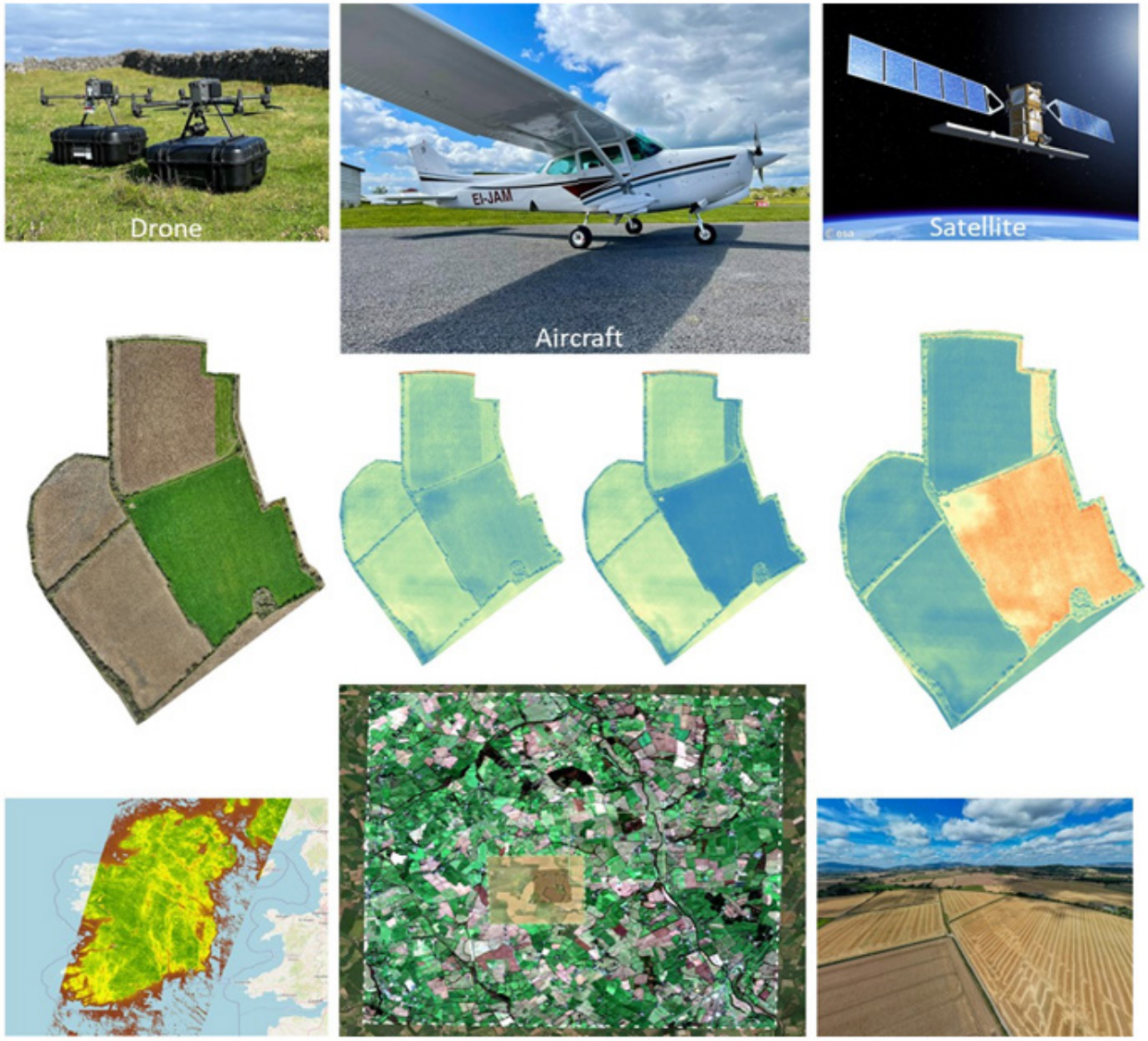


Figure 4. L-R/Row 1: Geospatial Data Stack: GeoAerospace Drone Data, GeoAerospace Aircraft Data combined with ESA Satellite Data; **L-R/Row 2:** Temporal & spatial time series analysis for investigating land use change over time; **L-R/Row 3:** NDVI spaceborne at national scale, Spaceborne Sentinel-2 and aerial data at regional/local scale, drone imagery at farm/field scale

Icon Geo in ESA Pathfinder success

Icon Geo was selected by ESA in partnership with Maynooth University to carry out a Pathfinder project. This involved the novel use of satellite imagery to evaluate Irish hedgerows using criteria that defines the contributions this vast natural resource offers.

Hedgerows provide food and shelter for insects, birds and other animals, forming corridors that permit wildlife to move between habitats. They also contribute to soil health and protection and overall farmland productivity.

The project created an inventory and analysis of over 750,000 separate hedgerows in Ireland. It used a combination of different image types to explore methods of measuring biomass and vegetation health. A series of change over time processes also aided monitoring. The approach taken will allow a 'look-back' to any point in time from 2016 onwards using an online image archive.

Figure 5. The image shows the Optical and Synthetic Aperture Radar (SAR) data sensed by the satellite and identification of hedgerows using AI-type processes © Icon Geo, Sentinel1 & Sentinel 2, 2022

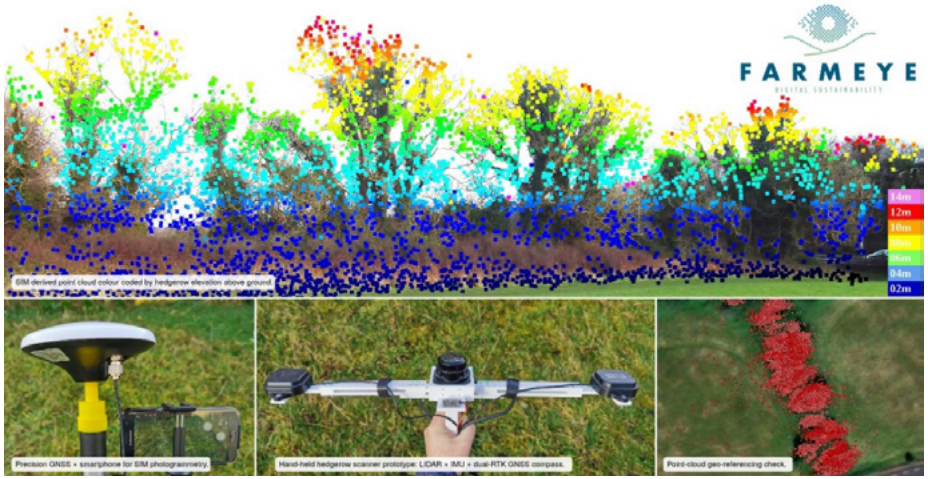
FARMEYE concludes feasibility study on measuring hedgerows for carbon sequestration and biodiversity potential

FARMEYE successfully concluded its ESA-funded feasibility study into building scalable and affordable methods to measure, report and verify hedgerows on farms. Hedgerows play a significant role in carbon capture and biodiversity protection on farms and contribute to sustainable agricultural production.

During the feasibility study, the use of Structure-from-Motion photogrammetry obtained from smartphone video coupled with low-cost precision-GPS/GNSS was explored. An algorithm to convert the resulting point cloud to estimated woody volume was adapted from published literature.

The project – named 'Project Purlieu' – aims to build a high-resolution dataset of hedgerows at selected locations and to use this to build machine-learning models using aerial and space imagery. A side benefit of the use of photogrammetry is the possibility of automated species identification and tree ivy detection.

Figure 6. Hedgerow point cloud visualisation obtained from a prototype hand-held scanner combining photogrammetry, lidar and low-cost precision GNSS © FARMEYE



Geodesignhub are computing urban sprawl metrics with earth observation data

Geodesignhub provides technology to conduct digital negotiations in infrastructure investments, tourism, environmental management, climate change adaptation, urban form changes and more. It is hoped the project will become key in developing an analytical understanding of the impacts of negotiated actions. Despite many efforts to curb urban sprawl, it continues to progress dramatically – from 1990 to 2014, urban sprawl increased by 95% worldwide. During this period, the built-up area grew by an average of around 1.2 square kilometers (more than 160 football fields) every hour.

The main objective of this project is to develop cloud-based technology to compute sprawl using data from ESA. Geodesignhub used the Global Human Settlements Layer (GHSL) to build base data needed to run algorithms. This work is part of an extensive analytics toolkit being built around the impact of land use and urban management decisions.

03 Positioning and navigation solutions powered by space

Eblana Photonics develops laser diodes for space-based Optical Clocks

Dublin-based Eblana Photonics, a manufacturer of advanced laser diodes, was awarded funding in 2022 by ESA to develop compact laser diodes for future space-based optical clocks. Timekeeping is a critical component for a wide array of technologies, from high-frequency trading, 5G communications to navigation. Space-based applications place some of the most stringent requirements on lasers, requiring exceptional performance in harsh environments, while also demanding low size, weight and power requirements. ESA is one of the forces pushing the technology of next generation optical atomic clock forward with the Space Optical Clock – 2 programme. Laser diodes are key components in Strontium optical clocks and will be developed by Eblana.

Figure 7. Eblana photonics proprietary Discrete Mode semiconductor laser diode © Eblana Photonics

Drone Consultants Ireland's GEONAV IoT - Real time indoor / outdoor precise tracking solution

Through the Horizon 2020 program, with the support of EUSPA, Drone Consultants Ireland – and their consortium partners Thales, ChipCraft, HertzSystems and Telespazio – have been developing an aviation quality, reliable navigation solution that improves location accuracy for both indoor and outdoor applications.

Drone Consultants Ireland have been focused on the UAV (Unmanned Aerial Vehicles) version of the device to enable the future of reliable autonomous UAV applications, while additional versions include elite sport and asset-tracking.

In November 2022 the consortium partners gathered in IADT Dun Laoghaire, Co Dublin. After many years of work, they conducted a successful prototype test successfully tracking the device in 3D on their new dashboard – furthering the development of the associated beacons for augmentation in hard-to-reach places.

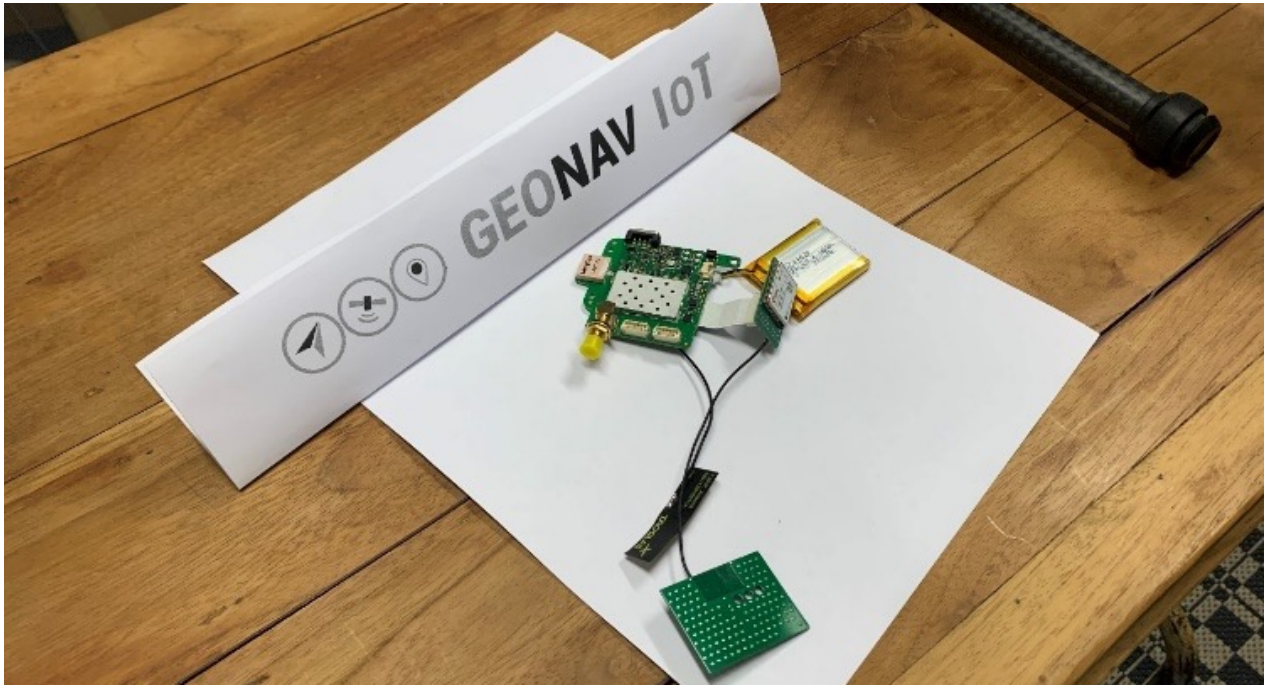


Figure 8a. GEONAV IoT Preparing for flight © Drone Consultants Ireland

Figure 8b. GEONAV IoT Device © Drone Consultants Ireland

Drone Consultants Ireland's Space for Urban Air Mobility Feasibility Study - Expanding the use of space data

As part of an ESA initiative to identify and develop new tools to apply space data as a solution to aid in the expansion of UAM (Urban Air Mobility), Drone Consultants Ireland, along with Thales, Aldorane, Onera, Neometsys and ESSP-SAS, interviewed UAV (unmanned aerial vehicles/ drones) companies and investigated suitable locations, business-use cases and end users to fully research the scope and needs of the technology.

Drone Consultants Ireland primarily focused on Dun Laoghaire harbour with the support of DLRCOCO and Parcel Planet in West Dublin as potential locations. The company also received help from the Irish Aviation Authority, Enterprise Ireland and ESA-BIC when the consortium gathered in Ireland to conduct workshops and research.

Figure 9a. Dun Laoghaire Harbour potential hub for UAM © Drone Consultants Ireland

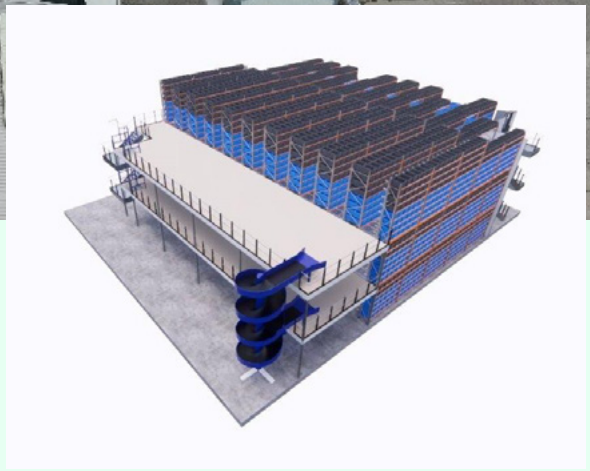


Figure 9b. Parcel dispatch to be connected with UAV delivery © Drone Consultants Ireland

Taoglas paves the way for GNSS innovation with ESA's support

As technology advances, the robotics, automotive, micro-mobility and precision agriculture industries increasingly rely on high-precision positional accuracy. Real-time tracking and navigation are essential for ensuring safety, functionality and sustainability.

Taoglas is a firm innovating in GNSS antennas, offering precise location capabilities in lightweight, impact-resistant and compact structures. In 2022, thanks to ESA's support through the Navigation Innovation and Support Programme (NAVISP), Taoglas invested in RD&I, leading to the release of two new multiband high-performance patches, with more to follow in 2023.

As the global GNSS market grows, Taoglas' GNSS product sales have also increased; in 2022, the company shipped millions of GNSS antennas worldwide.

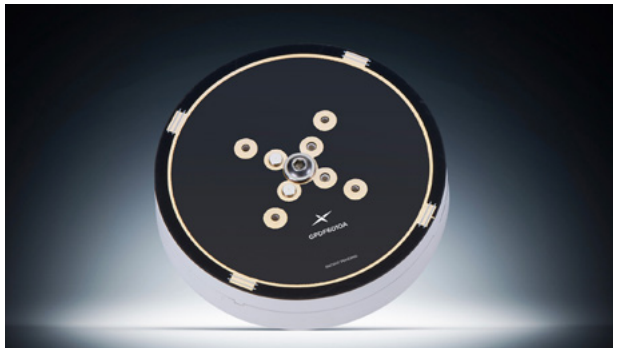


Figure 10. Taoglas all-band High Precision GNSS Stacked Patch Antenna © Taoglas

Cillian O'Driscoll Consulting Ltd delivers state-of-the-art navigation authentication test platform

The demand for high-precision positioning from GNSS is constantly increasing. More dependence on these systems means increased potential for attack – a malicious party could "spoof" satellite signals to throw off positional data. To counter this threat, the European GNSS, Galileo, is introducing several features to authenticate navigation signals.

Cillian O'Driscoll Consulting Ltd, a Cork-based GNSS R&D company, has been working closely with ESA since 2017, providing development tools and RD&I support to the development of authentication techniques for Galileo. This work culminated in December 2022 with the delivery of Nautilus, a low-cost navigation authentication testing platform that is the first of its kind. Nautilus is currently being used in system performance evaluation and in the development of implementation guidelines for GNSS receiver manufacturers.

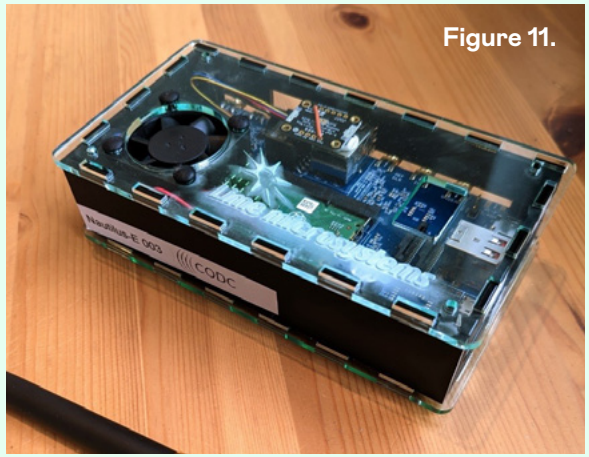


Figure 11. The Nautilus embedded navigation authentication test platform, based on the LimeNet-Micro development board from Lime microsystems.
© Cillian O'Driscoll Consulting Ltd.

danalto is extending GNSS Location Coverage Indoors in a Lightweight Manner

Dublin-based software company danalto Ltd. specialises in positioning and spatial intelligence technologies and won a contract with ESA to demonstrate low-infrastructure indoor location technologies that complement GNSS/Galileo. During 2022, danalto undertook extensive research and development to build a prototype of collaborate RTLS-boosters (Real Time Location Systems). Integrating and synchronizing multiple location-aware radio technologies, these boosters can measure location positioning with high accuracy in real time. This is a significant development, extending the reach of GNSS into indoor spaces and danalto hopes that this will allow impactful applications and serve as a building block for future location services.

04 Satellite communications systems

Space Exploration's New Optical Satellite Communications Ground Stations and Space Debris Detection

Space Exploration Ltd. (SEL) is a new company in Ireland's space industry and has recently established a remotely operated Optical Ground Station (OGS) and Space Debris Detection Network (SDDN) in Southern Spain.

OGS operations can receive and transmit data to and from in-orbit satellites at the OGS site, which is presently in receiver mode. The Network Operations Centre in Boyle, County Roscommon can access the OGS site, and receive real-time weather and satellite status, as well as predictive cloud analysis. This operation interfaces through web and app-based software, providing near real-time status of satellites and data downlinks. Its ground stations can also detect and catalogue space debris to mitigate any debris that may crash into satellites.

In 2022, SEL participated in key networking/marketing events sponsored by ESA in The Netherlands and Germany, establishing SEL's position in the laser communication/OGS field.

During 2022, strategic partnerships were established with companies in Ireland and abroad to utilise SEL's knowledge and manufacturing experience for the development of a turn-key OGS for eventual manufacture.

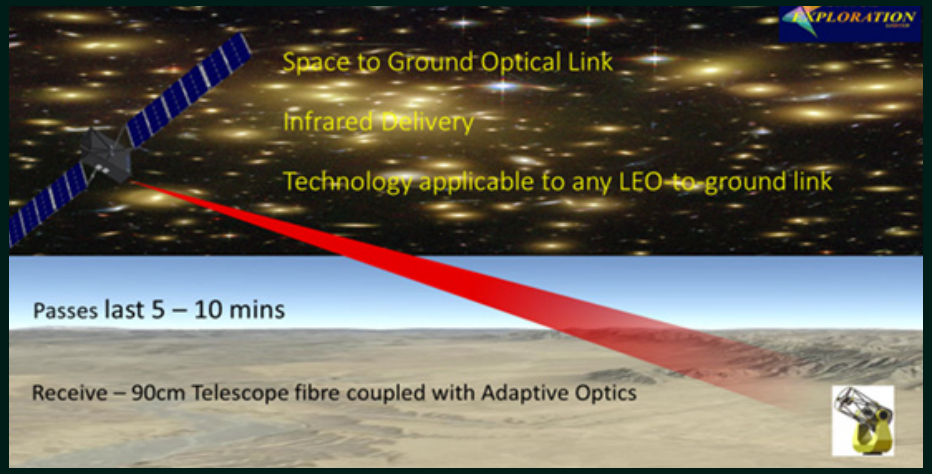


Figure 12a. Space to Optical Ground Station link © Space Exploration Ltd. (SEL)

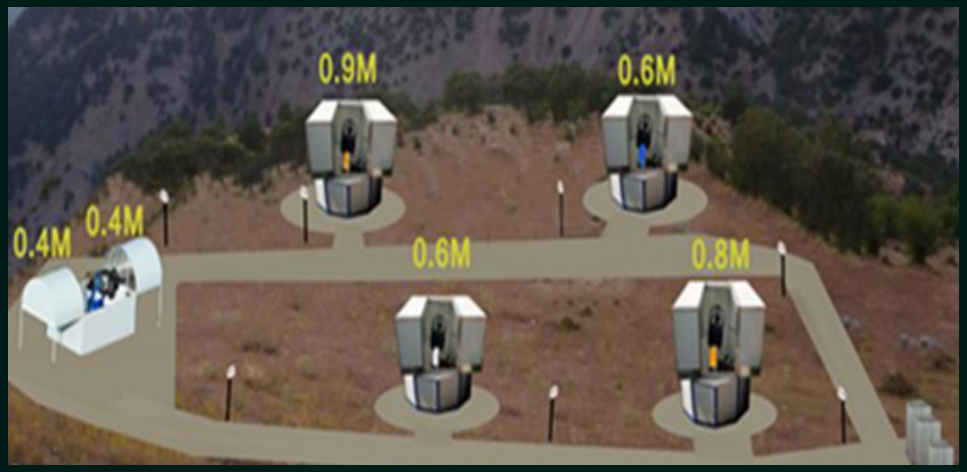


Figure 12b. Suite of Optical Satellite Ground Stations and Space Debris Detection Network at 1500m mountain site, Spain © Space Exploration Ltd. (SEL)

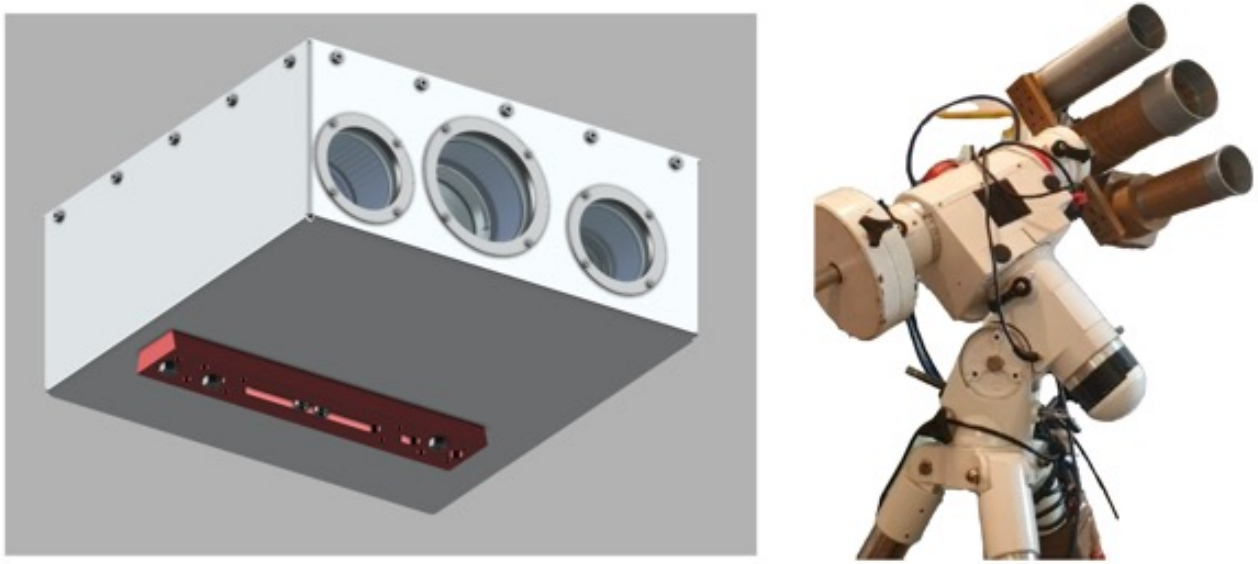


Figure 13. Prototype render of the video system (left), including a 3D printed model of HALO attached to a robotic telescope mount (right) © Mbryonics

Mbryonics' HALO system is a key enabler for autonomous optical ground stations

In 2022, ESA selected Mbryonics for the HALO (High Altitude Laser from Orbit) Gateway project to design and manufacture a laser safety system for autonomous optical ground stations that will be deployed in urban and isolated areas to guarantee the safety of any aircraft flying within range. The HALO system consists of a multi-spectral video imaging system which employs AI and machine learning for image processing detection algorithms to identify aircraft around a zone of interest. The cameras in use cover the visible, short-wave infra-red (in case of low-level haze) and long-wave infra-red parts of the spectrum, as the primary detection system.

This solution is predominantly for Laser ranging applications, but will become essential for high-power optical feeder links requiring higher data throughput in the future. The project is to begin field testing in Q4 2023 at a European laser ranging station.

05 Delivering technology innovation to the space and non-space sector

Innalabs innovative gyros win new contracts as deliveries to customers start

In 2022, InnaLabs was awarded the contract to deliver ARIETIS gyro to ESA's ARIEL Science mission, with Airbus Defence & Space (ADS) selected as the prime contractor. The purpose of the mission is to answer key cosmological questions, like: what are the physical processes shaping planetary atmospheres? What are exoplanets made of? How do planets and planetary systems form and evolve?

In parallel, ARIETIS gyro passed Critical Design Review (CDR) and the first Engineering Model was shipped to the ESA PLATO mission. ARIETIS-NS, a commercial space gyro, completed CDR and Engineering Models were shipped to several commercial and institutional customers, including the ESA Hera mission. New orders were received for Earth Observation, Telecom and science applications.

Figure 14. ARIETIS-NS gyro as delivered to the ESA Hera mission © InnaLabs

ÉireComposites – advancing space technology with lightweight composite structures

ÉireComposites, a developer of upstream technologies, has created the test models of the stray light baffles for ESA's Altius mission. Working in partnership with OIP Space Instruments and QinetiQ, they have employed advanced composite materials designed to withstand the challenging space environment and filter stray light for the advanced optical system onboard the satellite. The flight models will be installed in preparation for a launch from Kourou, French Guiana, in 2025.

In 2022, ÉireComposites was also awarded an ESA contract to develop large sandwich panel structures without using an autoclave – an expensive piece of equipment that applies pressure and heat to cure composite materials. This innovative technology allows for the manufacture of large composite structures for satellites and launchers at reduced cost. ÉireComposites also manufactured a full-scale lattice structure for ATG Europe, using advanced composite materials to create a novel launcher structure that is both lightweight and exceptionally strong.

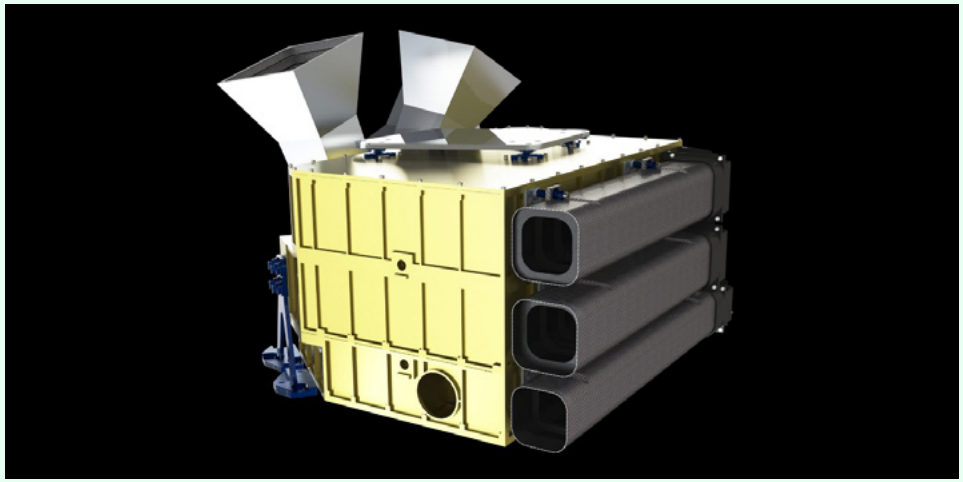


Figure 15. Altius Optical Instrument with the three stray light baffles affixed on the right, under development at ÉireComposites. © OIP Space Instruments

Lios has secured a significant development contract with ESA

Lios is a young Irish company on the road to increasing involvement in space and is part of Ireland's ever-growing space sector.

A Phase 1 development contract between ESA and Lios took place over 12 months, finishing in 2022. Through this work, Lios successfully demonstrated the acoustic insulation performance of SoundBounce for Fairing Acoustic Protection (FAP) through large-scale laboratory testing. The project focused on the low-frequency noise and vibration generated during the launch and separation phases of launcher flight.

Lios has now been awarded the Phase 2 contract for this large-scale collaborative project, valued at almost €1m in co-funding with ESA. The renewed ESA contract will support advanced material innovations for the future of acoustics in space.

Figure 16. L to R: Lios Founders Eimear O'Carroll (CTO) and Rhona Togher (CEO) © The Business Post

ATG Innovation completes extensive test campaign to validate interfaces on composite lattice Satellite Central Tubes

In 2022, ATG Innovation continued their ESA-funded development project to verify interface zones of their ultra-lightweight composite lattice space structures, specifically with regard to Satellite Central Tube applications. The Central Tube is the backbone of a satellite, supporting the payload, fuel tanks and avionics boxes while also providing the primary interface between the spacecraft and the launcher. ATG's lattice structures provide mass savings of up to 30%, along with cost savings due to their one-shot manufacturing process that integrates all of the interface zones. An extensive test campaign consisting of over 150 samples of various attachment types was conducted to validate interface zones in lattice structures, with the results fed into the manufacture of a representative full-scale satellite central tube. Verification of the interface zones on this representative structure will result in progressing the technology from Technology Readiness Level (TRL) 5 to TRL6.

Figure 17. Integrated interface zones to be used in ATG Innovation's lattice satellite central tube structures. © ATG Innovation Ltd.

Telemetry subsystem for Vega-C developed by Curtiss-Wright

Dublin-based aerospace company Curtiss-Wright has developed and qualified the Telemetry subsystem for the new European launcher Vega-C. This measuring equipment is distributed across all four launcher stages and the subsystem has been designed to acquire and process vital launcher data from over 250 analogue and digital sensors. During the flight, this data is transmitted to ground stations via radio link using an RF Telemetry transmitter also designed by Curtiss-Wright.

The inaugural flight of Vega-C launcher supported by Curtiss-Wright's products was successfully completed in July 2022. Curtiss-Wright has commenced manufacturing and acceptance testing of telemetry equipment for the first fifteen Vega-C flights, with deliveries expected from 2022 to 2024.

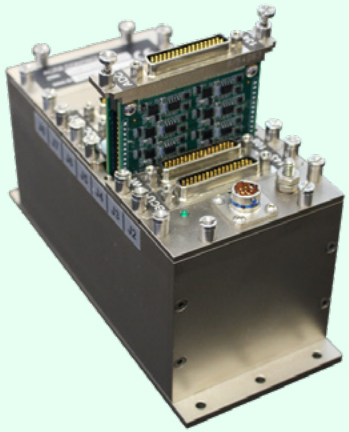


Figure 18. Curtiss-Wright KAM-500 Data Acquisition Unit © Curtiss-Wright

Figure 19. The next-generation, AI-Enabled high-speed HD video camera from Réaltra that is being developed for the new European re-usable launcher THEMIS as part of the SALTO project under Horizon Europe programme © Réaltra Space Systems Engineering

Réaltra to provide the HD Video Camera for tests of Europe's first reusable rocket

Réaltra has been selected to provide the high-speed HD video camera in the Horizon Europe-funded SALTO (reuSable strAtegic space Launcher Technologies & Operations) project that will help develop Europe's first reusable rocket, THEMIS.

Réaltra will be responsible for the development, test and delivery of the cameras that will be mounted on the new launcher as part of the test campaigns for the SALTO project.

The SALTO project – a consortium involving 25 partners from 12 countries with a budget of €39m – will test vertical landing by a reusable launcher stage prototype within the next three years.

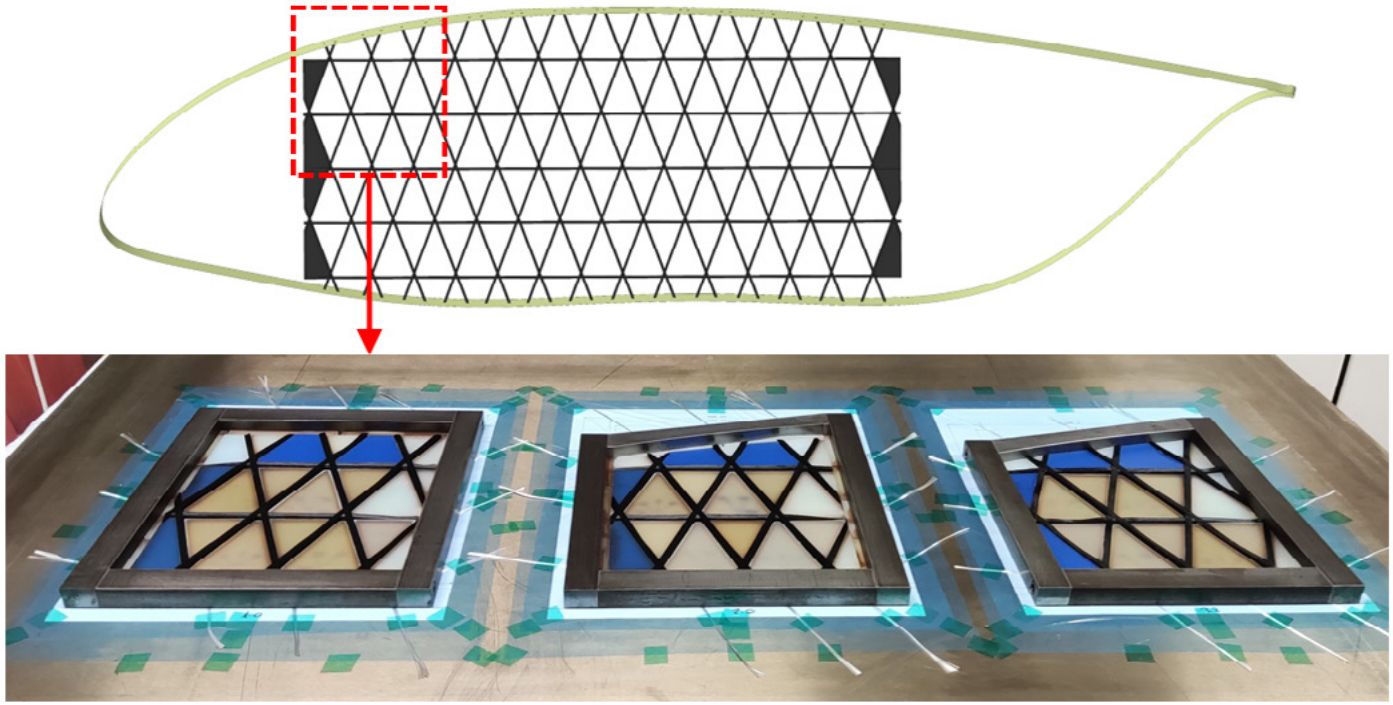


Figure 20. Demonstrators for optimisation of ATG Innovation's one-shot manufacturing process for lattice aircraft ribs. © ATG innovation Ltd.

ATG Innovation adapts its composite lattice structure technology to aircraft applications

ATG Innovation's composite lattice technology has been applied to the design and manufacture of aircraft ribs. Commercial aircraft ribs are still typically aluminium structures that involve multiple components and highly intensive manufacturing processes, including machining, forming, cutting, bonding and fastening. Implementing ATG's CFRP lattice technology provides multiple benefits, including the ability to tailor the structure to optimise design, making further significant weight savings due to efficient and light materials, and allowing assembly and maintenance via an open-lattice structure. Its one-shot manufacturing process also reduces costs. The investigation of this opportunity was funded in 2022 through the ESA Business Incubation Centre (ESA BIC) Technology Transfer programme and focused on optimising the manufacturing process to allow the high-volume production required by the aviation industry.

O.C.E. Technology and multinational partner develop operating system

In 2022, O.C.E. completed an ESA contract to develop a highly secure, real-time operating system for radiation-hardened microcontrollers. These are being used on next-generation satellite subsystems, such as star trackers, which O.C.E. also sells. Star trackers use an internal, multi-directional map of the stars to allow a satellite to determine its orientation. O.C.E. has also successfully concluded negotiations with ESA to develop a multicore version of its operating system. O.C.E.'s AI technology, currently under evaluation by ESA, was independently tested by a European AI software company and found to be the highest performing and easiest to use for porting AI applications from the cloud to the target embedded hardware.

Figure 21a. O.C.E.'s embedded AI development kit package © O.C.E. Technology Ltd

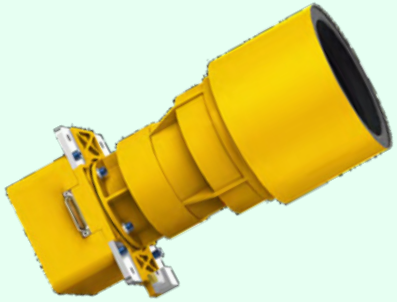


Figure 21b. Star tracker to determine satellite orientation © O.C.E. Technology Ltd

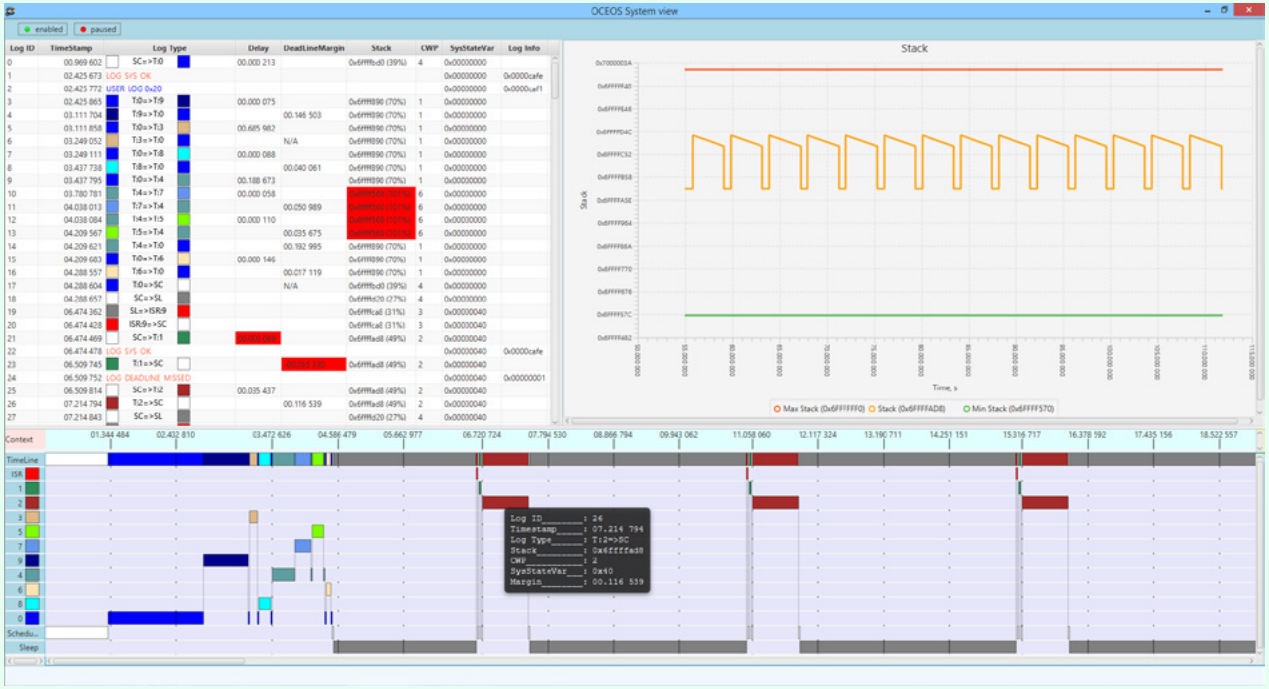


Figure 21c. O.C.E.'s debug tool display's operating system activity © O.C.E. Technology Ltd

Varadis radiation sensors detect ionizing radiation on Artemis moon missions

When NASA launched Artemis 1 in 2022 in a return to the Moon, Varadis radiation sensors were on board the Orion crew module to monitor the levels of ionising radiation throughout the mission.

The sensors, called RADFETS, are designed and developed by Cork-based Varadis and allow space agencies to accurately measure the absorbed doses of ionizing radiation – including gamma rays, protons and x-rays – during their space missions.

With the successful completion of the uncrewed mission and the performance of the Varadis RADFETs, a piece of Irish-designed technology will be on board future Artemis missions to the Moon. Varadis RADFETs are now in use both on the International Space Station, as well as in the Artemis Orion crew module.

Figure 22. Varadis radiation sensors detect ionizing radiation on Artemis Moon missions © Varadis

06 Irish companies supporting access to space

Microchip Technology designs a power core module demonstrator for space launch vehicles

Microchip Technology's integrated power solutions team designed a Power Core Module (PCM) demonstrator for future space launch vehicles under ESA's General Support Technology Programme. The PCM can drive and control electrical motors for thrust vector control, which guides the vehicle during flight. The product contains silicon carbide semiconductors and innovative packaging, which result in improved performance, lower power consumption and comparable smaller size. Its reliability and performance will be tested in an environment simulating satellite launcher conditions on-site in Ennis and the PCM can be used in general aerospace where control of an actuator using an electrical motor is required, such as a commercial aircraft.

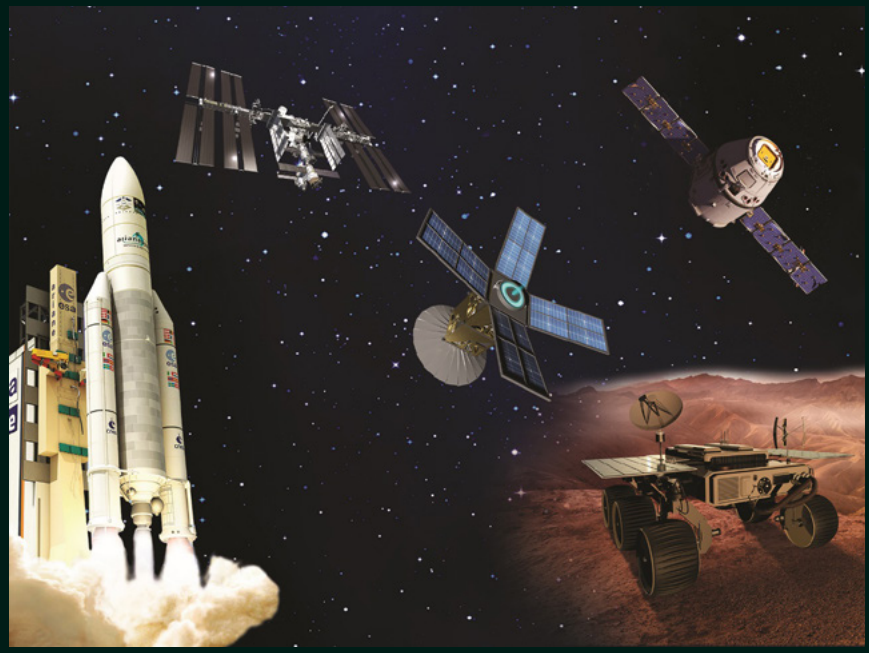


Figure 23. Aiming higher with Microchip Space Solutions © Microchip

Critical Propulsion Technologies allow Nammo Ireland to enter U.S. and Asian markets

Nammo Ireland contributed to three successful flights of Ariane 5, the European heavy lift launch vehicle, during 2022. Each flight successfully delivered multinational payloads for Earth observation, telecommunication and meteorological missions launched from the spaceport in French Guiana.

With support from Enterprise Ireland and ESA, the company developed numerous propellant control valves for future flight opportunities in Europe and the U.S., including reusable technologies. These opportunities allowed Nammo Ireland to grow along with its Irish supply chain.

Nammo Ireland has also recently developed a commercially leveraged propellant control valve, developed under ESA, for customers in Europe and Asia, allowing the company to grow its highly skilled workforce by 10% across the year.

07 Space-related events in 2022

All-Island Space Industry Day, May 2022

The third All-Island Space Industry Day, a collaborative event between Enterprise Ireland, ADS Group and Invest NI, took place in May at Maynooth College. The return to in-person events and the growth in interest in space – and in particular its downstream aspects – resulted in a strong attendance drawn from across the Irish Space Industry, leading to excellent networking and information-sharing opportunities. The focus for this event was mainly on the downstream and Space as a Service, with particular emphasis on the green agenda. The event was opened by the Minister of State for Business, Employment and Retail, while attendees also heard from ESA, EUSPA and the UK Space Agency, as well as details on academic and industry developments. In addition, four break-out sessions – Aerospace/Aviation, Agriculture / Forestry / Disaster Mitigation, Climate Sustainability, Maritime Security / Off-shore Energy – were conducted to allow for in-depth discussion.

Trade Mission to Italy, October 2022

In October 2022, 10 Enterprise Ireland-supported companies attended a Trade Mission to Italy which included a visit to ESRIN, ESA's centre for Earth Observation. During the visit, ESA's Director of the Earth Observation programme announced that two Irish companies have been awarded co-funding under ESA's Earth Observation programme, with a total value over €3m.

Following an intensive day at ESA, the following day was spent nearby at ASI, Italy's Space Agency, where bilateral meetings were held with eight Italian space companies.

Figure 24. Trade Mission to ESA, Oct. 2022 © ESA

Navigation Workshop, Dublin December 2022

Over 20 companies participated in a workshop in Dublin based around the core navigation programmes from ESA that aim to support new developments in PNT (Positioning, Navigation and Timing) technologies with a commercial focus. EUSPA also participated remotely, providing an overview of research programmes through Horizon Europe. Companies that presented their developments included Taoglas and danalto.

Figure 25. Navigation Workshop, Dublin Dec. 2022 © Enterprise Ireland

ESA Council of Ministers 2022 (CM22)

The Minister of State for Business, Employment and Retail attended ESA's triennial Ministerial Council meeting, CM22, in Paris. The CM22 agreed future ESA policies and strategies and made decisions on Member States' investment in future space programmes.

During CM22, Ireland committed €125m investment (running to 2027) in both ESA's Mandatory Programmes (ESA's Scientific Programme and the ESA General Budget) and several of ESA's Optional Programmes.

Ireland continued its investment in several of ESA's future space programmes at CM22, including Human Space Flight and Robotic Exploration, Earth Observation, Navigation, Telecommunications and Integrated Applications, Technology, Space Transportation and PRODEX.

Figure 26. Members of the Irish Delegation, with Minister of State for Business, Employment and Retail Damien English, announcing the launch of "ESA Activities in Ireland 2021" report at CM22 © Enterprise Ireland

08 European Union space developments in 2022

The EU Strategic Compass, a framework document, was published in March 2022 and outlined plans to strengthen the EU's security and defence policy by 2030. It recognises space as a contested strategic domain and set out the publication of this strategy as a key deliverable. Its publication is part of wider conversation on vulnerabilities in space.

Two formal and one informal EU Competitiveness Councils on Space took place in 2022. An informal Competitiveness Council (Space) took place in Toulouse in February where Commissioner Thierry Breton presented ways forward for an EU strategy on Space Traffic Management and an update on a proposed EU Secure Connectivity Initiative. ESA Director General, Mr Josef Aschbacher, presented two of ESA's new 'Accelerators' titled "Protection of Space Assets" and "Rapid and Resilient Crisis Response".

The President of France, Mr Emmanuel Macron, also made an address to Ministers on the importance of European sovereignty and competitiveness in space, the alignment between space and defence, space traffic management and France's view on the future of European space exploration.

At the two Formal EU Competitiveness Councils on Space Ministers exchanged views on the importance of the EU having secure, autonomous, and affordable access to space and, barriers hindering the uptake of EU space services at European and national levels.

2022 Space Calls under Horizon Europe Cluster 4 (Digital, Industry and Space)

On 16 Feb 2022, 11 Horizon Europe space calls closed, with a combined budget of €87.5m. Of that budget, €39.2m was allotted to foster competitiveness of space systems, with three calls focusing on future space ecosystems, electrical propulsion and end-to-end Earth observation systems and associated services. A further €21m was allocated for using Copernicus, the Earth Observation (EO) component of the EU space programme, to evolve services, with another three calls focusing on marine environment monitoring, anthropogenic CO_2 emissions monitoring and verification and land monitoring. A wider 'targeted and strategic actions supporting the EU space sector' research area (budget: €18.5m) focused on space science and exploration technologies, as well as on space technologies for European non-dependence and competitiveness. Remaining research areas focused on space weather, improving interoperability of European access to space ground facilities and education and skills for the EU space sector.

Two Irish applicants were successfully funded in 2022, under separate calls, winning a total of more than €620,000. The ARCAFF (Active Region Classification and Flare Forecasting) project, co-ordinated by the Dublin Institute for Advanced

Studies (DIAS) and with collaborators in Hungary, Italy and the UK, will develop a new forecasting system using end-to-end deep learning models to improve traditional flare forecasting capabilities. It will increase the accuracy and timeliness of current operational flare forecast products and create new time series flare forecasts.

Irish company ISD Aerospace Ltd. participated in the successfully funded SCOPS project, together with collaborators in Belgium, France and Greece and co-ordinated by Thales Alenia Space in Spain. The project will design and evaluate the performance in space of an application-specific integrated circuit, with the aim of controlling several power supply phases in parallel using a non-dependent supply chain. The full award was substantial (€3.4m) with €212,000 going to ISD.

Winning Horizon Europe funding in the space sector – given space's broad applicability into other technology areas – is frequently a stepping stone to winning European funding in other areas; Irish companies previously successfully funded under Horizon Europe have gone on to win significant sums under other European funding mechanisms.

Figure 27. L-R: Simon Chambers (CEO, Axsysnav), Lina Silveira (Project manager, F6S), Martyna Krasauskaitė (Innovation consultant, CIVITTA / Start-up Division), Inga Baltaševičiūtė (Consultant, CIVITTA/ Start-up Division), Simone Carli (Project Manager, Science Park Graz), Paul Silye (Junior Researcher, Brimatech), Cristiana Peres (Communication manager, F6S), Alexandru Duicu (Management consultant, Civitta) © F6S

F6S Network Ireland went to space with the Space Hubs Network

The Space Hubs Network (SUN) programme is a Horizon 2020 initiative aiming to foster the development of start-ups and entrepreneurs in the space technology sector. As a result, the SUN programme helped accelerate the growth of 77 European space start-ups and scale-ups through tailored mentoring programmes, offering opportunities and support at different levels of business maturity: pre-incubation, pre-acceleration and post-acceleration levels. With SUN support, six new spacetech start-ups were established, and 20 were able to attract funding. The programme also gathered knowledge on the key challenges that space start-ups are facing, developing a report, "SUN Position Paper", providing policy recommendations on how to address these challenges, and contributed to raising awareness and the growth of the space community by organising and cooperating with more than 30 events between roadshows, hackathons, webinars at a European level. F6S ran this project with Start-up Division, Civitta, Brimatech, Axsysnav, Science Park Graz and the Polish Space Agency.

Engagement with the European Union Agency for the Space Programme (EUSPA)

The European Union Agency for the Space Programme (EUSPA) has actively engaged with the Irish space sector in 2022 with contributions to the All-Island Space Industry Day in May and the Navigation event in December. There also continues to be strong interest in the EUSPA / Horizon / Cassini programmes from Irish industry.

EUSPA is responsible for operational management of the European Geostationary Navigation Overlay Service (EGNOS) and Galileo satellite navigation programmes and for ensuring the continuous provision of their services. This involves the management, operation, maintenance, continuous improvement, evolution and protection of the systems' infrastructure, including upgrades and obsolescence management. The Agency is also responsible for developing future generations of the systems, the evolution of their services, and for activities related to the extension of their coverage.

EUSPA support the development of downstream and integrated applications based on Galileo, EGNOS and Copernicus, including through the Fundamental Elements funding mechanism and Horizon Europe. They also support the development of fundamental technological elements, such as Galileo-enabled chipsets and receivers, and provide the European Commission with expertise, including in preparing research priorities related to the downstream space market.

Another key part of their work is communications, market development and promotion of Galileo and EGNOS, and of the data, information and services offered by Copernicus, to promote user uptake of these data and services with a view to maximising their socio-economic benefits.

09 Supporting the next generation of space start-ups in Ireland

Ireland hosts an ESA Business Incubation Centre (ESA BIC), which is funded by the Department of Enterprise Trade and Employment, through Ireland's membership of ESA and Enterprise Ireland. ESA BIC Ireland is managed by ESA Space Solutions Ireland (SSI) and comprises of five consortium locations. ESA BIC Ireland offers technical, business, financial and incubation support, as well as national and international networking opportunities to start-ups that have a connection with space and which are developing either upstream or downstream applications.

The primary supports are delivered through the provision of a structured incubation programme that includes financial supports (up to €50k), technical support through ESA and business development training. ESA BIC Ireland is a two-year business incubation programme supporting high potential start-up companies developing a broad range of applications in sectors including agritech, medical device, health and wellness, materials science, semiconductor, maritime, cybersecurity, disability support, sports performance and elite sports.

ESA SSI also offers ESA Spark Funding, a technology transfer funding mechanism that is designed to accelerate product development in companies that are

integrating space technology with a view to developing a new market application. ESA Spark Funding provides €40k to companies for eligible projects that have a maximum duration of 12 months.

ESA BIC Ireland is part of a network of 29 ESA BICs operating across 23 ESA Member States, which were established to empower entrepreneurship and to allow local economies to benefit from space data, technologies and assets.

In 2022 the consortium, led by Tyndall National Institute partnering with Maynooth University, Technological University of the Shannon and University College Dublin signed ESA BIC Ireland incubation contracts with five start-up companies – Cortex, Eco Urban Scooters (Zeus), Oblivious, PlantQuest and StrongBó AgriTech. MMIC-LAB was also selected to participate in ESA BIC Ireland. One ESA Spark Funding application was approved for PixQuanta with a funding allocation of €40k.

In October 2022 ESA SSI hosted its first National Networking Event in Portlaoise, Co. Laois. In November 2022 ESA SSI supported a delegation of 3 ESA BIC Ireland companies to participate in Space Tech Expo Bremen in Germany.

By the end of 2022, ESA BIC Ireland companies had raised €37m in equity funding and employ 165 people.

10 Ireland at the forefront of space research

Research contracts awarded to third-level institutions in 2022 include:

Institution	Description	ESA Programme
Dublin City University	Studies and technology development-Discovery	Basic Activities
Dublin Institute for Advanced Studies (DIAS)	Studies and technology development-Preparation Element	Basic Activities
Dublin Institute for Advanced Studies (DIAS)	Studies and technology development-Discovery	Basic Activities
National University of Ireland, Maynooth	Mission preparation, operations and exploitation	Future Earth Observation Programme Segment 1 (Future EO-1)
Trinity College Dublin	Studies and technology development	General Support Technology Programme (GSTP) Element 1 “Develop”
Tyndall National Institute	Administrative services	General Support Technology Programme (GSTP) Element 1 “Develop”
University College Dublin	Development / Production of space segment ready for launch	PRODEX (PROgramme de Développement d’EXpériences scientifiques)
University College Dublin	Mission preparation, operations and exploitation	Future Earth Observation Programme Segment 1 (Future EO-1)

Jupiter's Radio and Plasma Environment to be studied from Dublin

Scientists at DIAS have been formally named as part of the ESA Jupiter Icy moons Explorer (JUICE) mission's Radio and Plasma Wave Instrument (RPWI) team. Dr. Mika Holmberg (Co-Investigator), Prof. Caitriona Jackman and Dr. Corentin Louis (Associate Scientists) are working with the RPWI team, led from the Swedish Institute for Space Physics and involving colleagues across Europe, the U.S. and Japan.

After launch in April 2023, JUICE will conduct several planetary swing-bys before reaching Jupiter in 2031. Its primary focus is the search for conditions that can support habitability on Jupiter's moons Ganymede, Europa and Callisto.

The RPWI instrument includes Langmuir Probes, a Search Coil Magnetometer, and a three-axis antenna consisting of three electric dipoles. RPWI will study the electrodynamic influence of Jupiter's magnetosphere on the exospheres, surfaces and oceans of Jupiter's moons.

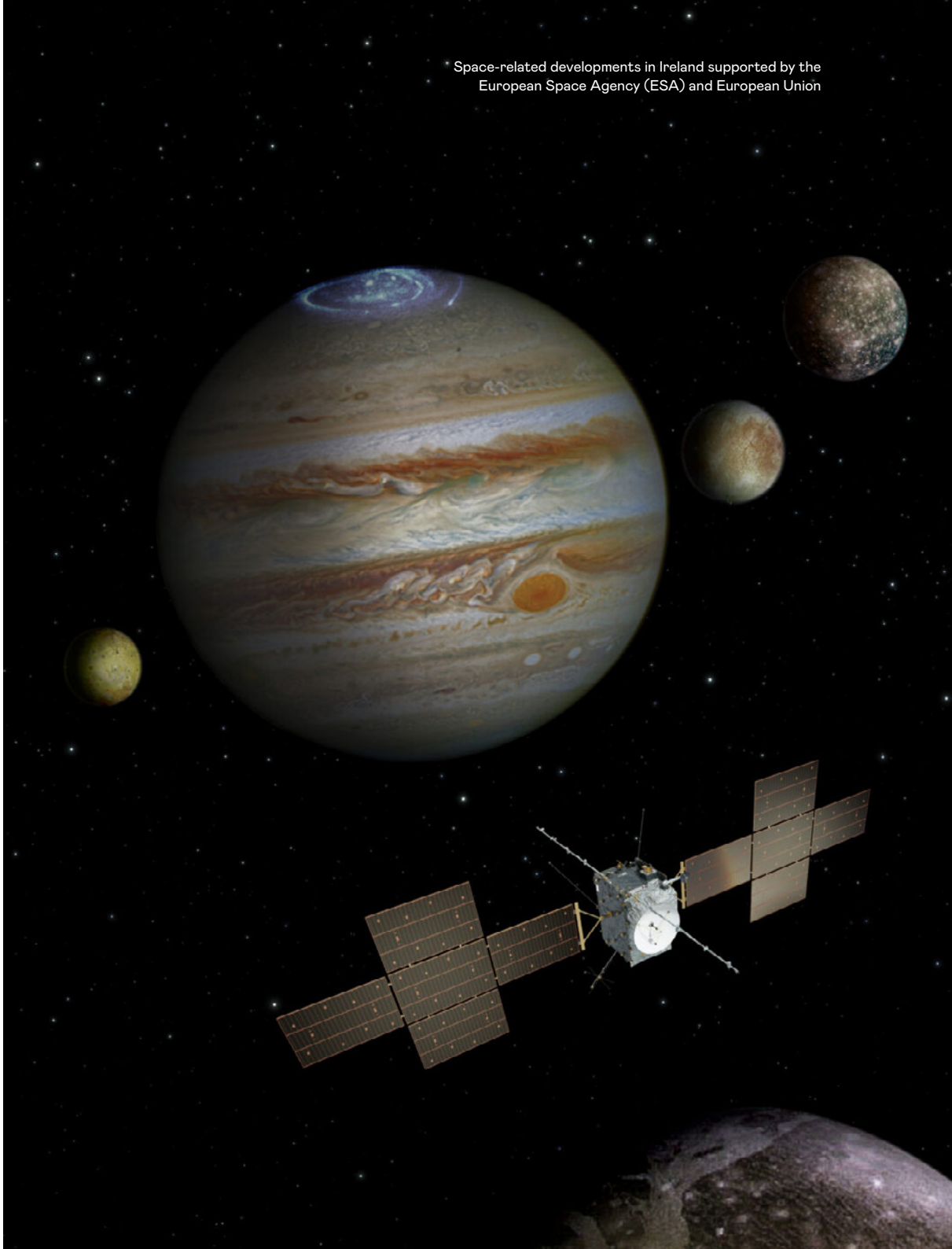


Figure 28. JUICE – JUpiter ICy moons Explorer – is the first large-class mission in ESA's Cosmic Vision 2015-2025 programme. Originally planned for launch in May 2022 and arrival at Jupiter in October 2029, it will spend at least three years making detailed observations of the giant gaseous planet Jupiter and three of its largest moons, Ganymede, Callisto and Europa © ESA

Tánaiste signs Exchange of Letters with ESA and Registration and Supervision Agreement with University College Dublin

A milestone day in the annals of Irish astronomy and spaceflight was achieved as then Tánaiste and Minister for Enterprise, Trade and Employment Leo Varadkar and then Minister of State for Business, Employment and Retail Damien English signed an Exchange of Letters with ESA to facilitate the launch of Ireland's first satellite, Educational Irish Research Satellite 1 (EIRSAT-1). EIRSAT-1 is a flagship project of University College Dublin C-Space, the Centre for Space Research at UCD, supported by the ESA Education Office under its Fly Your Satellite! programme. The satellite has been designed and built by academic staff and students at UCD. This event marked a historic milestone in Ireland's first space mission, which will see the launch of EIRSAT-1 for a 4-year mission from ESA's base in French Guiana.

The Exchange of Letters between the Government of Ireland and ESA sets out their mutual understanding of the EIRSAT-1 mission, the first Irish mission carried out under Ireland's domestic jurisdiction. The Government granted authorisation to the Tánaiste to sign the letters on their behalf at the Cabinet meeting on 4 October 2022. The Tánaiste and UCD also signed a Registration and Supervision Agreement which sets out the details required for the registration and supervision of the mission throughout its lifetime.

Figure 29. Tánaiste Leo Varadkar and Prof. Orla Feely (President, UCD) at Government Buildings, October 2022 © Jason Byrne/University College Dublin

11 Space helps inspire future generations of Irish students

‘GIFTS’ for space-based astrophysics research

Funding for space-based astrophysics research received a boost in 2022 with funding through the SFI Frontiers for the Future programme awarded to Prof. Sheila McBreen from UCD C-Space for development of a mission for time-domain astrophysics called ‘Gamma-ray Investigation of the Full Transient Sky’ (GIFTS). The PhD student who will work on GIFTS, Cuán de Barra, was awarded the McEnery medal in 2022 for achieving first place in UCD’s Masters programme in Space Science and Technology. This award from SFI is in addition to previous SFI funding to Prof. Lorraine Hanlon for a ‘Compton CubeSat’ (COMCUBE) mission, which has also received support through the EU Horizon 2020 €10M Research Infrastructures project, AHEAD2020.

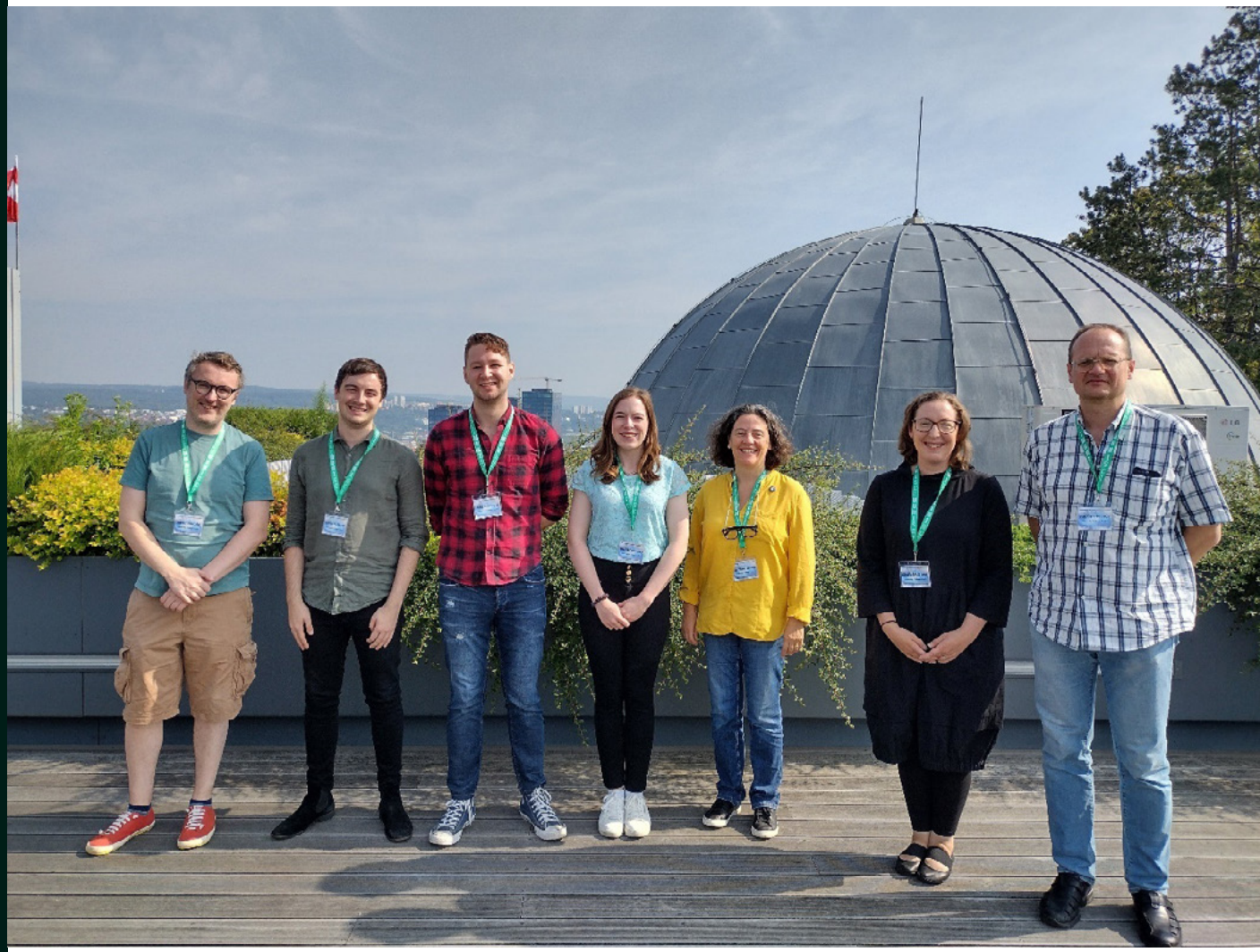


Figure 30. Members of the IE COMCUBE & GIFTS teams at the High-Energy Nanosats conference in Brno, Czech Republic, September 2022: (L-R) David Murphy, Cuán de Barra, Joseph Mangan, Rachel Dunwoody, Lorraine Hanlon, Sheila McBreen, Alexey Ulyanov © University College Dublin

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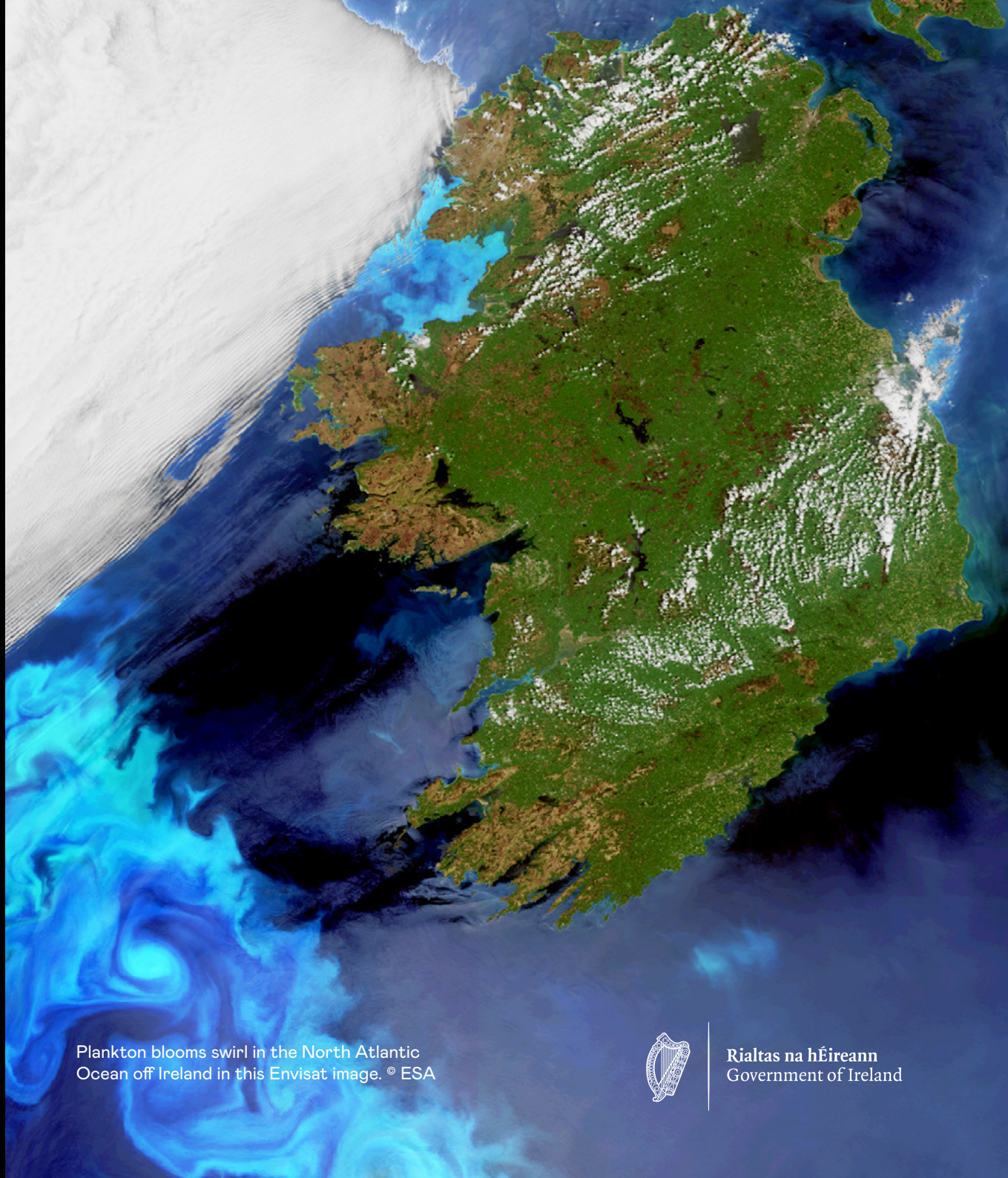

Plankton blooms swirl in the North Atlantic Ocean off Ireland in this Envisat image. © ESA

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