



ESA ACTIVITIES IN IRELAND 2021

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



Riailtas na hÉireann
Government of Ireland

Foreword

Irish companies continued to offer innovative solutions to the global space sector in 2021, particularly through the inclusion of advanced technologies from other industrial sectors. In line with the National Space Strategy for Enterprise, Irish companies are also increasingly exploiting space technologies in non-space markets, including the automotive, energy, and medical device markets. For instance, Irish enterprise has demonstrated the novel use of satellite positioning data using antennae to track and gather data on patient progress in hospitals.

The Earth Observation sector in Ireland is contributing to our understanding of the impacts of climate change in Ireland 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 and biodiversity, as well as offshore and renewable energy.

In 2021, Irish research institutions were responsible for developing the Mid-Infrared Instrument (MIRI) for the James Webb Space Telescope, a key instrument which breaks up the light into its various components, to produce scientific images sent back to Earth by the spacecraft. In a European first, a HD camera system – developed by an Irish company – was deployed on an ESA launcher to monitor the deployment of the telescope.

Heading into next year the future for the sector here in Ireland looks extremely bright – recently the Tánaiste and I signed an Exchange of Letters with ESA to facilitate the launch of Ireland’s first satellite, EIRSAT-1 which has been designed and built by academic staff and students at University College Dublin (UCD) and I look forward to watching it launch early next year from French Guiana on board an ESA launch vehicle.

The number of Irish companies actively engaged with the European Space Agency is at its highest ever – 94 organisations in total, with 14 coming on stream in the last year alone. I look forward to following the continued and impressive contributions of industry in Ireland to the European and global space activities.

Minister Damien English

Minister of State at the Department of Enterprise, Trade and Employment

Introduction

2021 proved to be another landmark year for the Irish space sector, with Irish companies and researchers involved in several high-profile and highly challenging space missions, including the successful launch of the James Webb Space Telescope; the joint National Aeronautics and Space Administration (NASA)/European Space Agency (ESA) asteroid impact mission, Hera; and ESA's exoplanet-hunter mission, PLANetary Transits and Oscillations of stars (PLATO).

The value of contracts placed by ESA grew for the second consecutive year in 2021, to €19 million, of which €15.8 million was placed with 36 Irish-based companies, with an additional €4.8 million in industry co-funding. ESA placed €3.2 million in contracts with Irish universities and research institutes supporting space-related research and technology development, including the ESA Business Incubation Centres (BICs) in Ireland.

In line with the overall growth in commercial space sector activities, 2021 was another year of substantial growth in the number of Irish companies securing ESA contracts, with 14 companies securing their first ESA contracts. This brings the total number of Irish companies actively engaged with ESA to 94. Of note in 2021 is the high number of Irish start-ups being supported by ESA, with 16 start-up companies securing ESA contracts in 2021.

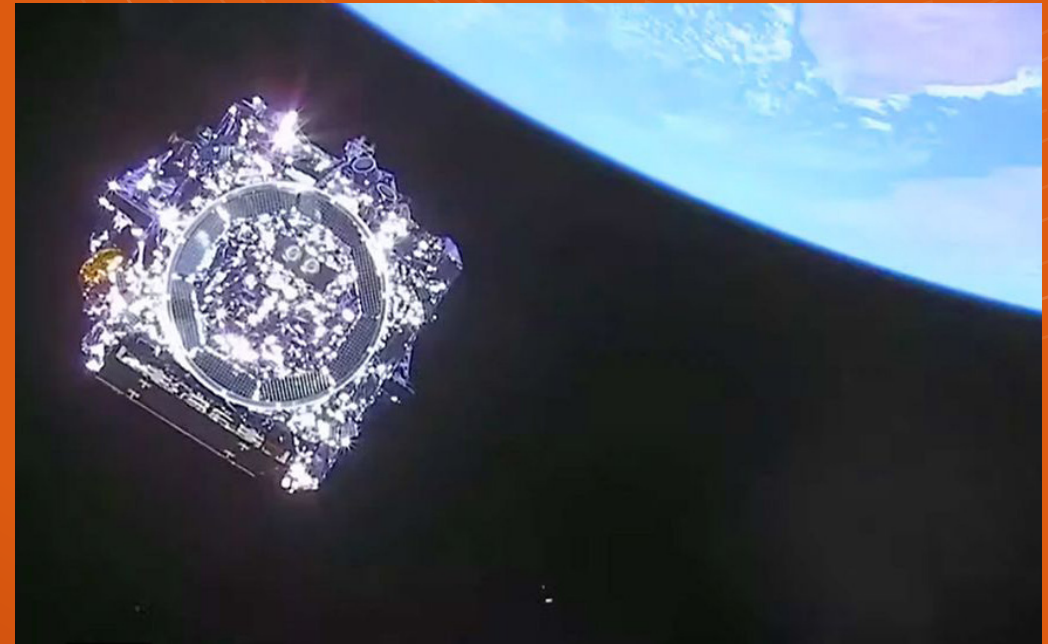


Figure 1: The James Webb Space Telescope starting on its journey into space, as captured by the VIKI camera system developed by Réaltra Space Systems Engineering. © ESA/Arianespace

The scope of ESA-supported activities in Ireland continues to expand to include a diverse set of technologies, ranging from power management and data systems for space transportation, to software for human spaceflight, artificial intelligence (AI) technologies and advanced composite thermoplastic structures for satellites. The trend of collaboration between Irish space companies continued in 2021, building on complementary technologies and capabilities to develop higher-value solutions for both ESA missions and the commercial space market. This trend is leading to a rapidly developing space technologies ecosystem in Ireland. There was also significant growth in Irish companies developing innovative uses of space-based systems, with an increasing level of activity in satellite-based solutions in a diverse range of sectors, including smart transportation, offshore energy, smart agriculture, environmental monitoring, and health management.

Irish companies continue to exploit their ESA support by developing new market opportunities for the technologies, products and services developed with this support. An analysis of the impact of Ireland's investment in ESA found that ESA-supported companies were expected to generate sales revenue of more than 6 times

the initial ESA research and development (R&D) investment by 2025, and this was projected to rise to more than 12 times the investment by 2030. The analysis concluded that these ratios are a strong indication that ESA funding delivers high economic return on State investment.

This report provides an overview of the space-related activities supported through Ireland's investment in ESA in 2021.

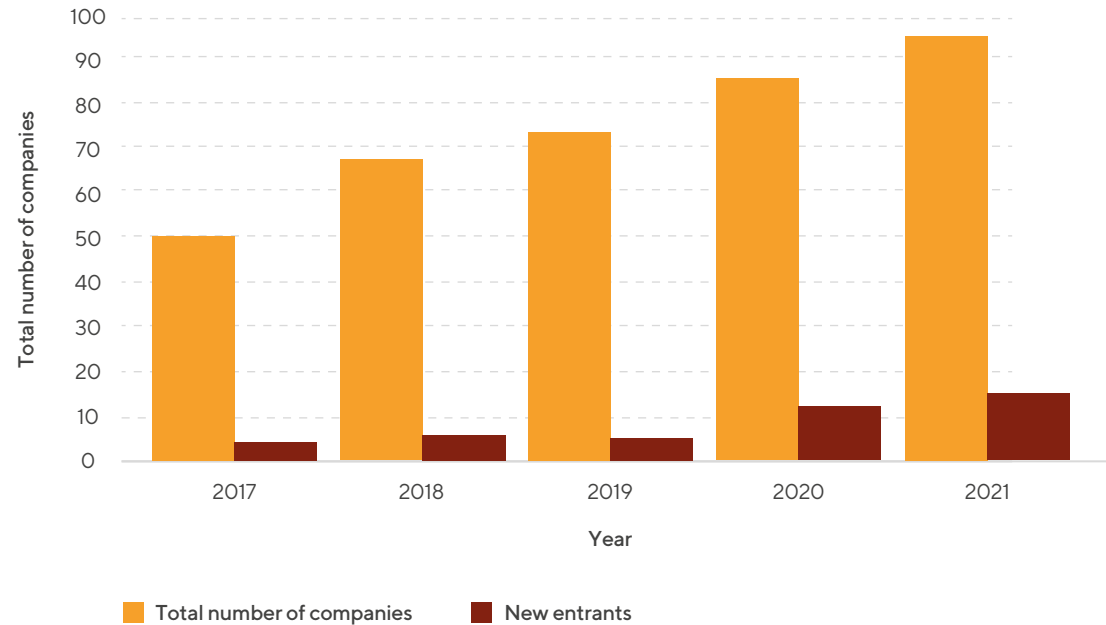


Figure 2: Number of Irish companies actively engaged with ESA (includes direct ESA contractors, subcontractors, and ESA BIC-supported companies), 2017-2021

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1.0 Delivering technology innovation to the space and non space sector

A growing number of Irish companies continued to bring technology innovation to the space sector in 2021, including through the ‘spinning in’ of innovative technologies from other industrial sectors. In line with the National Space Strategy for Enterprise, Irish companies are also increasingly exploiting space technologies in non-space markets, including the automotive, energy, and medical device markets. The following sections describe some of the industrial technology innovations supported by the European Space Agency (ESA), as well as a number of space-related highlights from 2021.

Réaltra Space Systems Engineering flies video kit on Ariane 5 launch of James Webb Space Telescope

The high-profile James Webb Space Telescope (Webb), an international project led by the National Aeronautics and Space Administration (NASA) with its partners ESA and the Canadian Space Agency, was launched successfully on Christmas Day 2021.

Réaltra Space Systems Engineering designed and manufactured the video system that was mounted on the Ariane 5 launch vehicle, and which relayed high-definition video images of the separation of the launcher’s fairing (equipment that enclosed and protected the Webb telescope during launch) from the telescope as it began its journey to its final orbit location. This is the first time the video system has been used, having originally been developed for the Ariane 6 launch vehicle (the successor to Ariane 5).

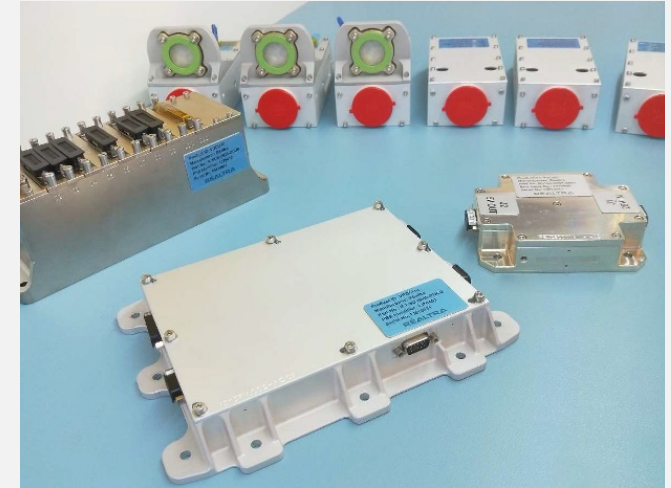


Figure 3: HD Video Telemetry Kit (VIKI) hardware, developed by Réaltra Space Systems Engineering. © Réaltra Space Systems Engineering



Figure 4: The VIKI hardware (developed by Réaltra Space Systems Engineering) is visible in the centre of this image of the James Webb Space telescope being encapsulated in the Ariane 5 fairing.

© ESA/National Centre for Space Studies (Centre national d’études spatiales; CNES)/Arianespace

InnaLabs wins contracts for ESA/European Union (EU) Copernicus and Airbus OneSat missions

InnaLabs was awarded the contract for ESA's Copernicus Land Surface Temperature Monitoring (LSTM) Science mission, with Airbus Defence & Space (ADS) selected as the prime contractor. The purpose of this mission is to respond to priority requirements of the agricultural user community to improve sustainable agricultural productivity at field scale in a world of increasing variability and water scarcity.

ARIETIS-NS is a game-changing commercial space product developed by InnaLabs which was selected by the European space prime contractor ADS as the technology of choice on the ADS next-generation OneSat programme for both Low-Earth Orbit (LEO) and Geostationary (GEO) platforms. The purpose of this programme is to be reconfigurable while in orbit, able to adjust its coverage area, capacity and frequency 'on the fly' to meet evolving mission scenarios.

InnaLabs was also one of several companies pre-selected by ADS to be part of the industrial consortium to build the Ariel mission

spacecraft. InnaLabs will be responsible for the Rate Measurement Unit (RMU) and Acceleration Measurement Unit (AMU) on this mission to detect and measure the atmospheric composition of exoplanets.

mBryonics marks a strong year with OneWeb Innovation Challenge win

Galway-based mBryonics was one of five winners worldwide of the prestigious OneWeb Innovation Challenge 2021. mBryonics' fibre-coupled freeform optical terminals and photonics solutions for the next generation of satellite constellations have been designed from the ground up to power the digital space age; the company will now work

with OneWeb on its mission to bridge the digital divide with its LEO constellation of telecommunications satellites aimed at bringing the internet to remote locations.

mBryonics' next-generation >100 Gigabit-per-second (Gbps) optical communications demonstration mission reached another milestone in 2021. As part of the European Commission's in-orbit demonstration programme, ESA awarded a contract to build and operate the satellite that will host mBryonics' industry-leading StarCom 100bps optical terminal, and which will launch on an Ariane 6 launcher. A world breakthrough, 100 Gbps optical communications is the most important technology to enable high-speed satellite broadband from megaconstellations in LEO.



Figure 5: On the left, ARIETIS-NS and the Copernicus LSTM Science mission; on the right, ARIETIS-NS and the OneSat mission. © InnaLabs

ÉireComposites to build 'stray light baffles' for ESA Altius mission

The Atmospheric Limb Tracker for Investigation of the Upcoming Stratosphere (Altius) mission will deliver high-resolution profiles of stratospheric ozone and other atmospheric trace gases and other atmospheric trace gases. In 2021, ÉireComposites won an ESA Contract to develop 'stray light baffles' for Altius.

Stray light is one of the major aspects impacting the performance of optical sensors. A stray light optical baffle is an opto-mechanical construction designed to block light from a source shining into the front of an optical system and reaching the image as unwanted light. These stray light baffles will prevent out-of-field stray light from reaching the lenses of the satellite's optical instruments. Stray light baffles rely on highly controlled and precise manufacturing and finishing. The baffles will be attached to the side of the satellite, which is to be launched from French Guiana by the end of 2023. They will be the first external part and the largest functioning piece of equipment to be manufactured in Ireland and launched into space.

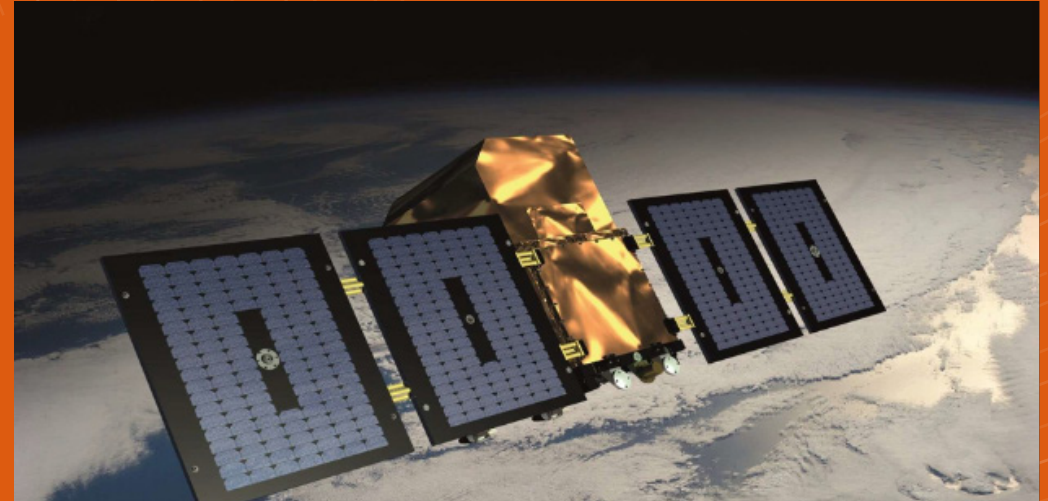


Figure 6: Artist's impression of the ESA Altius satellite. © QinetiQ Space



Figure 7: Tomás Flanagan, Chief Executive Officer (CEO) of ÉireComposites. © ÉireComposites

OCE Technology to adapt its space expertise to non-space applications

In 2021, ESA contracted OCE Technology to develop a real-time operating system for Arm® microcontrollers. Arm microcontrollers are used in many non-space domains, and OCE Technology intends to grow its activities by targeting the new operating system at other high-reliability markets, such as medical devices or smart manufacturing.

In line with this objective, OCE Technology is participating in an ESA Technology Transfer Demonstrator awarded by the ESA Business Incubation Centre (BIC). The project is a joint venture between OCE Technology and the Tyndall National Institute wireless communications laboratory to demonstrate the advantages of OCE Technology's new operating system, called OCEOS, for



Figure 8: OCE Technology's embedded AI development kit. © OCE Technology

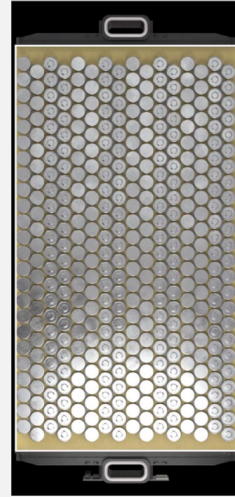
next-generation embedded wireless applications. Typical applications include robot coordination in smart manufacturing and remote robotic surgery. In June 2021, at the ESA On-Board Data Processing conference, OCE Technology presented a paper on its new artificial intelligence (AI) chip called HISAOR, from the Irish for 'artificial intelligence'.

Xerotech to develop next-generation battery safety technology for ESA

Galway-based Xerotech, a leading manufacturer of advanced lithium-ion battery systems, announced that it will qualify one of its core proprietary battery safety technologies for space applications in conjunction with ESA.

The technology, known as passive propagation resistant (PPR) design, is a critical safety requirement of future space missions, including crewed spaceflight. Xerotech's PPR technology can prevent single- and multi-cell thermal runaway within a battery pack by utilising an ultra-lightweight, fire-retardant structural foam which is 90% lighter than competing PPR technologies. The technology can be applied to all current space battery designs and has the potential to enable previously impossible mission profiles and applications. The technology will also have applications in the automotive sector.

Figure 9: Screen grab of Xerotech's PPR technology. © Xerotech



ISD Aerospace targets telecommunications market with novel power converter

ISD Aerospace (a newly established Cork-based company), as part of a consortium including ISD S.A. from Greece and Thales Alenia Space from France, was awarded an ESA contract

for designing, manufacturing and testing an electrical and functional model of a compact, low-voltage power converter for the telecommunications satellite market.

The reduced size and increased computational capabilities of electronic devices are of major importance for the overall performance of any satellite. Satellite subsystems are evolving to be massively digitalised, mainly due to the introduction of highly integrated digital cores (e.g. field-programmable gate arrays (FPGAs), application-specific integrated circuits (ASICs), microcontrollers, or microprocessors) and high data-rate links in order to send data back to Earth.

The Cork team will be responsible for the design of two critical parts: custom magnetic components, and testing the model of the power converter.

The test campaign, which will be prepared and conducted by ISD Aerospace, will ensure that the model of the power converter meets the strict requirements for spaceflight equipment.

Nammo Ireland expands its range of flow control valves for space transportation

Nammo Ireland was awarded an ESA contract to develop a torque motor flow control valve to support its growth as a recognised supplier in the space sector. Targeted primarily at space system integrators for use in space transportation vehicle propulsion, the torque motor valve development will also allow Nammo Ireland to expand into the USA and other international space markets.

The development, funded through the ESA General Support Technology Programme (GSTP), will focus on bipropellant chemical propulsion, commonly used on spacecraft for apogee insertion and station-keeping activities.

Nammo Ireland is focusing on the technical know-how for the actuator, flexure tube, and sealing, which will allow for a scalable design and the production of a series of platform products for the growing space market. Nammo Ireland is forecasting significant growth in both revenues and head count arising from this technological development programme.

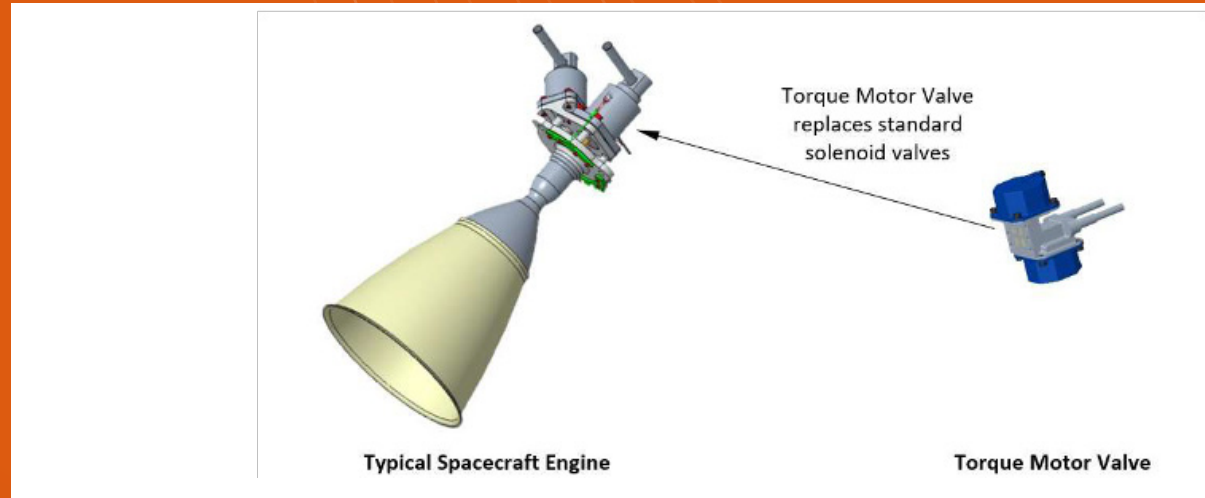


Figure 10: Typical spacecraft engine with Nammo Ireland valves. The Torque Motor Valve (TMV) is used in place of the standard solenoid valves. © Nammo Ireland

Ubotica Technologies expands space applications of AI

During 2021, Dublin-based Ubotica Technologies began working with a consortium led by Thales Alenia Space to develop an AI-enabled on-satellite Internet of Things (IoT) satellite communications (satcoms) solution. Funded through the ESA Advanced Research in Telecommunications Systems (ARTES) programme, the goal of the project is to automatically analyse radio frequency (RF) data streams, which contain short messages, in

order to reduce interference between messages. Ubotica Technologies is supporting the AI aspect of the system architecture, and in 2022 will contribute to building the prototype solution on a hardware breadboard. Ubotica Technologies will also manage the AI verification and demonstration tasks. This project represents the first satcoms integration for Ubotica Technologies and will pave the way for further collaboration with Thales Alenia Space to progress to an in-orbit demonstration.

Under a separate ESA programme, Ubotica Technologies is developing an intelligent space camera for launch vehicles and satellite visual monitoring applications. The hardware design for the small-form-factor Myriad X-based camera was developed during 2021. In tandem, Ubotica Technologies has developed a firmware suite to enable real-time image processing from a directly connected S-mount sensor. In 2022, the hardware prototype will be built and the firmware will be upgraded to enable the application of streaming AI on the input frames. The intelligent space camera is a key programme for Ubotica Technologies, as it paves the way for access to the expanding commercial space launcher market and has already led to collaboration with a launch systems supplier for a 2023 flight opportunity.

Lios wins second prize in ESA's Global Space Markets Challenge

Enterprise Ireland client company Lios won second prize in the upstream category of ESA's Global Space Markets Challenge, a competition intended to be a springboard into international markets for promising small, space-based companies in Europe and Canada with the most convincing internationalisation plans for their specialised products or services in upstream and downstream activities. Lios is currently developing acoustic protection technologies for launch vehicles through the Future Launchers Preparatory Programme.

The prize included €10,000 in cash, participation in an ESA mentoring programme, a company booth at ESA's Industry Space Days in the Netherlands, plus participation in the 2021 International Astronautical Congress in Dubai, United Arab Emirates.

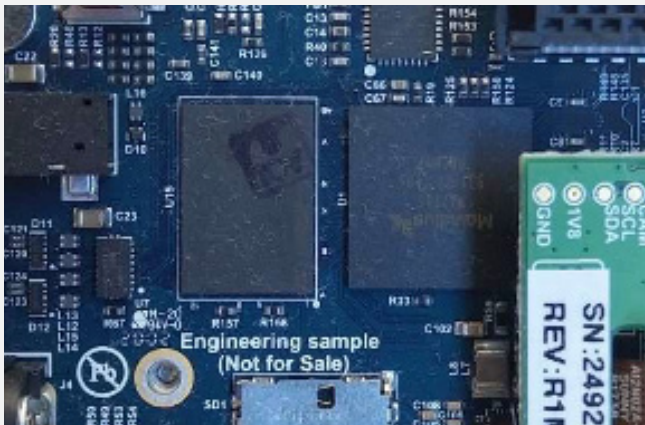


Figure 11: The Movidius development board from which Ubotica Technologies' intelligent space camera will be developed. © Ubotica Technologies

2.0 Space supporting the green agenda

Space-based solutions are increasingly being used in environmental monitoring and in mitigating some of the impacts of climate change on our planet. Irish companies are developing solutions that incorporate advanced satellite systems to address some of these challenges and their impacts on specific sectors, including agriculture, as well as offshore and renewable energy.

TechWorks Marine kicks off new ESA contract to develop an *E. coli* Alert Data Service

Ireland's coastal waters are an important source of recreation for many, providing benefits for both physical and mental well-being. However, there may be adverse health effects associated with recreational use if the water is polluted. Over a four-year period (from January 2017 to December

2020), approximately 8.875 million cubic metres of raw sewage was discharged into Dublin Bay alone, causing serious environmental and public health issues.

TechWorks Marine, in collaboration with ESA, will examine historical and current data to establish relationships between in-situ measurements of *E. coli* and satellite-derived (optical, Synthetic Aperture Radar (SAR), or thermal) measurements of water quality in Irish coastal waters. The EADS will allow for the identification of potential *E. coli* events, as well as the provision of actionable, timely information to the public and key stakeholders.

Figure 12: Landsat 8 high-resolution image of Dublin Bay. © ESA



ProvEye wins ESA funding to develop grass measurement tool

ProvEye won funding from ESA (through the Kick-start programme) which will be used to develop ProvEye's advanced grass measurement tool, ProvGRASS. This tool will provide an unprecedented level of information on grass composition and quality over large areas using unmanned aerial vehicles (UAVs), satellites, and AI technology.

Farmeye links up with ESA to gauge carbon value of hedgerows

Farmeye signed a contract with ESA's Space Solutions department in a new deal which will see the company measuring hedgerow carbon and habitat value. The project will set out to do this using a range of space assets, including satellite imagery. The project will focus on hedgerows as they are a dominant but undervalued feature of Western European farms. This is particularly the case in Ireland where they cover 6% of the land area.

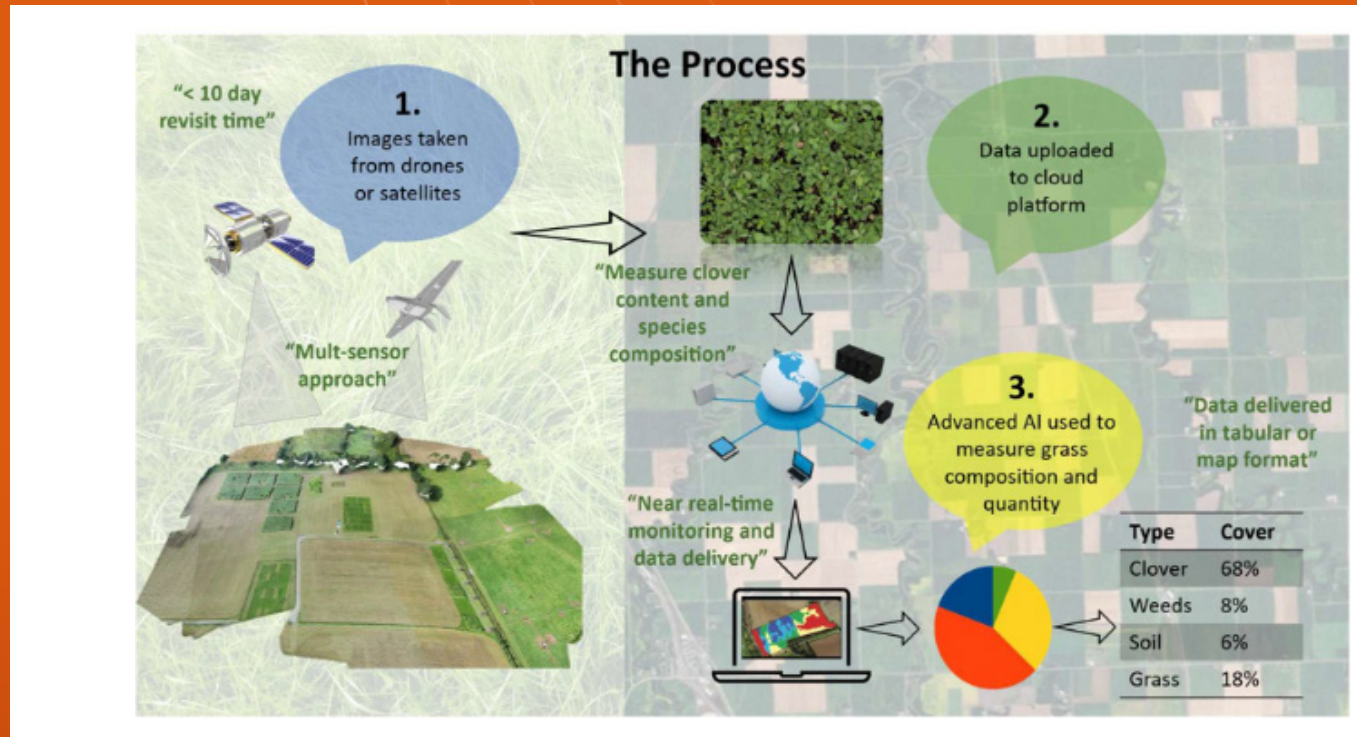


Figure 13: ProvEye's process to deliver grass quantity and quality information. © ProvEye

Mindseed and Ocean Energy team up to assess marine energy potential

Two Irish companies have partnered to assess the potential of satellite-based services for use in the renewable marine energy industry.

Mindseed, a Dublin-based information and communications technology consultancy that specialises in space-related technologies, teamed up with Cork-based wave technology specialist Ocean Energy to win a contract under the Marine Energy tender in collaboration with ESA and the Dutch Marine Energy Centre. The project aims to assess the potential benefits of utilising satellite-based services within the marine energy sector to address key operational challenges.

Figure 14: Ocean Energy's one-quarter-scale buoy undergoing sea trials. © Ocean Energy



Figure 15: Offshore wind turbines. © Principal Power

Dublin Offshore undertakes feasibility study with ESA on cost reduction for floating offshore wind

Dublin Offshore is undertaking a feasibility study to investigate how the application of space technology and systems can be used to deliver cost reductions for floating offshore wind (FOW). The study is supported through the ESA Space Solutions/Business Applications programme.

The project is investigating the use of Satellite Earth Observation (SatEO) data to characterise metocean conditions at FOW development sites. The results will be used to drive down FOW

levelised cost of energy through the optimisation of Dublin Offshore's Load Reduction Device. Dublin Offshore will deliver the feasibility study in collaboration with TechWorks Marine, which is providing expert advice on the SatEO aspects of the system.

Woodco Energy expands satellite-enabled sanitation monitoring

In 2021, Woodco Energy expanded its ongoing ESA-supported activity to develop further market opportunities for its satellite-enabled sanitation management and monitoring services in developing countries. Topics for discussion will include antimicrobial resistance, nutrition, active pharmaceutical ingredients, pandemic preparedness, and infectious disease control.



Figure 16: Installation of a sanitation management system in South Africa. © Woodco Energy

3.0 Delivering innovative commercial services via satellite

The most significant increase in activity by Irish companies in ESA-supported projects has been in the 'downstream' sector, by integrating innovative satellite-based systems into products and services across a range of applications and sectors, including in the agrifood, recreation, and logistics management sectors.

Taoglas expands its GNSS portfolio with ESA support

As the demand for higher-precision global navigation satellite system (GNSS) positioning increases, use cases such as autonomous driving, robotics, agriculture and wearable devices require much more advanced antennas. In 2021, the ESA Navigation Innovation and Support Program (NAVISP) enabled Taoglas to invest in research and development (R&D), which saw it release several multiband high-performance patches to add to its already extensive GNSS portfolio.

As the global GNSS market continues to grow rapidly each year, Taoglas product sales have also been rapidly increasing. In 2021, Taoglas shipped more than 7 million GNSS antennas, and with the cost of multiband GNSS modules decreasing, the demand for multiband GNSS antennas is growing. Taoglas is consistently at the forefront in releasing innovative GNSS antennas and RF products for the global market.

Some of the latest products Taoglas has developed under ESA programmes are manufactured using high-grade ceramics and Taoglas's own specially developed composite material, Terrablast, giving it a competitive edge in a high-value market.

danalto selected by ESA to improve indoor location solutions

danalto Ltd., a Dublin-based IoT software company specialising in positioning and spatial intelligence technologies, won a contract with ESA to demonstrate the best-in-class, low-infrastructure indoor location technologies that complement GNSS/Galileo. Currently, GNSS only partially operates indoors, and there is a growing need for more reliable, cost-efficient

indoor positioning with minimal infrastructure. ESA continuously seeks to improve this European capability to enable impactful societal use cases, thus prompting its call for this investigation, assessment and demonstration by danalto.



Figure 17: The Taoglas Laboratory at DCU Alpha. © Taoglas



Figure 18: Minister Damien English visited danalto upon the announcement of the ESA contract. From left to right: Minister Damien English TD, Mary Kathryn Midgett (danalto), Tom Kelly (Enterprise Ireland) and David McDonald (danalto). © Danalto

Verifact proving food supply chain provenance using satellite technology

Verifact, a software company based in Cork city, was awarded a contract by ESA to provide transparent, reliable information about food supply chains through the combination of satellite and blockchain technology. While the solution can be applied across a range of sectors, a specific opportunity has been identified for a premium food product in the Asian market, where it is essential to verify the claims made about the provenance and conditions in which the product is produced. The solution Verifact proposed to ESA is to implement the use of tags for individual animals which would transmit information to a cloud-based blockchain database and thus provide the required verification, with the information ultimately being passed on to consumers using QR codes. While Verifact has a wealth of experience in the seafood sector, this project will allow the company to expand its customer base to include primary producers in a range of food markets.

Davra Networks rolls out patient management and monitoring solution

In response to the Covid-19 crisis, Dublin-based Davra Networks are demonstrating their location technology in a new patient management and monitoring solution, Lifesaving Location Service, which can be used by any hospital, nursing home or home care service. The solution, with ESA support, integrates advanced satellite positioning and communications systems to track and trace 'free-to-move' patients and other relevant people in indoor and outdoor spaces. This enables rapid response to possible incidents (e.g. 'patient down') or lost patients and dynamically plans new, safe paths for transfers in case adverse events happen in the indoor and outdoor environments. The system is being trialled in an Italian healthcare facility in Rome with a view to rolling it out in the wider healthcare market.

ST Engineering iDirect develops next-generation satcoms platform

The ST Engineering iDirect (Ireland) engineering team was awarded an ESA contract to develop a next-generation platform (NGP) satcoms system. The Killarney team will be responsible for the development and testing of the NGP 'control plane' subsystem, which is a new and critical component of the NGP product offering. The addition of the control plane allows the NGP system to be more flexible in real time, which is critical to supporting emerging multi-orbit satellite systems and flexible satellite payload systems.

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

In line with the growing trend towards increasing entrepreneurship and start-up activity in the space market, Ireland saw a rapid increase in the level of space-related start-up company activity, supported by Enterprise Ireland in partnership with ESA. This included the activity of the ESA BIC Ireland.

Ireland's ESA BIC continues to expand

Following a successful initial five years of activity in which 23 space-related start-up companies were incubated, in 2021 ESA BIC Ireland secured funding for an additional four years.

The centre also supported 16 technology demonstrator projects in this period, supporting Irish companies to bring technologies originally developed for space back down to Earth and apply them to a broad range of terrestrial applications.

The initial ESA BIC Ireland consortium (the Tyndall National Institute, Maynooth University, MaREI and the Athlone Institute of Technology) has now been expanded to include NovaUCD.

A number of the ESA BIC Ireland companies have progressed their relationship with ESA to further develop technologies for the commercial space market, as well as innovative applications of space-based systems. The following sections outline a number of successful follow-on ESA contracts secured by ESA BIC Ireland companies.

Varadis to develop novel radiation detectors for use in space and healthcare

Varadis, a Cork-based deep technology radiation detection company, announced in 2021 that it won a significant contract with ESA.

The company's novel radiation detection sensors and subsystems are well known to the global space exploration industry and have already been used by astronauts on the International Space Station (ISS). Varadis's technology is also used by several of the largest private and public sector organisations around the world.

The technology, Radiation Sensing Field Effect Transistors (RADFETs), is built on 30 years of research at the Tyndall National Institute, and accurately measures the absorbed doses of ionising radiation such as gamma rays, protons, and X-rays. Now ESA is expanding the use of this technology to satellites.

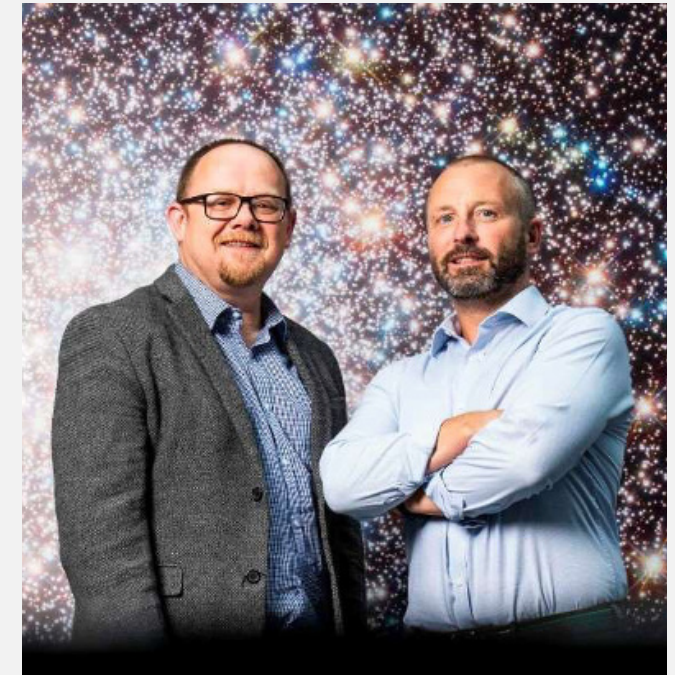


Figure 19: Professor William Scanlon, CEO of Tyndall National Institute, and Brad Wrigley, Co-founder and CEO of Varadis. © Varadis

PlasmaBound goes from strength to strength in composites bonding

In 2021, ESA BIC Ireland alumnus PlasmaBound commenced an ESA-supported Technology De-Risk programme, which supports the adoption of Controlled Polymer Ablation (CPA) in two space applications: composite struts and solar array panels. It targets the swift elevation of CPA from an entry point of TRL3 (experimental proof on concept) to TRL4 (validated technology) status in both areas, with plans to progress to commercial spaceflight qualification.

The ESA activity will further enhance PlasmaBound's ability to offer a first-in-class disruptive solution to the primary challenge in lightweight composite manufacturing, impacting on the automotive and transport, consumer electronics, sports and leisure, and renewable energy sectors.

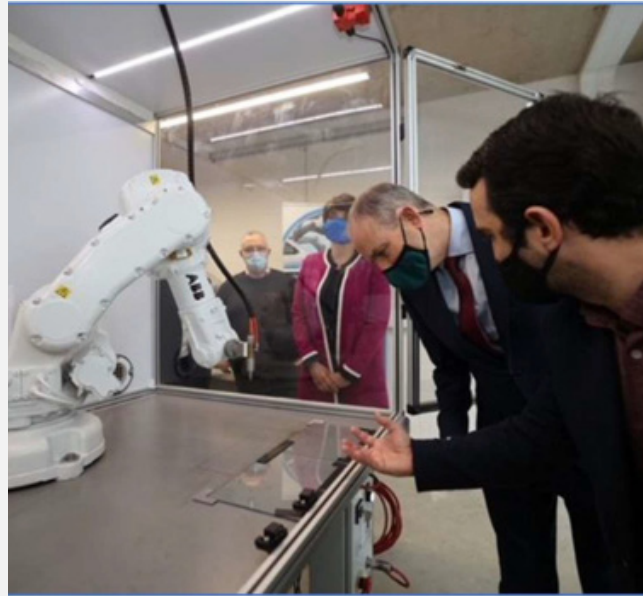


Figure 20: Dr Nick Barry demonstrating PlasmaBound's CPA process, using its ESA-funded platform, to An Taoiseach Micheál Martin. © PlasmaBound

PixQuanta advances Light Detection and Ranging (LiDAR) technology for space and automotive sectors

Cork-based PixQuanta has executed the design, end-to-end manufacturing description, and test plan required to fabricate its innovative photodiode sensors for LiDAR and 3D imaging.

In this contract from ESA, PixQuanta fully described the steps necessary to develop its photodiode technology for the next stages, enabling a new era of low-cost, mass-manufacturable sensors ready for monolithic integration into silicon readout-integrated circuits. By leveraging space applications with PixQuanta commercial target applications in consumer 3D imaging and automotive LiDAR, PixQuanta is positioned to provide a sensor technology for low-cost missions in LEO as well as high-value missions in GEO orbit. Space applications include in-orbit rendezvous, such as docking with the ISS; collision avoidance; debris identification; and attitude identification for landing on unknown surfaces, such as asteroids.



Figure 21: From left to right: David Gibbons (ATOS), Kevin O'Neill (PixQuanta), Prof. William Scanlon (CEO Tyndall National Institute). © PixQuanta

Applied Aerial Technology kick-starts space data to support rural development

Applied Aerial Technology (AAT) secured an ESA contract under its Kick-start initiative to promote and facilitate the utilisation of Earth observation data by citizens, businesses, and local authorities in rural areas of Ireland in order to improve decision-making at the local level. The Finding Intelligent Environment-led Data (FiELD) initiative aims to develop a cooperative framework in rural hubs to facilitate the implementation of space data by end users through the concept of citizen science. A knowledge transfer community hub will provide a physical location for interaction, ensuring this initiative instils a sense of place and encourages citizen engagement with satellite Earth observation data.

The enhanced decision-making ability at the citizen and societal levels may contribute to a new movement of citizen scientists who are actively interested and engaged in promoting responsible decision-making as a method of insightful natural resource management in response to climate change.



Figure 22: Damir Akhmetshin and Cian Gallagher of AAT. © AAT

Tisalabs securing the future of satellite-based IoT solutions

Cork-based start-up Tisalabs, supported by Enterprise Ireland and ESA, is developing satellite-based IoT solutions to protect critical IoT infrastructure. The development will combine data encryption and device identity management with cloud-based solutions to provide secure communications over terrestrial and satellite networks. Tisalabs is focused on the management challenges of protecting IoT infrastructure from intrusion, data falsification and hacking. As the IoT industry matures, the focus is moving from acquiring sensor data to

providing security for the sensor network, the geolocation of the sensors, and the transmission of IoT data to secured repositories. The ESA-supported SecureSat project will enable Tisalabs to develop and test, at scale, a software solution for enabling very secure communications between IoT-enabled devices, gateways, and the cloud data centre using a security framework with encrypted communications. Working with ESA on this project will allow Tisalabs to develop a highly resilient satellite-based technology that is approved and validated by ESA, and which will position Tisalabs at the forefront of advanced IoT security solutions for use in multiple market verticals.



Figure 23: Diagram showing how satellite-based IoT solutions protect critical IoT infrastructure. © Tisalabs

5.0 Ireland at the forefront of space research

Space-related research activities in Ireland continued to expand in 2021 across a broad range of topics, including the following activities:

University of Limerick to develop novel micropump for space applications

Stokes Laboratories at the University of Limerick (UL) was awarded an ESA contract to investigate space applications for its novel magnetic shuttle pump, including pumped two-phase loops for thermal management of spacecraft electronic systems and lubrication of reaction wheel bearings.

The successful application was made through ESA's Open Space Innovation Platform (OSIP), a web-based approach that enables the submission of novel ideas for space technology and applications.



Figure 24: Novel micropump developed by Stokes Laboratories. © UL

The innovative design of the liquid micropump improves performance and reliability, lowers power consumption and results in mass savings compared with conventional solutions.

The inventors plan to commercialise the technology in space and non-space markets (including cooling of data centre servers) through a spin-out company.

EIRSAT-1, Ireland's first satellite, passes rigorous testing prior to launch

University College Dublin's Educational Irish Research Satellite-1 (EIRSAT-1) team, participating in the second round of ESA's Fly Your Satellite! programme, has successfully concluded the environmental test campaign on its Engineering Qualification Model (EQM).

EIRSAT-1's EQM campaign saw the CubeSat exposed to conditions representing space. For example, an electrodynamic shaker system mimicked the extreme vibrations that the satellite will experience along three axes during launch. Meanwhile, EIRSAT-1's Flight Model communications subsystem (CMC) and Antenna Deployment Module (ADM) were sealed in a thermal vacuum environment and then repeatedly heated and cooled to extreme levels. The EQM was then installed and tested in the thermal vacuum chamber over the course of several weeks.



Figure 25: The EIRSAT-1 team with the EQM in the thermal vacuum chamber. © ESA

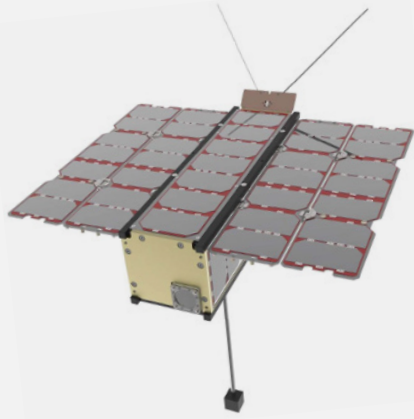


Figure 26: Artist's impression of the RadCube satellite. © ESA

Technological University Dublin applies innovative coating to increase solar panel output

Researchers at the Dublin Energy Lab in the Technological University Dublin (TU Dublin) won a contract through ESA's OSIP to apply thin film plasmonic luminescent concentrators to photovoltaic arrays (solar panels) to enhance their power output.

Initially focusing on increasing the power available for ground segment equipment (cellular base stations), the research will also investigate the suitability of the technology to operate in the harsh environment of space for satellite solar panels.

Irish scientist awarded research fellowship in space science at ESA

Dr Laura Hayes was selected as one of 10 Research Fellows in Space Science at ESA, and will work on the topic of quasi-periodic pulsations – a key to understanding solar flare energy release.

Laura received her undergraduate degree in theoretical physics from Trinity College Dublin, and soon after joined the astrophysics research group at Trinity to complete her PhD in solar flare physics. Following this, she joined the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center in 2019 as a postdoctoral fellow, where she continued to work on solar flares with a focus on X-ray observations of flare emissions.

Laura's project aims to build towards a better understanding of energy release and heating processes that occur in the atmosphere of the Sun during a solar flare. Her research focuses on the X-ray time variability associated with solar flare emission, and how this variability can be utilised to further constrain the physical models of solar flares. Her project will take advantage of the new and unique observations from the instrument suite on board ESA's Solar Orbiter and will use these observations

to make new discoveries about the true nature and underpinning physical mechanisms of time-dependent signatures in solar flare emission.



Figure 27: Dr Laura Hayes, ESA Research Fellow. © ESA

Irish intern develops software for ESA space experiment

An Irish student interning at ESA saw her work launched into space in 2021. Meadhbh Griffin of University College Dublin spent five months writing and testing software for an experiment on the Hungarian-led RadCube CubeSat, launched in August 2021. While its main mission is to probe space weather in Earth orbit, RadCube will also host a miniature experiment to test how commercial computer memories withstand space radiation.

Irish scientific contribution to the James Webb Space Telescope

The James Webb Space Telescope (Webb) was successfully launched from Europe's Spaceport in Kourou, French Guiana in December 2021. Webb is an international project led by NASA, along with its partners ESA and the Canadian Space Agency (CSA).

It is the next great space science observatory following the Hubble Space Telescope, and was designed to answer outstanding questions about the universe and to make breakthrough discoveries in all fields of astronomy. Webb will see further into our origins, from the formation of stars and planets to the birth of the first galaxies in the early universe.

Professor Tom Ray of the Dublin Institute for Advanced Studies (DIAS) is Co-Principal Investigator for the Mid-Infrared Instrument (MIRI), part of the telescope's instrument suite. Out of the four instruments in the suite, MIRI is the only one covering the mid-infrared wavelength range (from 5.0 to 28.3 microns). MIRI will produce mid-infrared images and

spectra with an unprecedented combination of sharpness and sensitivity.

Professor Ray and his team were responsible for providing MIRI's infrared filters, which break up the light into its various components, and for developing imaging software that will be used to analyse the instrument data the spacecraft sends back to Earth and to produce scientific images.

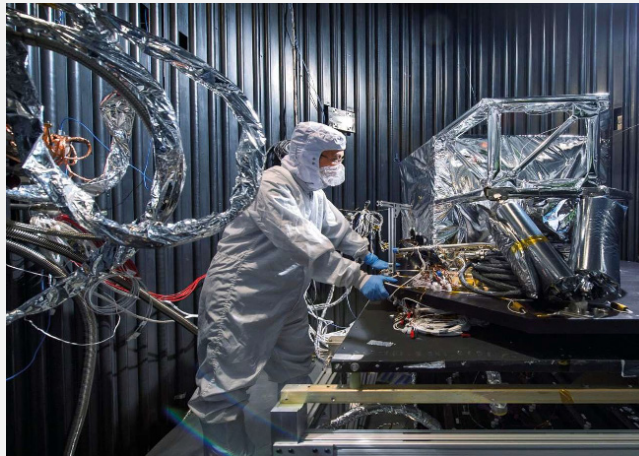


Figure 28: MIRI, which will see infrared light on the Webb telescope. © NASA/Chris Gunn

DIAS to help squeeze more from JUICE

Professor Caitriona Jackman and colleagues at DIAS were successful in their application to ESA's Open Space Innovation Platform (OSIP) for a co-funded research project on ESA's Spacecraft Plasma Interaction System (SPIS) to maximise the scientific outcome of the Jupiter Icy moons Explorer (JUICE) mission.

They propose novel applications of SPIS: to develop an interplanetary and planetary plasma environment 'tool' capability, to better understand the effects of environmental perturbations, and to improve calibration and data analysis routines. To develop the analysis method, they will use SPIS simulations and will compare these with the first JUICE measurements, which will be obtained soon after launch in 2023.

The new analysis method developed within this project will contribute significantly to improvements of analyses of space plasma and field data, not only for the JUICE mission but for all future planetary missions carrying the relevant instrumentation.

6.0 In other space news...

Enbio expands services to include thermal vacuum chamber testing

In 2021, Enbio continued several space-related development activities, including NEOSAT, the next-generation all-electric telecommunications satellite being developed by Thales Alenia Space and ADS with ESA support, which is intended to deliver commercially competitive satellites to the global market. Enbio is qualifying its SolarWhite surface treatment technology for NEOSAT's 15-year mission lifetimes, and it is expected to generate steady recurring revenue for the company.

Enbio was also involved in an ESA project as part of an international consortium with the aim of developing a compact louver for applications where deployment of classical louver blades is not possible because of a lack of room/clearance. The device is intended to act as a temperature-control mechanism by opening or closing depending on a device's temperature requirements in space.

This programme has acted as a 'test bed' for Enbio's new thermal vacuum cycling facility for the wider European market. The facility was used for projects and qualification activities for at least four Irish companies in 2021, including Réaltra Space Systems Engineering's payload interface unit for ESA's PLANetary Transits and Oscillations of stars (PLATO) mission.



Figure 29: Enbio's thermal vacuum chamber. © Enbio

Enbio is also actively exploring several additional development opportunities relating to the European contribution to the Lunar Gateway I-Hab programme, as well as to ESA's Large Logistics Lander.

All-Island Space Industry Days

Two events were held in 2021 to promote increased collaboration in space research and development between companies and research groups in Ireland and Northern Ireland. A physical meeting was held in Armagh, Northern Ireland in October, following on from a virtual event held earlier in the year.

The events were organised by ADS Northern Ireland, in conjunction with Invest Northern Ireland and Enterprise Ireland, with the aim of bringing together the flourishing space industry from across the island of Ireland, identifying further business opportunities, developing partnerships, and together growing the space industry in the region.

With more than 70 companies from across the island of Ireland in attendance, the physical event included presentations by European space system integrators on growing opportunities in the European space supply chain. Several follow-on cross-border collaboration opportunities have been identified as a result of the events.

PayLoad Data Router (PLDR) launches to the ISS

Dublin-based Curtiss-Wright was responsible for the design and on-ground testing of the PLDR, a data acquisition system which will record experimental measurements on the ISS, having been launched on a SpaceX Falcon 9 resupply mission in February 2021.

This is the first time that an Irish-based company has been the prime contractor from start to finish in the delivery of a complete system to the ISS.

The PLDR is now located in the Columbus module of the ISS, where it will be used to measure radiation and acceleration levels for life and physical science experiments in a microgravity environment.

The system's electronics were manufactured in Dublin by Realtime Technologies, while some of the radiation sensors that will be used in commissioning the PLDR on the ISS are provided by Tyndall/Varadis in Cork.

Réaltra Space Systems Engineering releases AI accelerator and computer vision processing board for CubeSats

Réaltra Space Systems Engineering announced the release of the RLT-AIA-001 AI Accelerator & Computer Vision Processing Board for CubeSats in collaboration with its technology partner, Ubotica Technologies.

The RLT-AIA-001 board is manufactured by Réaltra Space Systems Engineering under licence from Ubotica Technologies and is based on the CogniSat™ platform, which is the first CubeSat-compatible board capable of running sophisticated machine learning (ML) and AI algorithms for computer vision (CV) and other applications in real time on board a satellite.



Figure 30: Réaltra Space Systems Engineering's RLT-AIA-001 AI Accelerator & Computer Vision Processing Board for CubeSats. © Réaltra Space Systems Engineering

CAMEO project will democratise access to Earth observation data

The CAMEO (Creating an Architecture for Manipulating Earth Observation data) consortium, led by University College Dublin, secured funding from the Department of Enterprise, Trade and Employment's (DETE's) Disruptive Technologies Innovation Fund (DTIF) to establish a new Earth Observation (EO) platform designed for non-specialist users. The CAMEO project seeks to democratise access to an ever-increasing volume of EO data with the aim of developing a sustainable, internationally trading EO services sector in Ireland.

CAMEO will provide a new means of accessing international EO/unmanned aerial vehicle (UAV)/land-based sensor data and mechanisms, and for combining these with national climate, agriculture, and marine databases to unlock real, tangible potential for Irish industry, the public sector and researchers, establishing Ireland as an international leader in the use of EO data for economic and societal benefit. The members of this project consortium, led by University College Dublin, include Vertice, Edgescan, The ICON Group, Treemetrics, TechWorks Marine, and Dell Technologies.

7.0 Space helps inspire future generations of Irish students

Another successful year for the European Space Education Resource Office

The European Space Education Resource Office (ESERO) Ireland is an education project of ESA, co-funded by ESA and Science Foundation Ireland (SFI), in active fields of education and space.

ESERO uses space-related context and the genuine fascination with space that young people feel to engage them in science, technology, engineering and maths (STEM) subjects. ESERO also highlights the associated applications from space and raises awareness of the large range of space-related career possibilities.



Almost 1,500 primary and secondary teachers participated in ESERO Ireland professional learning experiences in 2021. These were run in partnership with projects and organisations such as the SFI Discover Primary Science and Maths programme, the Blackrock Castle Observatory, I-LOFAR, the Sustainable Energy Authority of Ireland, and Junior Cycle for Teachers. ESERO Ireland delivered a new Department of Education-approved online summer course for primary teachers titled 'STEAMing through Dark Skies and Biodiversity'.

The coming together of space experts and educators focused on the Solar Orbiter Mission, with presenters John O'Donoghue (CEO of Irish company Enbio), Thomas Ormston from ESA and Dr Sophie Murray from DIAS sharing their expertise with teachers.



Space Week was delivered virtually again in 2021 and had an audience of more than 96,000 people for its mix of school and public events. Space Week was supported through the SFI Discover Programme annual funding call and managed by Blackrock Castle Observatory.

More than 2,300 senior cycle second-level students attended the ESERO Space Careers Virtual Roadshows which took place during the Technology, Space, and Science Weeks in 2021. Students had the opportunity to engage with speakers from organisations such as Arup, Maynooth University, ESA, the CSA and the European Southern Observatory. The themes for the 2021 events were 'Using Earth Observation Data' (Technology Week), 'Women in Space' (Space Week) and 'Irish Scientists and Engineers working at ESA' (Science Week).

ESERO Ireland was privileged to partner with ESA, ESERO Germany and ESERO Czech Republic to participate in an in-flight call with German ESA astronaut Matthias Maurer on board the ISS on 24 November 2021. The event theme was 'Once an explorer, always an explorer', and it was hosted by Institute of Technology (IT) Carlow and attended by teachers and students from St Leo's College Carlow, Presentation College Carlow and Tyndall College Carlow, some of whom had the chance to ask their questions directly to Matthias. At the event, students learned about Maurer's Cosmic Kiss mission and the James Webb Space Telescope, which launched on Christmas Day 2021.



Figure 31: Ella Kennedy and Aimee Popescu from St Leo's College Carlow at the ESERO Ireland in-flight call with ESA astronaut Matthias Maurer, held at IT Carlow. © Mary Browne

Robotify brings innovation to teaching students to code

With the help of ESA Demonstration Project funding, a Dublin-based start-up, Robotify, has been able to integrate EO and terrain data into its advanced in-browser physics engine. The Robotify Severus engine is pioneering the in-browser 3D simulation space and making education in coding and robotics more accessible. Now, thanks to ESA, Robotify can provide simulations of any terrain in real time, all in-browser – and that is not just limited to Earth.

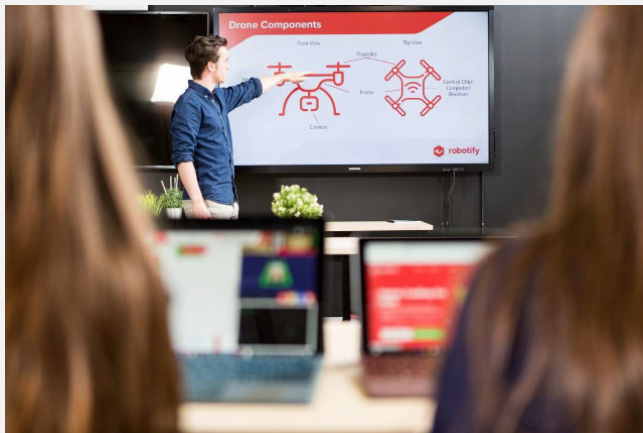


Figure 32: Robotify is making education in coding and robotics more accessible in the classroom. © Robotify

‘This is ESA’ published in Irish for St Patrick’s Day

An illustrated Irish-language brochure (created though a collaboration between ESA and Enterprise Ireland) that takes people on a vibrant journey through Europe’s space endeavours was launched during a global celebration of Ireland’s rich cultural heritage, just in time for St Patrick’s Day 2021.

The Irish translation of ‘This is ESA’ is expected to help teachers give Irish lessons a new cosmic angle.

It also presents an opportunity to inspire people about Ireland’s exciting contributions to ESA’s programmes, which include a small but growing group of space-based companies that actively use the country’s native tongue.

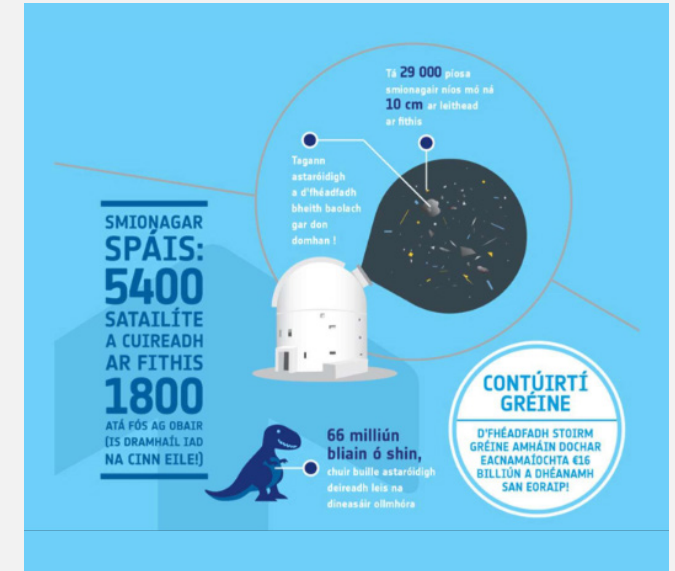


Figure 33: An extract from the Irish-language publication of ‘This is ESA’, looking at space debris. © ESA

8.0 European Union space developments in 2021

In January 2021, the European Union (EU) Commissioner for Internal Market, Thierry Breton, announced the European Commission's intention for a secure, space-based connectivity initiative to be the third EU flagship space programme, alongside the EU's satellite navigation programme, Galileo, and Earth observation programme, Copernicus. The initiative aims to ensure reliable, cost-effective, ultra-secure connectivity for governmental and commercial communications to support critical infrastructures, external actions, crisis management, telemedicine, and maritime and airspace surveillance. It will also provide universal high-speed broadband across the EU, Africa and the Arctic.

In April 2021, as part of the new Multiannual Framework Programme, the European Council and European Parliament adopted a regulation establishing the new €14.8 billion EU



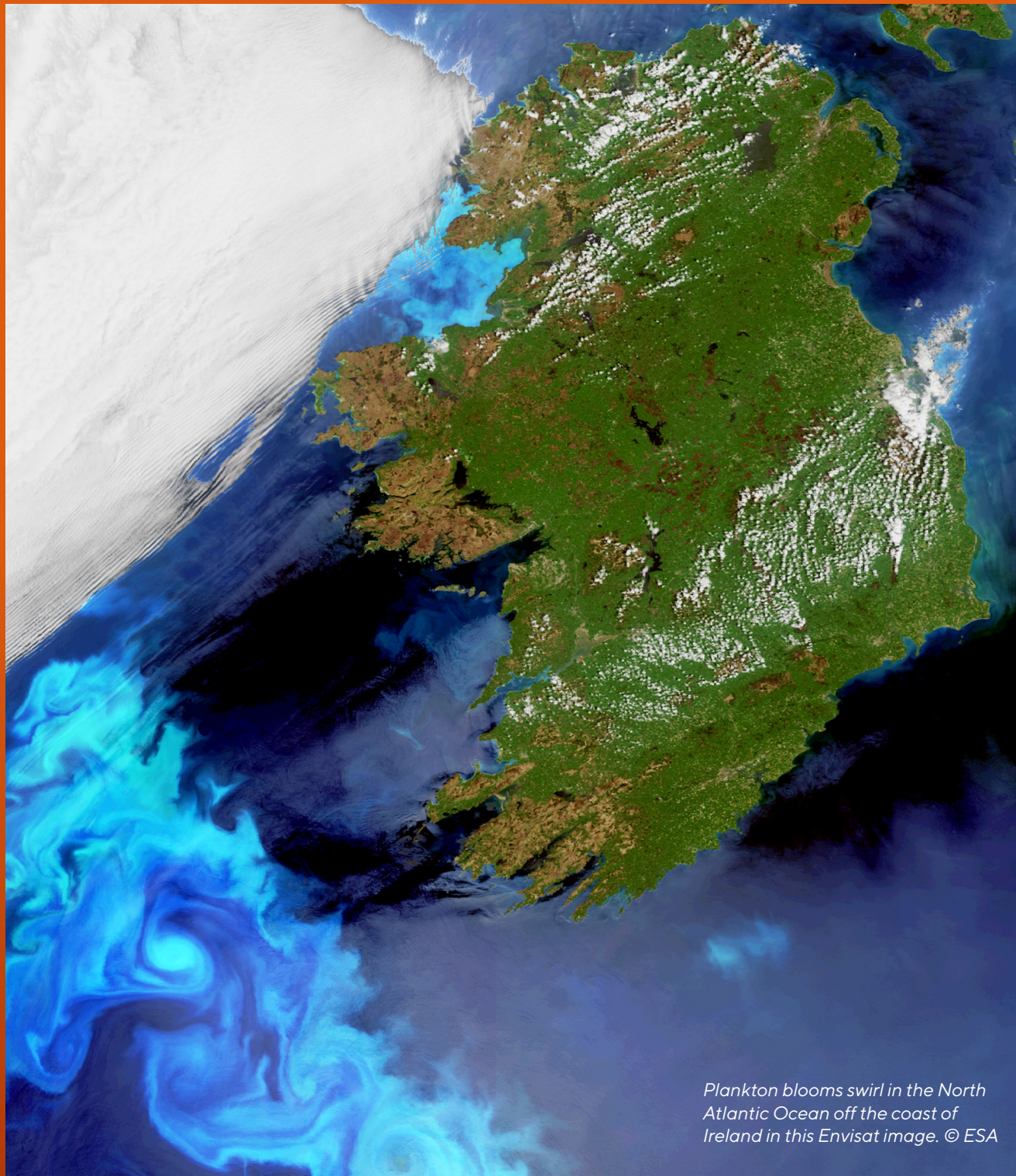
space programme for the years 2021 to 2027, consolidating existing flagship space programmes and establishing two new components – the Governmental Satellite Communication initiative (GOVSATCOM) and the Space and Situational Awareness (SSA) programme – in a single EU space programme.

Two EU Competitiveness Councils on Space took place in 2021, during which Ministers exchanged views on a range of topics relevant to strengthening the European space industry, including developing a European position on space traffic management and actions to support long-term sustainable development and financing of opportunities in the 'New Space' era.

Figure 34: EU Space Programme © European Commission

The European Union Agency for the Space Programme (EUSPA) was launched on May 12th 2021, replacing its predecessor the European Global Navigation Satellite System Supervisory Authority (GSA). EUSPA's primary function is to implement the EU Space Programme and to provide reliable, safe and secure space-related services, maximising their socio-economic benefits for European society and business

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



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