



Space Activities in Ireland 2023

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



Rialtas na hÉireann
Government of Ireland





Foreword by Minister

2023 was a momentous year for the Irish space sector with the successful launch of Ireland's first satellite EIRSAT-1 on 01 December which captured the hearts and mind of both young and old. This was a major step forward for the Irish space sector, not only in terms of the significance of finally becoming a space faring nation but also in terms of the learning and training offered across a range of disciplines to the students and researchers involved in the project. Importantly, this project also offered opportunity for Irish companies to test their services and technologies in the harsh space environment.

A huge congratulations to all involved in UCD, the European Space Agency (ESA) and my Department and I look forward to hearing about the on-board experiments during the course of its mission.

This Report of 2023 activities showcases the on-going success of the Irish space industry as companies continue to develop and scale through engagement with ESA and the European Union programmes. It is evident that Ireland's membership of ESA offers Irish companies and researchers the opportunity to innovate and develop leading edge technologies. Space technology and data have an important role to play in the provision of public services and in addressing many of the challenges that face us globally. It is great to see the range of Irish companies either using space technology or developing space technology to address these challenges across a range of sectors. It is also clear that the pipeline of new innovative space active companies in Ireland is strong with 6 new companies being supported by the ESA BIC programme in 2023.

I am also very pleased to see several Irish space active companies winning competitive funding through Horizon Europe and collaborating with other European partners for both the upstream and downstream markets.

Further evidence of the continued maturity of this sector in Ireland was the establishment of the Irish Space Association in 2023. This is a key development in terms of uniting the Irish space industry stakeholders so that they can promote the knowledge, know-how, technology, products and services offered by Irish space related companies to capture a greater share of this expanding global market. I look forward to engaging with the ISA on progressing the space enterprise agenda.

Emer Higgins

Minister of State for Business,
Employment and Retail
Department of Enterprise, Trade and Employment

Front cover image: An artist's render of EIRSAT-1 in orbit (credit: J. Thompson, D. Murphy (University College Dublin (UCD)))



Foreword by Enterprise Ireland

2023 was an outstanding year for the Irish space industry by any standards. Irish space-active companies were involved in a vast range of cutting-edge projects, many of which are delivering significant benefits here on Earth. These projects are helping to address climate change, improve farm efficiency, and supporting advances in next generation mobile communications, representing a growing band of highly innovative Irish companies in this sector.

Without doubt, the highlight of the year was the launch of Ireland's first satellite, EIRSAT-1, from the Vandenberg Space Force Base in California on 01 December 2023. The satellite was designed, built, and tested by students from University College Dublin (UCD) with the support of the ESA Academy's Fly Your Satellite! programme and the backing of the Irish Government. ESA experts provided training, guidance and testing facilities to the UCD team throughout the project. EIRSAT-1 carried payloads for gamma-ray astrophysics, advanced thermal materials, spacecraft control and an antenna deployment module, all of which were developed at UCD.

This was truly an historic milestone for the Irish space sector and with technology from Irish companies on board, is an excellent example of the collaborative nature of the Irish space ecosystem.

In another very significant development during the year, Irish company Ubotica Technologies brought the power of AI to space in its new CogniSAT product which maximise satellites' in-orbit data analysis capabilities and enables the delivery of actionable insights in real-time. This leading-edge technology is scheduled to be deployed in 2024 on what will be the first satellite launched with commercial backing from an Irish company.

In a demonstration of Ireland's position at the front rank of space technology development, Réaltra Space Systems Engineering has developed a state-of-the-art Global Navigation Satellite System (GNSS) which will provide improved navigation and positioning capabilities to spacecraft and satellites. The new system will be deployed for testing on the next-generation Ariane 6 launcher in 2024 and it is intended that it will replace the technology used in the previous generation of launch vehicles.

In an example of a down-to-earth application of space technology, consumers can verify the origins and full journey of the produce they buy from retailers all the way back to the farm, thanks to a solution developed by Verifact.

The ESA-funded Verified Life Story (VLS) service delivers proof of the full life story of the produce by collecting data on an individual animal basis, transmitting it via satellite and storing it in the cloud. The project also involved the development of a GNSS-based tagging sensor to track and verify the location of individual animals in real time.

A significant milestone for the Irish space industry during 2023 was the establishment of the Irish Space Association (ISA). The Association aims to bring together indigenous and foreign direct investment companies, research performing organisations (RPOs), educational institutions, and government agencies operating in the space sector in Ireland. The pace of the growth and development of the Irish space sector means that it now requires a platform like ISA to maximise the synergies made possible through collaboration and act as a catalyst for future innovation.

Enterprise Ireland was delighted to host ISA's first ever meeting at our HQ in Eastpoint on 27 April 2023, and I look forward to working with the Association and its members on what promises to be a very exciting future for the Irish space industry.

Leo Clancy

CEO

Enterprise Ireland

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Introduction

The space economy was estimated to be worth \$630 billion in 2023 and is forecast to reach \$1.8 trillion by 2035, growing at an average of 9% per annum – well above the growth rate of global gross domestic product (GDP)¹. This saw new opportunities emerging for ‘NewSpace’ – the emergence & growth of private space industry – companies developing innovative products and services.

In Ireland, the European Space Agency (ESA) placed contracts to the total value of €9.9m in 2023, with industrial activities accounting for the bulk of this figure. Industrial co-funding reached €2.2m during the year. Twenty-five companies, including three new space-active entities, were supported to develop high-tech products in Ireland.

The number of Irish companies actively engaged with ESA continues to grow and reached 109 at the end of 2023. Further details of several Irish technology developments supported in 2023 are outlined in this Report.

ESA BIC Ireland offers technical, business, financial and incubation support to start-ups that have a connection with space and are developing either upstream or downstream applications. 2023 was another successful year for ESA BIC Ireland during which it welcomed 7 new start-ups to the growing family of companies developing innovative products and services in the space arena.

A momentous milestone was reached on 01 December 2023, when Ireland became a spacefaring nation with the launch and deployment of EIRSAT-1 - “Educational Irish Research Satellite 1”. This was a significant achievement by the UCD team, the Irish technology company partners and all involved in this continuing success story.

Reflecting the growing level of space-related activity across both industry and research-performing organisations (RPOs) in Ireland, 2023 saw the establishment of the Irish Space Association (ISA). The purpose of this new organisation is to foster a vibrant network of space-active companies and researchers to share knowledge and information and contribute to the continued growth of this important national sector.

The Irish space community, through an innovative and agile approach to RD&I, continues to be well-placed to collaborate with European partners and successfully compete in the NewSpace-driven global space market.

1. Space: The \$1.8 Trillion Opportunity for Global Economic Growth. World Economic Forum 08 April 2024
<https://www.weforum.org/publications/space-the-1-8-trillion-opportunity-for-global-economic-growth/>

1.0

Space and the Green Agenda

Irish space-active companies are making an important contribution to the battle against climate change by bringing their expertise to bear on issues such as waste reduction, crop and soil monitoring and analysis, and the socio-economic impact of human activity on the planet.

Award-winning remote grassland monitoring

Proveye secured €1m in seed funding for its remote grassland management platform during 2023. The company was awarded a contract by ESA in late 2022 and the new funding will help to bring the solution to international markets.

Built for dairy and beef farms, Proveye for Grass offers the first full grass system analysis on the market by combining three key information streams: precision yield measurement, sward composition mapping, and biodiversity analysis. Data sources utilised include in-field sensors, drones, and satellite imagery.

In other achievements during 2023, the company won the Start-Up Innovator of the Year Award and the Ace Agritech Centre of Excellence Award at the Enterprise Ireland Innovation Arena at the National Ploughing Championships

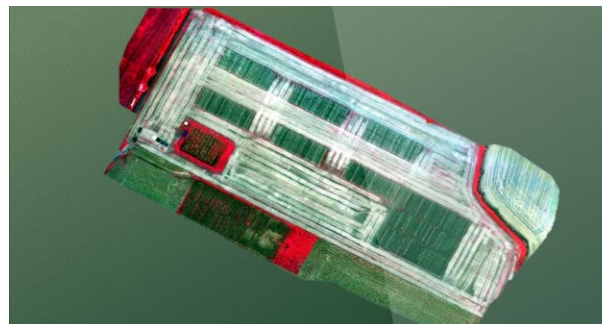


Figure 1. Proveye's multispectral analysis of grasslands from remote sensing data © Proveye

Waste crime investigation

Waste crime, including industrial non-compliance and destructive environmental activities, costs the Irish State millions each year, while simultaneously damaging the environment and posing considerable risks to human health.

Commercially tasked satellites, Earth Observation (EO) imagery and machine learning (ML) available through the EU Copernicus Programme can be used to detect ongoing waste crime activities, providing a historical log to retroactively detect waste crime and potential cover up activities.

Secure marine data specialist and EO product provider, TechWorks Marine, delivered a report to the Environmental Protection Agency (EPA) in 2023 following a year-long evaluation of satellite monitoring of industrial waste crime. The report was a project deliverable from a successful research funding application made to the EPA under their Research Programme 2021–2030 scheme and is published online (“The Use of Earth Observation and Machine Learning for Industrial and Waste Crime Identification and Prevention”), as an Agency Research Report (No. 438). The Synthetic Aperture Radar (SAR) imagery available through the Copernicus Programme is best suited to persistent monitoring and dating of short-lasting waste crimes in Ireland’s cloudy climate.

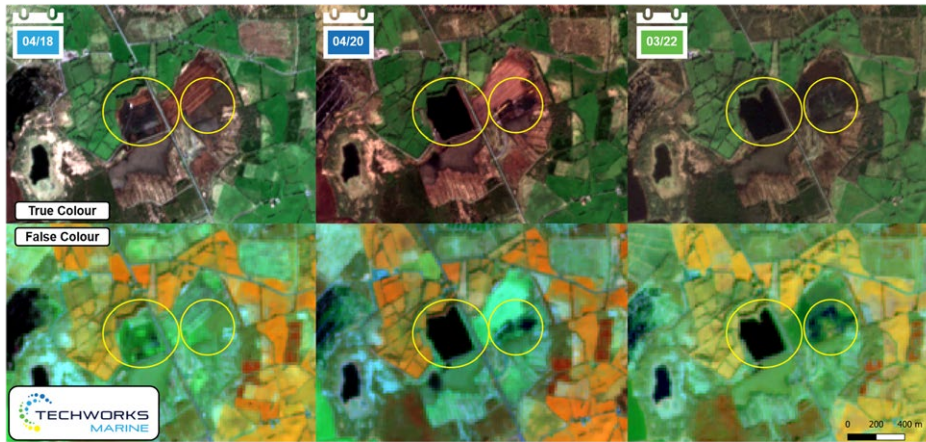


Figure 2. True and false colour satellite imagery showing periodic unauthorised peat harvesting from the EU's Copernicus Sentinel-2 satellite. © TechWorks Marine Ltd.

Geo-intelligence solution deployed with ESA support

Technology developed by Irish company Compass Informatics, now merged with Icon Geo and part of Tracsis Plc, is aiding EU Common Agriculture Policy (CAP) payment agencies to swiftly and accurately identify crop growth patterns to enable farm payments. The HubCAP solution blends geographic information systems, Earth Observation and machine learning based on expertise developed through ESA-supported activity.

Developed with support from the ESA InCubed Programme, HubCAP includes an innovative methodology to identify grazing patterns in Ireland.

Also in the sustainability space, the company, alongside international partners, successfully proposed novel solutions for sustainable cities under the ESA Green Transition Information Factory programme in the latter part of 2023.

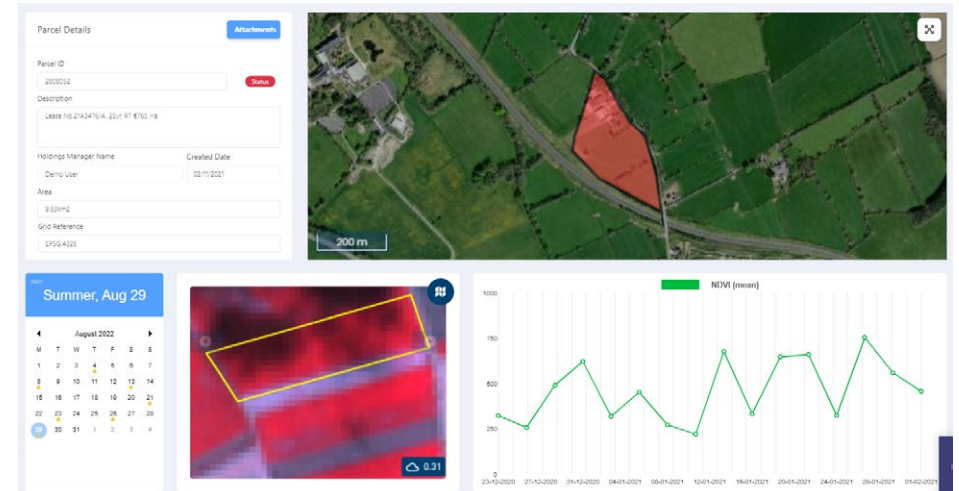


Figure 3. HubCAP Agriculture and Environmental Platform © Compass Informatics

Automated monitoring tool improves soil analysis

An innovative automated monitoring tool, that integrates satellite imagery with in-field photographs during soil sampling and improves the precision & accuracy of monitoring & assessment of soil conditions has the potential to significantly advance agricultural practices and environmental research.

Developed in 2023 by Irish company Farmeye and integrating technology from ESA, the new tool designates every soil sample site as an Area of Interest for automatic Earth Observation analysis, utilising Sentinel-2 satellite data, and pairs satellite images with corresponding in-field soil samples and field photographs taken within a similar time period.



Figure 4. Illustration of matching soil sample photos with Sentinel-2 imagery © FARMEYE

Applying tracing technology to EU forests

Cork-based Treemetrics is part of a €9m EU project (Sintetic) aimed at improving forestry management and combating deforestation. The project's goal is to trace wood products back to their source, enhancing production and increasing managed forest areas. The initiative involves 21 partners and is funded by Horizon Europe. Treemetrics is developing a digital platform for tracing all wooden products, similar to meat traceability. In 2023 the four-year project commenced which aims to reduce transportation costs and emissions by 5% and increase the yield of high-value sawn wood products by about 20%.

Democratising access to space data

Irish company Shamrock Space Services is bringing its expertise in system design and digital infrastructure to enable the use of satellite Earth Observation data for the exploration and analysis of complex earth systems, such as the natural landscape and climate, as well as the socio-economic impact of human activity on our planet.

Joining the Destination Earth (DestinE) project in 2023, the company is supporting ESA and several other European space-active companies in the transformation of Earth Observation data into practical, everyday insights. This has the potential to democratise access to the wealth of information contained in space data through the development of easy-to-use, interactive tools.



Figure 5. Destination Earth © ESA

2.0

Positioning and Navigation solutions powered by Space

Precise positioning and navigation are critically important in space. Irish companies are making a name for themselves in this highly specialised area.

New telemetry system to launch with Ariane 6

Irish space company Réaltra Space Systems Engineering has developed a state-of-the-art Global Navigation Satellite System (GNSS) telemetry system which will launch on the maiden flight of Ariane 6, the next generation of European launchers, in 2024. The contract between Réaltra and ArianeGroup was signed on 11 December 2023 at the Residence of France in Dublin, in the presence of Neale Richmond, Minister of State, and H. E. Mr Vincent Guérend, Ambassador of France to Ireland.

Manufactured in Dublin by Realtime Technologies, the new GNSS telemetry system is designed to provide accurate and reliable positioning information. It will fly as an autonomous experimental system on Ariane 6 to validate its functionality in space at high speeds, utilising advanced satellite navigation technology to ensure precise positioning, velocity, and timing measurements. Réaltra also won the 'Franco-Irish Newcomer of the Year' at the Ireland France Business Awards 2023 event, run by Network Irlande France in collaboration with France Ireland Chamber of Commerce.



Figure 6. GNSS contract signature. From left: Danny Gleeson (Chief Commercial Officer, Réaltra), Neale Richmond (Minister of State for Business, Employment and Retail), Paul White (Managing Director, Realtime Technologies), Laurent Mazo (Supplier Business Manager, ArianeGroup), H. E. Mr Vincent Guérend (Ambassador of France to Ireland), Oliver Charre (Head of Electrical Domain, ArianeGroup) © Réaltra Space Systems Engineering

Pure light developed for ESA

Advanced laser diode manufacturer Eblana Photonics was awarded – through their membership of ESA BIC led by Tyndall National Institute - ESA Spark funding in 2023, to develop pure light at 1064nm for future space-based quantum sensors. Spark funding is designed to accelerate the product development process of a company that is integrating space technology, as well as to hone the commercialisation roadmap. The project will enable Eblana's technology to meet the stringent requirements of space-based applications, including exceptional performance in harsh environments while maintaining low size, weight, and power (SWaP).

Novel technology on board Ireland's first satellite

When Ireland's first satellite, Educational Irish Research Satellite 1 (EIRSAT-1) successfully launched into space on 01 December 2023, it carried antenna technology and custom cabling solutions from Irish company Taoglas. The company is also an active participant in the ESA Navigation Innovation and Support Programme (NAVISP). One of those projects, Neptune, has led to the development of four new multiband GNSS antennas designed to support the growing needs of vehicle tracking and marine applications.



Figure 7. Artistic impression of EIRSAT-1 with deployed Taoglas antenna © Taoglas

3.0

Tackling industry challenges using Earth Observation satellite data

Much of the value of satellite data derives from its use to address real world issues. During 2023, two Irish companies played an important part in realising that value.

Smarts for Smart Satellites

Ubotica Technologies is delivering new cost efficiencies and performance enhancements to satellites by bringing AI into space. Satellites designed using the company's CogniSAT-XE2 AI platform deliver an accelerated return on investment by maximising in-orbit data analysis capabilities to deliver actionable insights in real-time and optimising downlink data load.

The Ubotica CogniSAT-CRC solution maximises Earth Observation asset utilisation by using state of the art lossless image compression combined with an AI-based cloud detection and removal algorithm to deliver a better than six-fold increase in useful data capture per orbit for satellites.

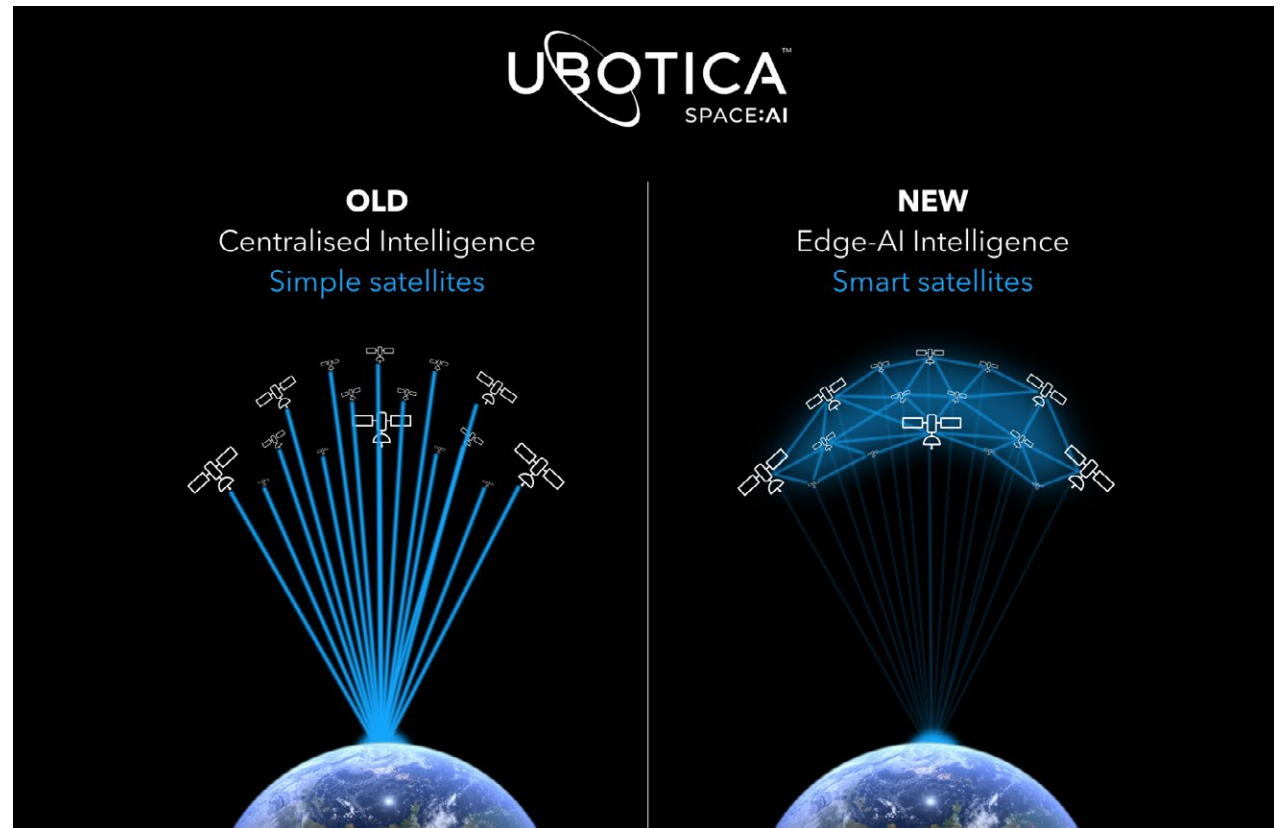


Figure 8. SPACE:AI - Smarts for Smart Satellites © Ubotica Technologies

Farm to fork in space

A space-based food traceability solution developed by Cork-based software development company Verifact became commercially available in 2023. The ESA-funded Verified Life Story (VLS) service delivers proof to retail clients of the 'Life Story' of the produce they sell in relation to claims Retailers have made about the origin and conditions in which the produce was reared.

The solution provides full supply chain assurance from farm to fork. The cloud-based platform collects data on an individual animal basis, transmits it via satellite and stores it in the cloud. The project also involved the development of a tagging sensor using GNSS to track and verify the location of individual animals in real time.

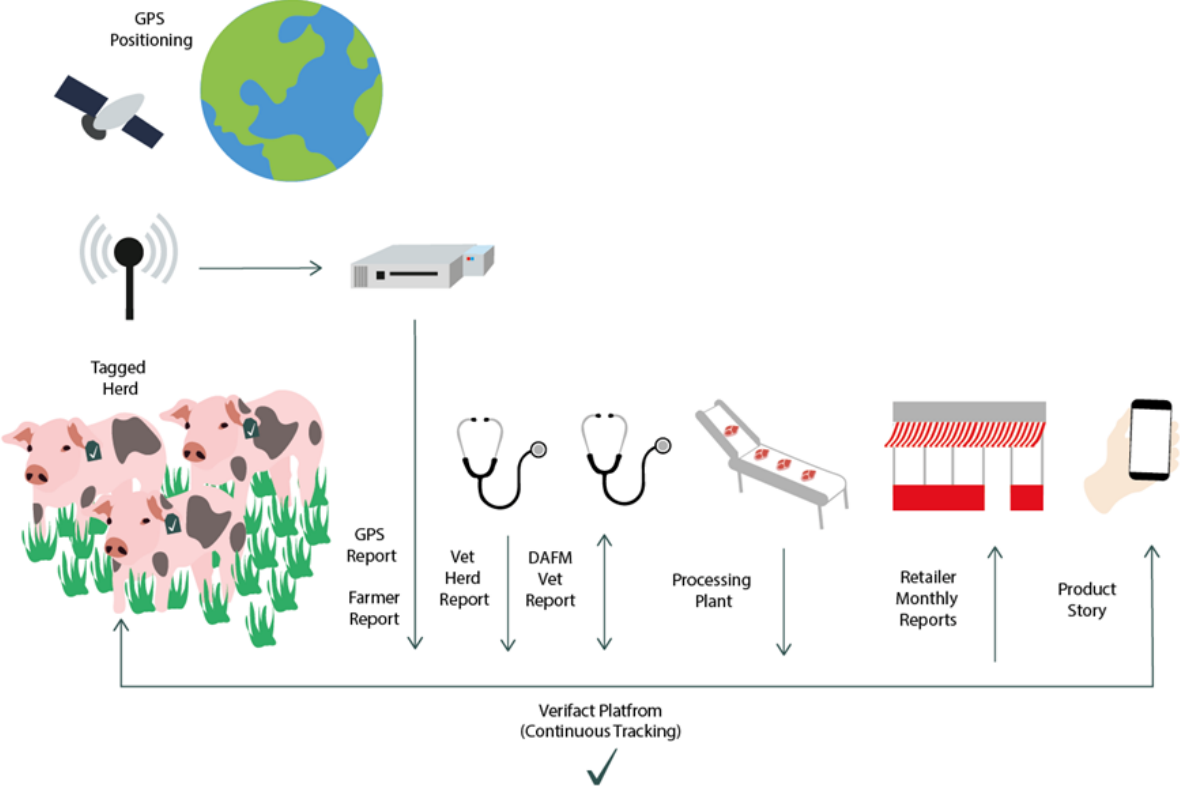


Figure 9. A schematic depicting the 'Verified Life Story' (VLS) platform service © Verifact Intl. Ltd.

4.0

Satellite Communications Systems

From ultra high-speed communications over vast distances once seen as the preserve of science fiction to the space-based technology required to power the next generation terrestrial 6G networks, Irish companies are at the leading edge of the latest developments.

Early warning system for application failure

Irish company O.C.E. Technology has been selected along with Réaltra to develop the terminal controller for a new constellation of optical communication satellites for a major multinational communications provider.

The company is also responsible for a new operating system which can predict faults in advance in high reliability applications such as those found on satellites and spacecraft. The new multicore operating system for RISC-V, ARM and SPARC processors, which was developed with co-funding support from ESA approved during 2023, implements a policing system for applications that detects anomalous behaviour prior to a failure allowing the application to take avoidance action. Aspects of the new operating system are under patent application.



Figure 10. O.C.E. Technology's embedded AI development board © O.C.E. Technology Ltd

Enabling next generation communications networks

High throughput satellites (HTS), with their increased data rates and network capacities, are essential for powering up the 5G and upcoming 6G networks. During 2023, Irish company Pilot Photonics continued to develop one of the key enabling components for these HTS satellites with ESA support; a variable frequency generator that can produce the radio frequency (RF) carriers for various transmission bands. The company is using its integrated comb-generation technique to manufacture a single photonic chip that will produce a very low-phase noise, variable frequency generator. Crucially, it will enable the payload to deliver multiple carriers simultaneously while remaining within low size, weight, and power parameters.

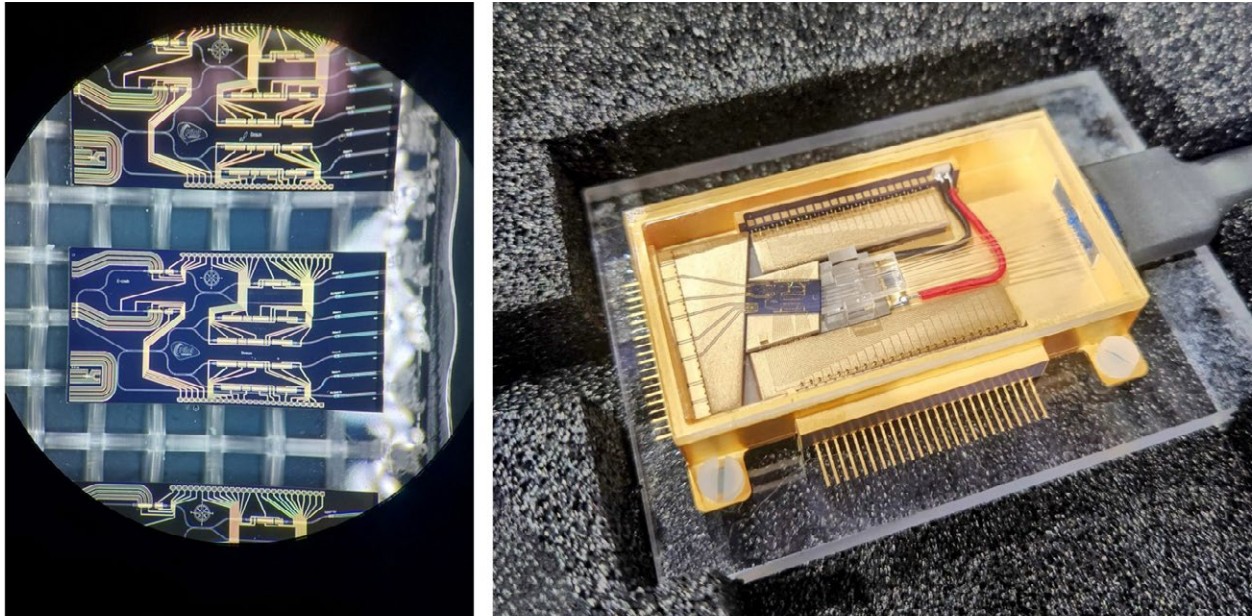


Figure 11. Integrated Comb Laser Assembly PIC (left) and optical butterfly package (right) © Pilot Photonics

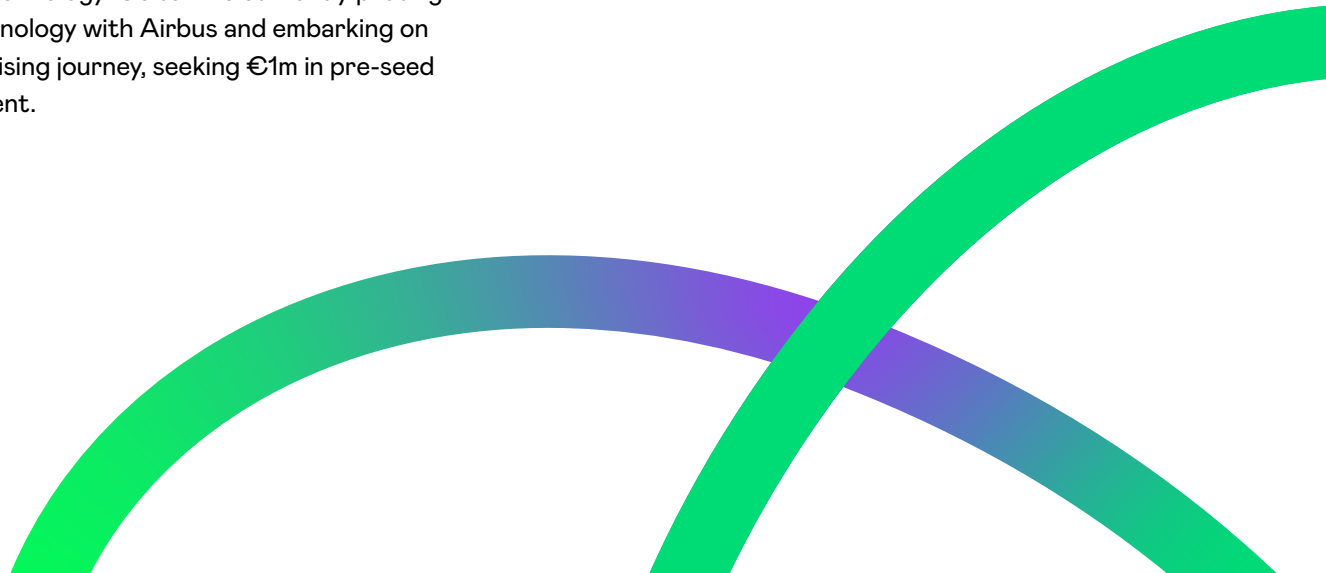
New technology to underpin 6G networks

In the 6G communications space, Irish female-led start-up Celtonn is crafting semiconductors which offer the higher frequencies required to access the bandwidth necessary to accommodate the vast quantities of data which will be carried on the new networks.

During 2023, Celtonn secured a coveted position within ESA BIC Ireland, underscoring their commitment to pushing the boundaries of space technology. Celtonn is currently piloting the technology with Airbus and embarking on a fundraising journey, seeking €1m in pre-seed investment.



Figure 12. Celtonn announced as one of Ireland's leading scale ups at South East BIC's 'The Big Pitch 2023' competition hosted at Kilkenny Castle (left to right) Aoife Kelly (COO), Marie Bourke (CEO), Mark Kelly (CTO) © Celtonn



Satellite and 5G integration

ST Engineering iDirect's ESA-funded COSMOS sequel project focuses on the integration of satellite and terrestrial 5G networks and specifically on the integration of the existing legacy satellite networks with the 5G core network. The project was successfully completed during 2023 and provided valuable insights and de-risking of the use of the company's product for the integration of 5G into existing satellite networks.

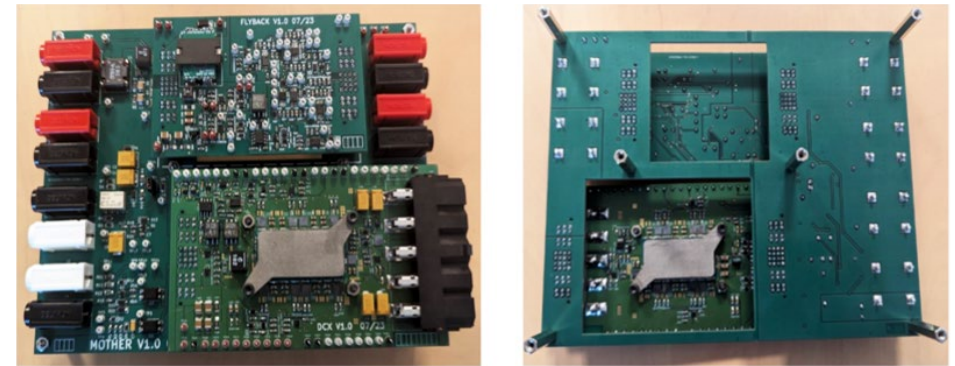


Figure 13. ST Engineering iDirect's ESA-funded COSMOS sequel project contributed to their New Space, New Ground, Global Telcom and IT convergence vision © ST Engineering iDirect

Supplying the power for high performance satellite electronics

High-performance electronic systems in advanced satellite applications require a stable, high current, low operating voltage to achieve their mission. During 2023, ISD Aerospace worked on two projects to develop such a power supply: one funded by ESA and one funded by the EU under the SPACE programme. In the ESA project, a prototype DC-DC controller system has been developed which is based on a resonant flyback architecture.

In the EU-funded SCOPS (Scalable COnroller for Power Sources) project, the PROMISE (Programmable Mixed Signal Electronics) Design Standard and Library is being used and expanded upon to develop a very high efficiency, low voltage, high current DC-DC power converter based on a novel architecture, which allows it to be flexible and reconfigurable as a function of application and fault tolerance requirements. In both projects, ISD Aerospace was involved in the testing and validation of the system architectures.



Top

Bottom

Figure 14. Images of the Top (Left) and Bottom (Right) Elevations of the Prototype DC-DC Controller Test Board © ESA

5.0

Delivering technology innovation to the space and non-space sector

The development of innovative lightweight, high-performance materials has been at the very heart of the space story almost since the very beginning. This is just one of the critically important areas where Irish companies have established global reputations for their work. Irish space-active companies are also making waves in highly specialised areas such as sensors, flight instrumentation and power systems.

Acoustic protection for spacecraft

Fairing Acoustic Protection (FAP) protects a spacecraft and its payload from the sound created by the rocket during lift-off. Irish acoustic metamaterial pioneer Lios is working to develop, test, and qualify its SoundBounce product as a new FAP material. Following the successful completion of the first phase of a development contract as part of ESA's Future Launchers Preparatory Programme (FLPP) in 2022, the company commenced a phase two contract in 2023. The 18-month project is valued at almost €1m in co-funding and focuses on proving the capability of SoundBounce to meet the low-mass targets necessary for space flight.

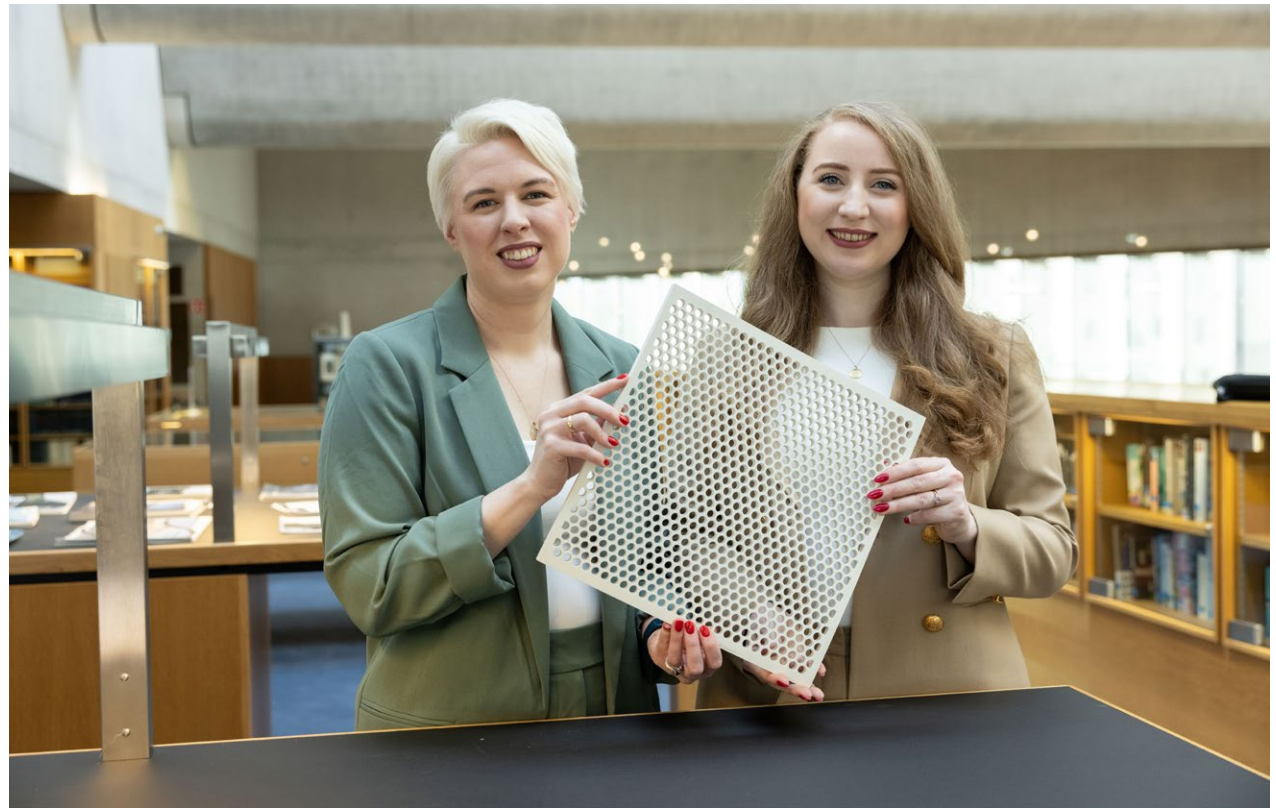


Figure 15. Lios cofounders Eimear O'Carroll, CTO (left) and Rhona Togher, CEO (right) display a sample of SoundBounce © Lios

New thermal testing facility

ENBIO has put its expertise in thermo-optical coatings to work by developing Ireland's first thermal vacuum test facility. The new facility will enable Irish companies to test, validate and qualify their hardware for space conditions here in Ireland. During 2023, the company successfully conducted a number of thermal vacuum qualifications for ESA and several Irish and European customers. This followed the successful first mission for ENBIO's thermo-optical coatings on ESA's Solar Orbiter and their qualification and integration into ESA's Jupiter Icy Moons Explorer (JUICE) mission launched in April 2023.

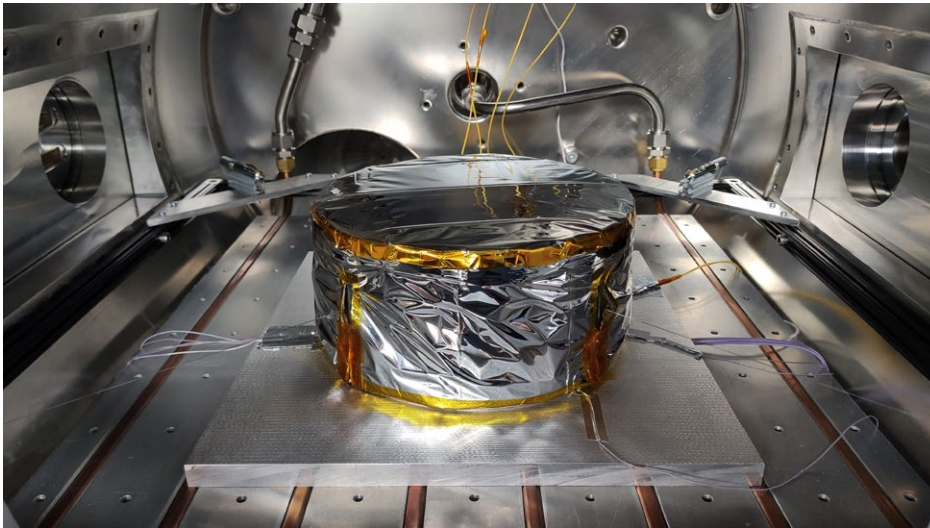


Figure 16. COOLER device suspended inside a bespoke shroud within ENBIO's TVAC T2 chamber © ENBIO Ltd.

Delivering lightweight composite structures for the space sector

Satellites utilise baffles to filter stray light and prevent it from reaching optical systems. Stray light baffles which use advanced carbon-fibre materials manufactured by ÉireComposites were successfully tested during 2023 for ESA's Altius Mission. Working in partnership with OIP Space Instruments and QinetiQ, the structural integrity of the baffles was confirmed. Work has now commenced on the flight models, with a launch from Kourou, French Guiana planned for 2026.

In 2023, ÉireComposites also carried out extensive work on a new manufacturing process for sandwich panels. Trials to date have demonstrated that large composite structures for satellites and launchers can be manufactured more cost-effectively using the new technique while still achieving the rigorous quality requirements demanded by space applications.

Lightening the satellite backbone

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. Working with ÉireComposites, ATG Innovation has developed a lattice central tube that is 37% lighter than the composite central tube being used in the ESA PLATO satellite. This kind of mass saving can translate into lower launch costs, increased payload capacity and increased operational capability for a satellite. In 2023, the company completed an ESA-funded development project to verify the interface zones of its ultra-lightweight composite lattice space structures, specifically regarding Satellite Central Tube applications.

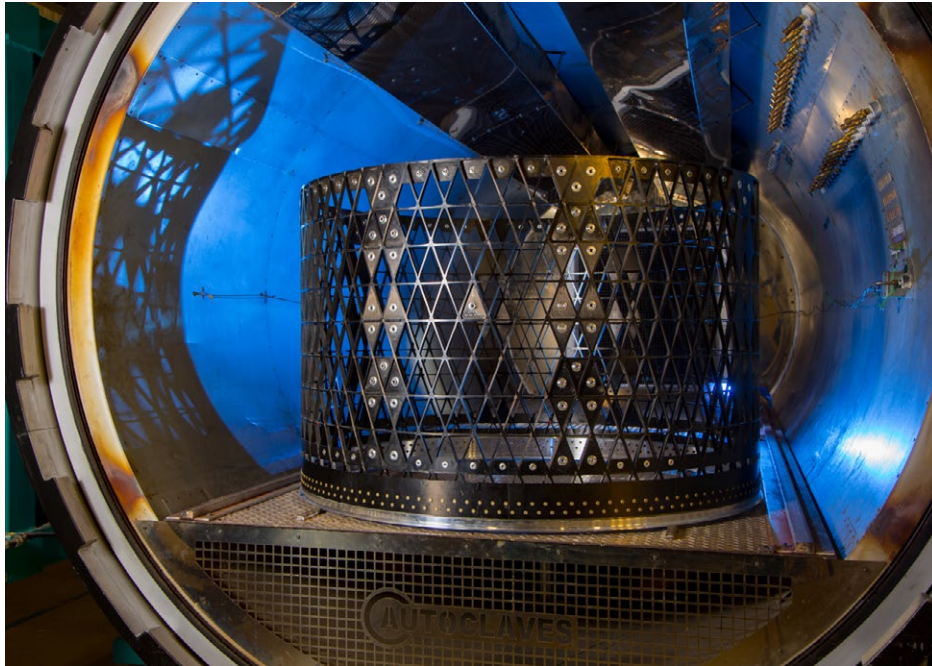


Figure 17. ATG Innovation's lattice satellite central tube © ATG Innovation Ltd.

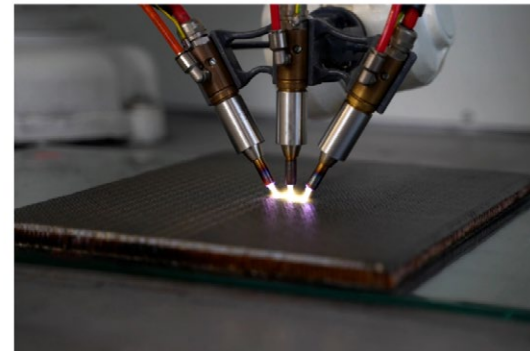
Advancing space technology with lightweight composite structures

Also in the lightweight composite materials space, Plasma Bound successfully de-risked critical material and process improvements for future spacecraft designs using their disruptive Controlled Polymer Ablation (CPA) technology for composite-to-composite and composite-to-core bonding in ESA's General Support Technology Programme (GSTP) de-risking programme during 2023.

This innovative solution for dissimilar materials bonding is poised to revolutionise composite-based products in space affecting structures, launchers, solar panels and truss structures. The Plasma Bound technology offers a highly repeatable and a fully automated process with quality assured through its process monitoring and control solution.



Plasma Bound's Vulcan product currently used to monitor & control the CPA treatment at line.



Controlled Polymer Ablation treatment on a Carbon Fibre Epoxy composite.

Figure 18. Plasma Bound's Vulcan (top) and CPA treatment (bottom) © Plasma Bound

More than once in a Blue Moon

Dublin-based aerospace company Curtiss-Wright has developed and qualified a data acquisition system for flight instrumentation on the Blue Moon lander - a multi-use vehicle designed to provide low-cost, recurring access to the Moon for both cargo and crew. The contract for the Blue Moon program was signed April 2023, with the first set of engineering hardware delivered December 2023. The highly engineered radiation tolerant equipment has been designed to acquire and process the vital data from over 200 sensors on board the lander. Data acquired by Curtiss-Wright's hardware during the mission and landing on the Moon will be processed by the lander's on-board computers and transmitted over a radio link back to the Earth.

The first Blue Moon cargo mission is planned for late 2024 with the first human mission expected to land four astronauts on the lunar surface in 2029. Blue Moon is a family of lunar landers and their associated infrastructure, intended to carry humans and cargo to the Moon, under development by a consortium led by Blue Origin, run by Amazon's founder, Jeff Bezos.

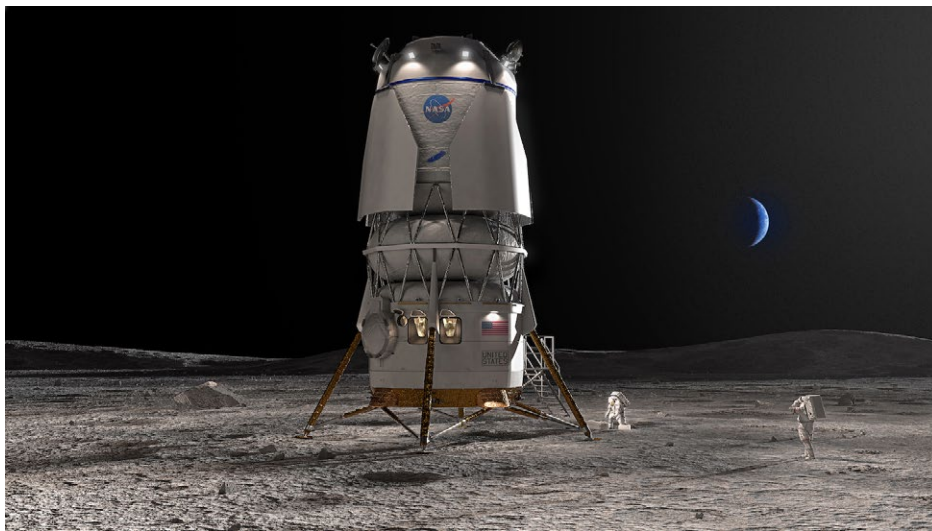


Figure 19. A rendering of crew Blue Moon lander © Blue Origin

Low cost, high reliability sensor solution

Irish company PixQuanta is in a strong position to provide high reliability sensor technology to future low-cost missions in low-earth orbit as well as high value missions in geostationary orbit. The company was awarded funding by ESA to develop innovative photodiode sensors for LiDAR and 3D imaging applications. The project, which was completed in early 2023, saw PixQuanta fully develop its thin film photodiode technology from design to execution. This will enable the production of low-cost, mass-manufacturable sensors ready for integration onto silicon readout-integrated circuits. In the course of the project, PixQuanta also developed a single platform silicon sensor capable of operation in visible, NIR and SWIR wavelengths, from 400nm to 1700nm.



Figure 20. PixQuanta Eval board for testing and customer sampling © PixQuanta

Deep space radiation detection

In July 2023, radiation detection sensors produced by Cork-based Varadis were selected for use in the Deep Space Radiation Probe (DSRP) lunar payload, Taiwan's first scientific payload for lunar lander use. The DSRP will be aboard the ispace HAKUTO-R Mission Lunar Lander when it lands on the moon in 2025. Just three months later, JAXA (the Japan Aerospace Exploration Agency) selected the Varadis NASA-screened VT06 radiation detection sensor to measure absorbed ionising radiation aboard its upcoming DESTINY+ mission. The mission will explore the Phaethon asteroid to conduct scientific observations of cosmic dust, considered to be a source of organic matter on Earth.

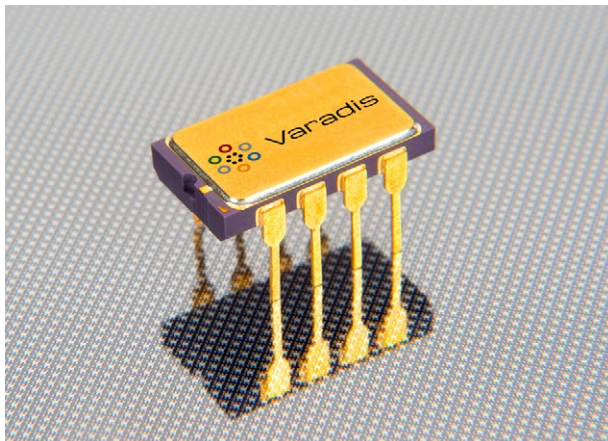


Figure 21. NASA Screened VT06 sensor used aboard the DESTINY+ Phaethon Asteroid mission © Varadis

Spectrometer calibration for future space missions

Pilot Photonics received funding from ESA in 2023 to develop its miniaturised optical frequency combs (OFCs) for use in the areas of spectrometer calibration and terahertz generation for future space missions. This work has focused on integrating two different types of OFCs in order to exploit the advantages of each. The company is working with Semiconductor Photonics Group in Trinity College Dublin in the development of the devices. The Royal Belgian Institute for Space Aeronomy and the Space Terahertz Research Group in Maynooth University are involved in testing the technology against the requirements of these two application areas.

Tackling battery overheating in space

The dangers associated with battery overheating are well-known and are amplified in space. One solution is to design lithium-ion battery packs that limit potential thermal runaway (TR) events to the initiation cell. TR events see batteries overheating dangerously following an event in one cell which spreads to others. Irish company Xerotech received funding from ESA in 2023 to develop a battery for aerospace applications using commercial off-the-shelf Li-ion cells embedded within passive propagation resistant (PPR) foam.

The aim is for the PPR foam to passively contain potential TR events to the compromised cell and prevent propagation to adjacent cells within the pack. The project showed that the foam worked for all induced TR events, but it was found to be not suitable for use in space in its current form. Further work will be carried out to optimise the chemistry and internal structure to develop a foam with higher temperature tolerances.



Figure 22. Typical Nail Penetration Test on Li-ion cell in a module causing TR with no foam (left). Nail Penetration Test with Full-Cell Encapsulation in PPR Foam (middle). TR fully contained with no fire and adjacent cells fully operational (right) © Xerotech Ltd.

6.0

Irish companies supporting access to space

Reducing space launch costs, improving navigation, and high precision propulsion components; these are just a few of the areas where highly innovative Irish companies are competing on the global stage.

Supporting high speed communications in space

In 2023, Réaltra Space Systems Engineering announced a collaboration with Austrian-based TTTech Computertechnik AG to develop a state-of-the-art ethernet network switch for use on future launchers and space applications. The modular system will offer high-speed communication capabilities and fault tolerance for critical applications. The project, which aims to meet the requirements of the next generation of rocket launchers, was funded by ESA under the Future Launchers Preparatory Program (FLPP).



Figure 23. Réaltra and TTTech_NetworkSwitch. From left: Matthias Mäke-Kail (TTTech / Marketing CX Manager), Harald Schloffer (TTTech / Senior Systems Engineer), Reinhard Schrammel (TTTech / Director Space Systems Development), Michael Martin (Réaltra / Engineering Manager), Ana Maria Dimitrijoska (TTTech / Project Manager), Jonathan Rodgers (Réaltra / Senior System Engineer), Thomas Maier (TTTech / Senior Key Account Manager), Sudarsan Srinivasa Rangachari (TTTech / Electronics Developer), Ivan Masar (TTTech / Senior Product Manager Space) © Réaltra Space Systems Engineering

Hybrid power solution for space launch

A new hybrid power drive unit (HPD) designed in 2023 by Microchip Technology's Integrated Power Solutions team delivers improved performance, increased power density and reliability, while reducing power consumption. The HPD has been tested using lower stage launcher mission profiles and characterised across the temperature range required in those applications. It offers reduced costs and has the potential to improve the competitiveness of European space launch vehicles. The new unit is designed for use within ESA's Future Launcher Preparatory Programme (FLPP) and expands on knowledge gained and technology developed under ESA's General Support Technology Programme (GSTP).

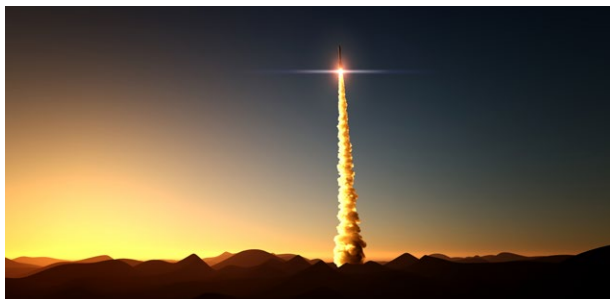


Figure 24. Taking off with Microchip © Space Solutions

Delivery of gyroscopes for HERA mission

Innalabs gyroscopes were incorporated in no fewer than 20 satellites during 2023 while several launch vehicles made use of the company's accelerometers for navigation into space.

The company has also successfully delivered a number of ARIETIS-NS flight models to customers around the world. Developed with the support of Enterprise Ireland and ESA, the flight model has been installed on the Hera satellite, which is expected to lift off in its mission to visit the Didymos binary asteroid system in October 2024.

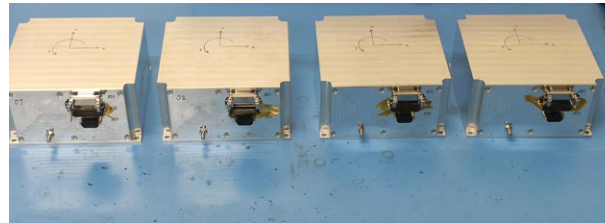


Figure 25. A group of ARIETIS-NS Flight Models before shipment to customers © InnaLabs

Flight qualification status achieved for novel propulsion valve technology

Space transportation requires a very complex set of propulsion components, from the powerful Vulcain and Vinci engines that deliver satellites into space, to the low thrust pulsing of the attitude control systems that keep bursts of downstream data pointing at a ground station.

Nammo Ireland designs and develops flow control devices for launcher and spacecraft applications and in 2023 successfully achieved flight qualification status, onboard a UK spacecraft, for its two-stage solenoid valve, SVS10. The company also completed a hot-fire test campaign on a monopropellant thruster during the year.

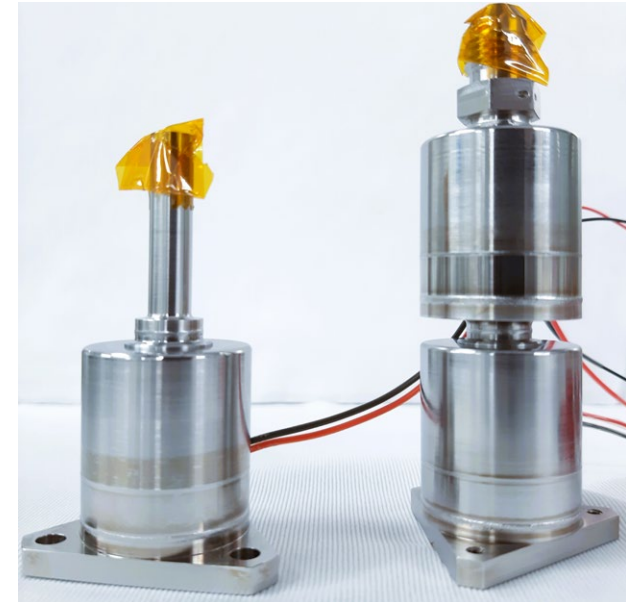


Figure 26. Single and Dual Stage SVS10 Thruster Valves © Nammo Ireland

Simplifying space access

Irish space infrastructure startup SUAS Aerospace has joined a consortium awarded €4.9m in 2023 under Horizon Europe which aims to simplify space access by creating reusable, modular launch equipment and test services. The EU-BEST project focuses on ground infrastructure mobility and adaptability for industrial-scale testing and aims to standardise rocket engine testing infrastructure, increasing cost efficiency and competitiveness for European aerospace companies. The project team will test Pangea Aerospace's ARCOS aerospike rocket engine at Aeroports de Catalunya, with SUAS validating infrastructure compatibility in Ireland. The project aims to support up to 200 engine tests annually, costing €25,000 per test, for engines up to 500kN thrust.

7.0

Supporting the next generation of space start-ups

Ireland hosts an ESA Business Incubation Centre (ESA BIC), which is funded by the Department of Enterprise Trade and Employment (DETE) through Enterprise Ireland. Part of a network of 27 ESA BICs across ESA Member States, ESA BIC Ireland is managed by ESA Space Solutions Ireland (SSI) and in 2023 had four consortium partners (Maynooth University, Technological University of the Shannon, University College Dublin and lead partner Tyndall National Institute). ESA BICs empower entrepreneurship and enable local economies to benefit from space data, technologies and assets.

ESA BIC Ireland supports start-ups that can demonstrate a tangible connection with space, and which are developing either upstream or downstream applications. The incubation centre's primary supports are delivered through the provision of a structured incubation programme that includes financial supports of up to €50,000, technical support through ESA and the various consortium partners, business mentoring, online training and structured networking opportunities both nationally and internationally. Participant companies can also access a range of ESA training opportunities and are made aware of various competitions and awards.

The two-year business incubation programme supports high potential start-up companies engaged in developing a broad range of applications in sectors including AgriTech, medical devices, materials science, semiconductors, FinTech, ClimateTech, cybersecurity, disability support and sports performance.

In 2023 ESA BIC Ireland incubation contracts were signed with six start-up companies – Celtonn, InfraPrint, ServBlock, Solsign, Sports Impact Technologies and Timing Solutions. PicoGlaze was also selected to participate in ESA BIC Ireland.

ESA SSI also offers ESA Spark Funding, a technology transfer funding mechanism 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 €40,000 to companies for eligible projects that have a maximum duration of 12 months. Two ESA Spark Funding contracts were signed with Eblana Photonics and PixQuanta, and another two ESA Spark Funding applications were approved for Enbio and PixQuanta during the reporting year.

In May 2023 the inaugural ESA BIC Ireland Showcase took place in NovaUCD, Dublin. The showcase attracted over 25 companies and was attended by Neale Richmond TD, Minister of State at the Department of Enterprise, Trade and Employment. By the end of 2023 ESA BIC Ireland had supported 35 companies, with a survival rate (contracted to ESA BIC & still trading as of end 2023) of 86%.

8.0

A busy calendar of space related events

An international brokerage event was held in February for prospective applicants interested in the Horizon Europe Space Call topics open at the time. The event was organised by Enterprise Ireland's National Contact Points (NCPs) for Space and Industry in collaboration with the Enterprise Europe Network (EEN).

Irish companies and research-performing organisations (RPOs) had the opportunity to showcase their cutting-edge innovations to an international audience. The event also included presentations from the European Commission (Directorate-General for Defence Industry and Space) and the EU Space Agency (EUSPA), as well as from the NCPs in Ireland and Belgium on space related topics.

Participants had the opportunity to meet with NCP and EEN experts and to pitch ideas and expertise in front of leading research organisations and innovators from industry. The event was open to SMEs, larger companies and research organisations based on the Island of Ireland and across Europe. Some 112 participants attended on the day – one third of them Irish, with 21 countries represented. In all, 189 partnering meetings were conducted, with 152 concrete opportunities identified.



Figure 27. 'Space brokerage' event flyer © ESA / EEN / Enterprise Ireland

Paris Space Week

A number of Irish companies attended Paris Space Week from 08-10 March, with Enbio, Innalabs, Mbryonics, Réaltra, Ubotica Technologies, and Plasma Bound participating in an Enterprise Ireland pavilion. The pavilion was organised by the Enterprise Ireland and IDA Paris offices, with support from members of Ireland's National Delegation to ESA. iDare Space Travel also had a booth at the show.



Figure 28. Enterprise Ireland / IDA booth at Paris Space Week © Enterprise Ireland

Visit by EUSPA to Department of Transport and ISA

The Irish Space Association (ISA) held its inaugural meeting at Enterprise Ireland HQ at Eastpoint on 27 April. The meeting was joined by Rodrigo da Costa, Executive Director of the EU Space Agency (EUSPA) who also visited the Department of Transport to meet with other Government agencies. Mr da Costa delivered an introductory presentation "EUSPA and the EU Space Programme" to attendees and was accompanied by Christina Giannopapa, Head of the Executive Director's Office, and Patrick Hamilton, Head of Administration.



Figure 29. Rodrigo da Costa (Exec. Director, EUSPA) speaking at Irish Space Association (ISA) inaugural meeting at Enterprise Ireland HQ, Eastpoint, Dublin © Enterprise Ireland

Workshop on ESA Earth Observation support programmes

A Workshop on ESA Earth Observation support programmes was held in May for those who need access to EO data for their business solutions as well as organisations who recognise the increasing importance of EO data and are interested in devising strategies around its implementation. Over 40 participants attended and following a briefing provided by Gordon Campbell and Michele Castorina of ESA, many attendees took up opportunities for pre-booked one-to-one meetings which ran into the late afternoon.



Figure 30. Earth Observation innovation support programmes: 'FutureEO' and 'InCubed' © ESA

Ireland's First Destination Earth workshop

October saw Ireland's first ever Destination Earth workshop. Organised by Met Éireann, the event took place in the National Convention Centre with input from Enterprise Ireland and ESA. The workshop had strong representation from across the spectrum of Government bodies, academia and industry and, as one of the first nationally organised Destination Earth events in Europe, attracted international interest and attendance.



Figure 31. Eoin Moran, Director of Ireland's National Meteorological Service, Met Éireann speaking at Ireland's First Destination Earth workshop © Met Éireann

Institute of International and European Affairs "Space: A New Frontier for Ireland?" event

Also in October, Minister Neale Richmond delivered the opening address at the Institute of International and European Affairs "Space: A New Frontier for Ireland?" event which highlighted the growth in global space activities in recent years and the implications for Ireland and our growing space industry sector. Minister Richmond was joined at this panel-based discussion by Sinead O'Sullivan, Harvard Business School's Institute for Strategy and Competitiveness, Rory Fitzpatrick, CEO of National Space Centre and Peter Smyth, Commercial Director at Tyndall, while attendees included Institute members, industry stakeholders, officials from a number of Government departments and members of the defence forces.



Figure 32. Rita Malosti of Mbryonics presenting (top) at ESA's inaugural EO Commercialisation Forum and (bottom) accepting "CommEO" prize from ESA Director General Josef Aschbacher © Enterprise Ireland

Inaugural EO Commercialisation Forum

ESA's first Earth Observation Commercialisation Forum took place in early November at the organisation's HQ in Paris. Over 300 participants attended at the venue with many more participating online. Several Irish companies attended, with Skytek on hand to present its asset monitoring solutions which leverage satellite data. Ubotica Technologies presented its concept of SPACE:AI (Autonomous In-Orbit Operations), while Mbryonics won a prize in the "CommEO" awards. It is expected that the event will be run annually from now on.

9.0

European Union Space Developments

Two formal meetings of the EU Competitiveness Council on Space took place in 2023 along with a Space Summit under the Spanish Presidency.

In May 2023, EU Ministers approved Council Conclusions on “Fair and sustainable use of space” and engaged in an exchange of views based on the Swedish Presidency paper on the “EU Space Policy in a new geographical landscape”.

In November the Spanish Presidency hosted a Space Summit in Seville, encompassing an informal meeting of EU Competitiveness Ministers, a meeting of ESA Ministers and a joint EU/ESA Ministerial meeting. At the EU informal Competitiveness meeting Ministers focused on EU strategic autonomy and on improving the resilience and sustainability of EU space assets.

At the joint EU-ESA meeting Ministers engaged in a policy debate on how space could best contribute to advance sustainable and Green European policy ambitions and how to ensure a pioneering role for Europe in safeguarding the Earth and space environment for future generations.

They also considered how to maximise the innovation potential of growing commercialisation in the European space sector through strengthening the public sector’s role as customer of space-related services and data.

Speaking at the Space Summit, Minister Richmond said **“The space sector plays a vital role in tackling the climate crisis. Space systems are changing rapidly, and we are in an era of increased competition and commercialisation, which offers great opportunity for Irish SMEs and start-ups. The participation of SMEs and start-ups in all elements of the EU space programme must be supported through funding as well as business supports.”**

In December, EU Ministers met to approve Council Conclusions on “Space Traffic Management: state of play” and to debate the “Future of EU policy on space in a changing world”.

2023 also saw the presentation of a Joint Communication from the European Commission to the European Parliament and Council on an EU Space Strategy for Security and Defence. In the context of the space threat landscape, the Communication looked at how the EU can enhance the resilience and protection of space systems and services in the EU, and use of space for security and defence.



Figure 33. Minister Richmond TD led the Irish Delegation to the Space Summit 2023. From left-right: Oliver Ginty (Enterprise Innovation Programmes Unit, Department of Enterprise Trade and Employment (DETE)), Emma-Jane Morgan (Head of Enterprise Innovation Programmes Unit, DETE), Neale Richmond (TD, Minister of State for Business, Employment & Retail), Julia O'Malley (Head of IE Delegation to ESA, DETE), Conor Sheehan (Deputy Head of Delegation, Enterprise Ireland) © Enterprise Ireland

EU space programme mid-term review

In October, the European Commission initiated a mid-term review of the EU's space programme, which has a budget of €14.9 billion for 2021-27. The programme funds various initiatives, including the Copernicus Earth Observation activities, the Galileo satellite navigation scheme and a new secure communications satellite scheme. The programme aims to support the space industry, foster Europe's space technological leadership, and promote entrepreneurship and competitiveness.

The mid-term evaluation, required by the programme's legislation, will assess the performance of the services provided, changes in user needs, and the services offered by competitors. The evaluation will help identify the evolving needs of EU space programme users and where new measures may be needed under the next multi-year EU budget. It will also assist in adjusting existing activities to respond to recent developments in the space sector.

IRIS² gets final approval

In March, the European Council adopted a regulation on the EU's secure connectivity programme for 2023-2027. This will see the deployment of an EU satellite constellation called 'IRIS²' (Infrastructure for Resilience, Interconnectivity and Security by Satellite) to provide ultra-fast and highly secure communication services by 2027. The new system will use advanced encryption technologies.

The space-based communication system will benefit governments in areas like protection of critical infrastructure, surveillance, support for external action and crisis management, thereby improving the EU's resilience and sovereignty. It will also ensure fast and secure communication services even when terrestrial networks are disrupted.

The system involves the development of new infrastructure, and this is expected to drive innovation and wider commercialisation in the Union. The programme, led by EUSPA, involves a large number of partners including Member States, ESA and private companies.

The programme, with a budget of €2.4 billion, will promote synergies with other components of the EU space programme, such as Galileo and Copernicus, and with space situational awareness capacities. It builds on the European Union Governmental Satellite Communications (GOVSATCOM).

Commission joins forces with ESA on climate action from space

Space-based technology and data have become increasingly important in the fight against climate change, providing actionable information to support knowledge-based policies and initiatives. As a result, the European Commission and ESA began collaborating in 2023 to accelerate the use of Earth Observation satellites to address climate change. The initiative aims to advance our understanding of Earth's climate system and enhance our ability to mitigate and adapt to climate change impacts, aligning with the European Green Deal.

ESA and the Commission's Directorate-General for Climate Action (CLIMA) are leveraging their combined expertise to bring about transformative change, particularly through the EU's Copernicus space programme and ESA's Space for a Green Future Accelerator.

The initiative includes better monitoring, reporting, and verification solutions for greenhouse gas emissions, deforestation, detecting methane leaks and identifying other activities that could benefit from Earth Observation data. It also supports the development of tailored tools such as the Green Transition Information Factory, and furthers the European Union's Land Use, Land Use Change and Forestry Regulation.

In addition, the initiative will assist companies and public organisations from multiple sectors to assess risks and implement decarbonisation strategies. The goal is to advance climate science, support policy implementation and boost green innovation, contributing to the European Green Deal and a carbon-neutral future.

European Union Member States join ASAT testing ban

In August 2023, the Member States of the European Union, but not the EU itself, pledged not to conduct destructive direct-ascent anti-satellite (ASAT) tests. This commitment was included in a joint contribution by the EU to the United Nations Open-Ended Working Group (OEWG) on Reducing Space Threats. The commitment is a response to concerns that destructive ASAT systems could have widespread and irreversible impacts on the outer space environment.

EU Member States see this commitment as an important step towards preventing damage to the outer space environment and contributing to the prevention of an arms race in outer space. While the EU welcomed this joint commitment, it clarified that the commitment did not apply to the EU itself, as such potential behaviour would fall outside of its competences.

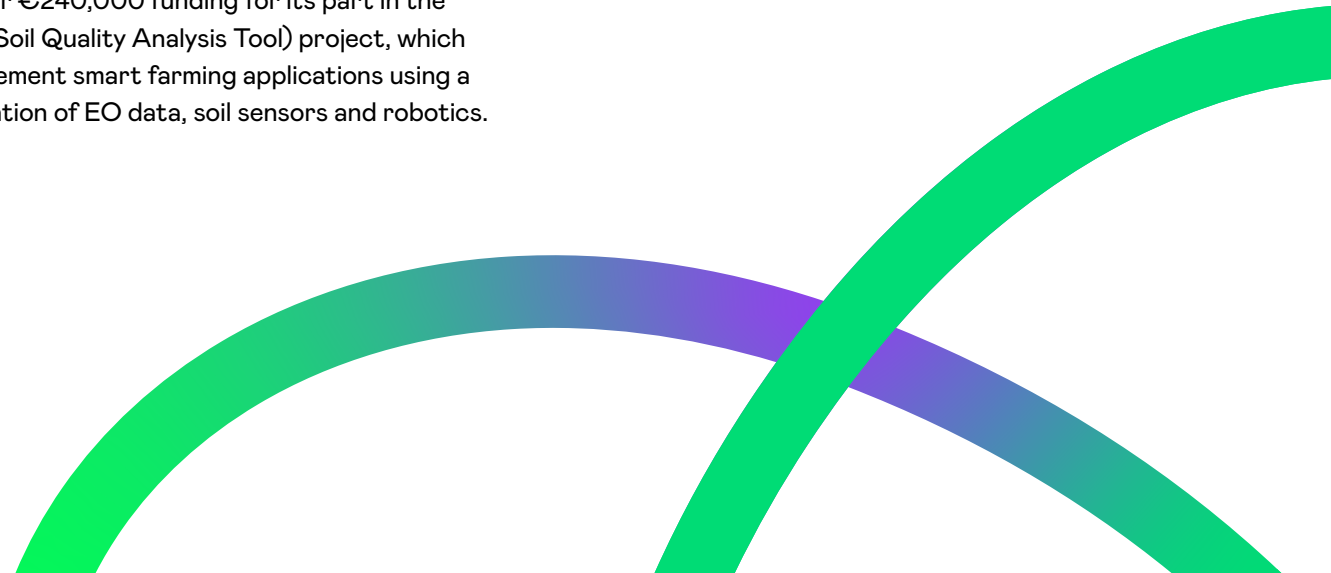
The OEWG is set to hold its final working session in the near future, with the intent to finalise recommended measures, like ASAT testing bans, to bring to the United Nations. In its document, the EU endorsed several norms of behaviour that address topics from intentional activities that create space debris to those that impair space-based services. It also backed transparency in space activities, such as sharing information about space policies and providing prelaunch notifications.

Horizon Europe 2023 Space Calls

A single Horizon Europe call with a budget of €137.5m, managed by the European Health and Digital Executive Agency (HaDEA), offered 14 space topics across five themes: Foster competitiveness of space systems; Reinforce EU capacity to access to space; Evolution of services (Copernicus); Innovative space capabilities (SSA, GOVSATCOM, Quantum) and Targeted and strategic actions supporting the EU space sector.

The call closed at the end of March 2023. As a member of a consortium involving seven countries, Ubotica Technologies received over €280,000 out of a total €2.3m EU contribution towards the MESEO project, which aims to design, prototype and demonstrate an open, flexible and scalable multi-mission EO end-to-end system for massive processing. SUAS Aerospace won over €220,000 funding out of a total €4.9m EU contribution towards the Eu-BEST (European Bench for Engine and Stage Testing) project, which will test rocket engines and stages from different manufacturers.

The second EUSPA Horizon Europe Call closed at the start of March. The call had an increased budget of €48.1m available to stimulate the development of innovative space downstream applications, split into six topics focused on European Global Navigation Satellite System (EGNSS) for Smart Mobility, Copernicus data and AI fusion, and the first ever GOVSATCOM-based area. A single Irish recipient – Farmeye Ireland – won over €240,000 funding for its part in the SQAT (Soil Quality Analysis Tool) project, which will implement smart farming applications using a combination of EO data, soil sensors and robotics.



10.0

Ireland at the
forefront of
space research

Research contracts awarded to third-level institutions in 2023:

Institution	Description	ESA Programme
University College Cork (UCC)	Earth Science for Society (Block 4)	Future EO Period-1 Segment 1
National University of Ireland, Maynooth (NUIM)	Foundation and Concepts (Block 1)	Future EO Period-1 Segment 1
Tyndall National Institute	CC-Competitiveness & Growth 4.0 Period 2	Core Competitiveness Period 2
Dublin City University (DCU)	Discovery	General Studies
Tyndall National Institute	Technology Development	Basic Technology
Tyndall National Institute	BASS 4.0 Period 1	BASS 4.0 Period 1
University College Dublin (UCD)	Discovery	General Studies
University College Dublin (UCD)	Preparation Element	General Studies
Science Foundation Ireland	ESA Education Programme	Education

Lift off for Ireland's first satellite

A new chapter in this country's space story was opened when Ireland's first satellite, EIRSAT-1 (Educational Irish Research Satellite 1), launched from Vandenberg Space Force Base in California aboard a SpaceX Falcon 9 rocket at 18:19 UTC on 01 December 2023. The satellite is in a sun synchronous orbit, with an anticipated lifetime of two to three years and is being operated from mission control in UCD.

The 2U CubeSat class satellite was designed, built and tested by a team of students in University College Dublin with support from academic and professional staff. A flagship programme of the UCD Centre for Space Research, the satellite was developed with the support of the ESA Education Office 'Fly Your Satellite!' programme.

First announced in 2017, the project has provided training for more than 50 students, including nine completed PhDs, in all major aspects of satellite and scientific payload development, and significantly advanced capability in space systems engineering. A gamma-ray detector for astrophysics, a materials science experiment, an antenna deployment module and an attitude control testbed were all developed in-house. Technology from four Irish companies (SensL, Réaltra, Enbio and Taoglas) is onboard the spacecraft.



Figure 34. EIRSAT-1 team in November 2023 Front row (left to right): Joseph Thompson, Antonio Martin-Carrillo, Sheila McBreen, Ronan Wall, David McKeown, Lorraine Hanlon, Laura Cotter, David Murphy, Rachel Dunwoody, Fionn Gibson-Kiely. Stairs (left to right): Caimin McKenna, Cuán de Barra, Joseph Fisher, Jack Reilly, Gabriel Finneran, Pádraig McDermott, Aaron Empey © UCD

Shedding new light on exploding stars

The Supernovae and Explosive Transients Group at Trinity College Dublin, led by Prof Kate Maguire, has been working on the exciting data coming from the James Webb Space Telescope.

During 2023, the group worked on data from an exploding star 60 million light years from Earth which has allowed the explosion physics of small dense stars, known as white dwarfs, to be studied in exquisite detail. The launch of the James Webb Space Telescope has opened up new wavelengths to be investigated that shed new light on how stars end their lives as supernova explosions.

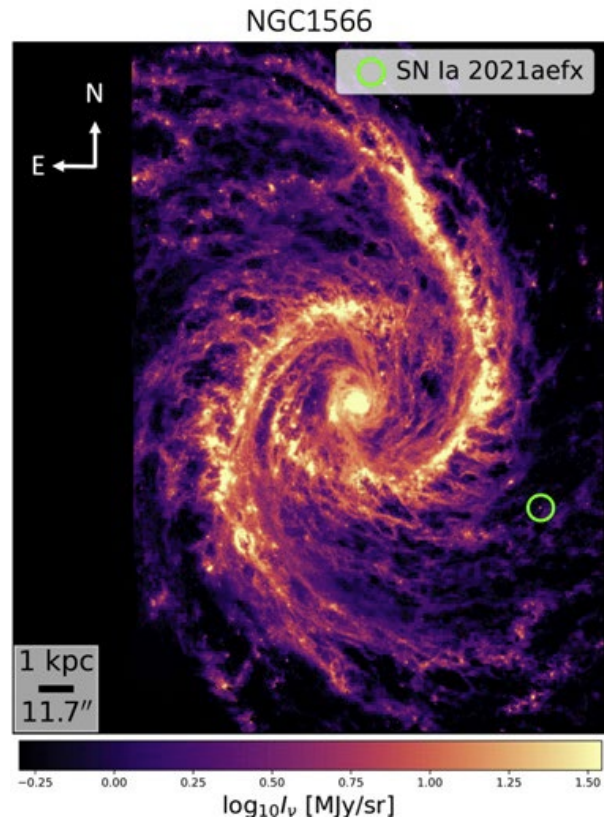


Figure 35. Image taken from Ness Myaker Chen et al 2023 ApJL, 944, L28, showing an image of the supernova, SN 2021aefx, taken with the James Webb Space Telescope MIRI instrument. The supernova is marked with the green circle © Ness Myaker Chen, Ohio State University, published in Astrophysical Journal Letters

Successful launch of ESA's JUICE Mission

The ESA JUperiter ICy moons Explorer (JUICE) mission was successfully launched from Europe's Spaceport in French Guiana on 14 April 2023. On board are a sophisticated suite of instruments to study the Jupiter system, with particular focus on the search for conditions that can support habitability on Jupiter's Ganymede, Europa and Callisto moons. Scientists at the Dublin Institute for Advanced Studies (DIAS) Planetary Group, led by Prof Caitriona Jackman, are working with the Radio and Plasma Wave Instrument (RPWI) and the Particle Environment Package (PEP). Their work includes modelling the effects of spacecraft charging on plasma measurements (lead Dr Mika Holmberg, ESA and SFI Fellow), and simulating possible subsurface oceans and plumes from Jovian moons (lead Dr Hans Huybrighs, DIAS Senior Research Fellow).



Figure 36. JUICE lifting off on an Ariane 5 rocket from Europe's Spaceport in French Guiana on 14 April 2023 to begin its eight-year journey to Jupiter, where it will study the planet's three large ocean-bearing moons: Ganymede, Callisto and Europa © ESA

UCD team selected for zero gravity experiment

The best way to determine the effects of gravity is to carry out an experiment in zero gravity. This can only be achieved, for any appreciable length of time, in space. Professor David Browne of University College Dublin has been awarded funding by ESA to study the effects of gravity on the solidification of metals. This is important for industrial manufacturing processes like casting, 3D printing or welding, producing metallic components for diverse applications such as human joint replacements or gas turbine engine blades. The UCD project is to prepare and execute an experiment on magnesium alloy solidification on board an ESA rocket in which 6 minutes of zero-g are achieved. X-rays will be used to monitor the growth of solid crystals from the liquid state, as the alloy cools from temperatures in excess of 600 degrees Celsius.

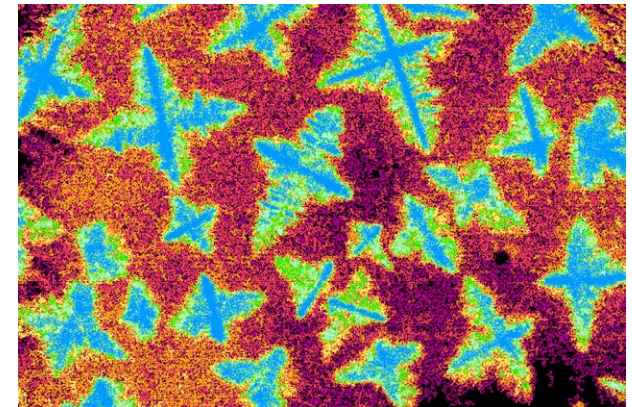


Figure 37. X-ray image of solidifying dendrites in an aluminium alloy, enhanced colour by machine learning; courtesy Jonathan Mullen, PhD student © UCD

COMCUBE-S: A swarm of CubeSats for polarisation measurements of cosmic gamma-ray bursts

CubeSats are small format satellites, usually weighing no more than a few kilograms, which provide affordable access to space for small countries, companies, research institutes and universities. Ireland's EIRSAT-1 satellite is an example of a CubeSat.

The UCD Centre for Space Research is leading the COMCUBE-S collaboration which includes IJCLab (France) and AAC Clyde Space (Scotland) and was awarded funding from ESA in 2023 under the 'Innovative Mission Concepts Enabled by Swarms of CubeSats' call to develop a concept for using a swarm of CubeSats to study gamma-ray bursts (GRBs).

The proposed mission would make polarimetric measurements of GRBs, giving a new, unique insight into these extreme astrophysical events. Each miniature spacecraft would carry a gamma-ray polarimeter instrument developed by UCD's Space Science group in partnership with IJCLab, providing all-sky coverage. Inter-satellite links will enable autonomous swarm behaviour, allowing rapid communication of detected transient astrophysical events for follow-up study by ground-based facilities. The study developed the mission concept, furthered the design of the instrument, and performed simulations demonstrating that a swarm of 27 CubeSats could fulfil the scientific objectives during a two-year mission lifetime.

Harnessing plant microbiome interactions in space

Researchers at UCD secured ESA and Canadian Space Agency (CSA) funding for the MARSCROP project, an EU-Canada genomics collaboration harnessing plant microbiome interactions to enable astrobotany and protect against soil pollution on Earth. The Irish group is also leading an international biomedical and data science team, including NASA collaborators, which is exploring the effects of spaceflight on mammalian microbiome interactions.

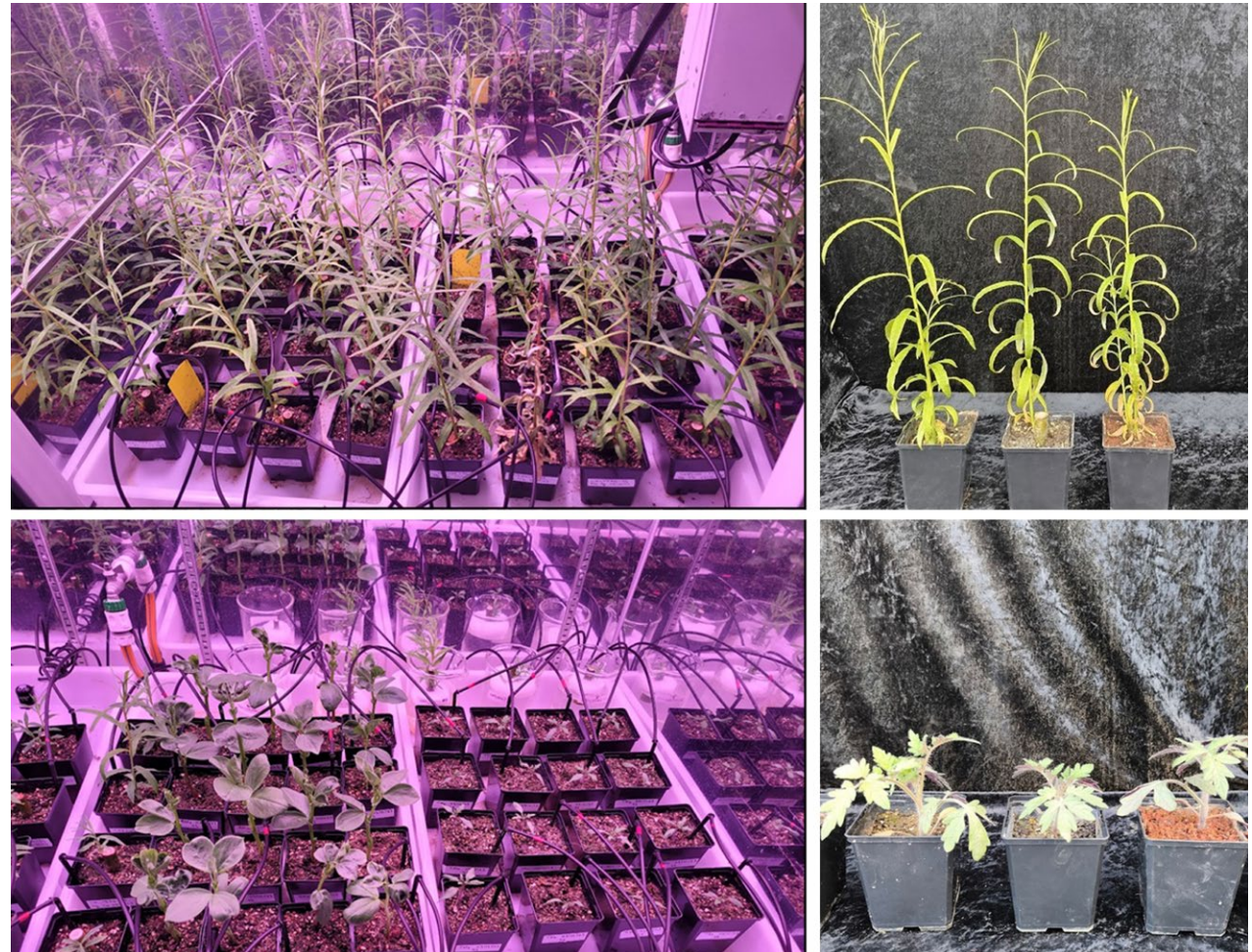


Figure 38. Willow, bean and tomato plants cultivated in control, Lunar (LHS-1) and Martian (MMS-1) simulant regolith at UCD as part of the ESA and CSA supported Marscrop project © UCD

11.0

Education and Public Engagement in Space

Space travel and exploration have vastly increased our understanding both of our own planet and of the universe itself. This has had tangible social and economic benefits as well as contributing to the sum of human knowledge. Communicating those benefits both to the next generation of potential space explorers and technologists as well as to the wider public is critically important in order maintain support for a vital field of human endeavour.

ESERO supports teachers and learners

ESERO Ireland (the Irish branch of the European Space Education Resource Office), co-funded by ESA and Science Foundation Ireland, provides supports to teachers and learners. ESERO partners with the SFI Curious Minds programme, MTU Blackrock Castle Observatory and Oide, the Department of Education's teacher support service, to provide continuous professional development (CPD) opportunities and classroom resources. 2,635 teachers nationwide availed of CPD in 2023.

The excitement generated by the launch of EIRSAT-1 provided a great opportunity to engage teachers, with related classroom resources developed in collaboration with the project team.

ESA's Europe-wide classroom project, Climate Detectives, had its first Irish national shared learning day in Athlone in April 2023. Ten schools took part in the learning day and submitted their projects to ESA's online platform, with The River Dodder Detectives project from Firhouse Community College, Dublin, singled out for commendation.

As part of the national Science Week school offer in November, ESERO Ireland worked with TikTok influencers Shanice Griffin and Brandon Caulfield to create shorts for secondary school aged viewers, attracting over 50,000 views.



CLIMATE DETECTIVES

Figure 39. Climate Detectives Logo © ESA

ESB Science Blast 2023

ESB Science Blast, the RDS's flagship science and technology programme for primary schools and one of the biggest events of its kind in Europe, kicked off its 2023 programme with a major event in Dublin in March. The ESA Education team attended for the first time, in collaboration with ESA Education Champion Dr Niamh Shaw and ESERO Ireland.

The ESA team presented a variety of interactive demonstrations about Earth Observation and space exploration activities, while representatives of the Irish space industry and academia were on hand to inspire the young attendees about the wide range of exciting jobs they might do in the future. Over 800 primary school teachers and 12,000 students attended the event during the week, with Minister for Education Norma Foley visiting the ESA stand.



Figure 40. Visitors to Science Blast enjoy interactive demonstrations © RDS



Figure 41. Minister for Education Norma Foley and RDS CEO Geraldine Ruane check out the ESA stand at Science Blast © RDS

Space Week 2023

Space Week, coordinated by MTU Blackrock Castle Observatory, ran from 04-10 October 2023 with 417 events nationwide, placing Ireland second in the overall global Space Week activity table. Space Week reached over 27,000 people and prompted over 100 media articles. Highlights included a Space Open Day at Cork School of Music, with panels hosted by Robin Ince of BBC4's the Infinite Monkey Cage, musical performances and hands-on workshops. At TU Dublin, primary school students had the opportunity to speak with astronaut Jasmin Moghbeli aboard the International Space Station via amateur radio.



Figure 42. Space Week workshops from CAPP (Centre for Advanced Photonics & Process Analysis) and IPIC (Irish Photonic Integration Centre) allowed visitors to explore the role light plays in technology. © Clare Keogh

Science Week: SpaceFest 2023

During Science Week from 19-23 November 2023, SpaceFest – run by the National Space Centre and Greywood Arts – hosted a range of science, engineering and arts events for over 1,500 visitors in East Cork. The centrepiece of the festival was an immersive installation and performance co-curated by French dance group Dahu Collective, projectionist Cormac O'Connor and Dr Niamh Shaw.



Figure 43. Dahu Collective at SpaceFest 2023 © National Space Centre Ltd.

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In other space
news...

Launch of the Irish Space
Association (ISA)

A key development for Ireland’s space sector in 2023 was the establishment of the Irish Space Association (ISA). ISA is an industry-led cluster of indigenous and foreign direct investment companies, research performing organisations (RPOs), educational organisations, and government agencies operating in the space sector in Ireland. The formation of ISA marks a significant milestone for the sector and reflects a strategic move by industry stakeholders to increase coordination, cooperation, and collaboration in this rapidly growing sector.

The primary goal of ISA is to support the Irish space sector by providing a platform for its membership to work collectively to identify and achieve common goals. By providing a unified voice and platform for collaboration, ISA aims to act as a catalyst to drive innovation, economic growth, and societal benefits through space-related activities. The organisation’s inaugural meeting, titled “The Cluster Effect: Accelerating the Space Business Roadmap in Ireland,” was held in July at ISA headquarters in DCU Alpha, Dublin City University’s innovation campus in Glasnevin, Dublin. The event featured representatives from the ISA Committee, DCU Alpha, and leading space companies like Ubotica Technologies, Enbio, Drone Consultants Ireland, and Viasat, along with the Irish Defence Forces.

Topics ranged from artificial intelligence (AI) in space and “flying close to the sun”, to the future of the drone sector in Ireland, showcasing the breadth and depth of Ireland’s space capabilities. In September, ISA held its second meeting to announce a major new initiative, “**Empowering Collaboration between Irish Research Performing Organisations (RPOs) and Irish Space Companies to Support the Growth of Ireland’s Space Industry.**” Hosted at Tyndall National Institute in Cork, the event, in collaboration with ESA Space Solutions Centre Ireland, brought together key stakeholders from the Irish space industry, RPOs, and government bodies to highlight the importance of partnerships between research institutions and companies. Finally in November, ISA participated in the UK Space Conference in Belfast, where it established strong connections with the UK space clusters.



Figure 44. A selection of images from various ISA events during 2023 © Irish Space Association (ISA)



